

Missouri University of Science and Technology

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U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2015



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# As-Built Project Manual

August 17, 2015

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## Summary of Changes

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

### November 18, 2014 Revision

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

- Rules Compliance Checklist
  - Rule 4-2, 4-3, 4-4, Rule 4-7, 6-3, 8-5, 11-4 updated with locations of drawings.
  - Rule 8-5 updated with location of calculations.
- Structural Calculations
  - Calculations revised and updated to show greater detail.
- Water Budget
  - The amount drawn for the fire suppression system changed from 150 gallons per draw to 300 gallons per draw.
- Interconnection Application Form
  - Electrical load calculations added after the Interconnection Application Form.
- Quantity Take-Offs
  - “Division 16 Electrical” was corrected to “Division 26 Electrical.”
- Construction Documents
  - Division 26
    - Section 26 05 00 added.
    - Section 26 05 19 added.

### February 12, 2015 Revision

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

- Rules Compliance Checklist
  - Rule 4-2: added O-102
  - Rule 4-2 (specs): added 01 54 19
  - Rule 4-3: added S-505
  - Rule 4-4: changed G-102 to S-101
  - Rule 4-6: added P-102, P-501
  - Rule 4-7: removed S-502; added S-501, S-505
  - Rule 5-2: removed A-101, added G-102, L-102
  - Rule 6-1: added S-101, S-102, S-103, S-501, S-502, S-503, S-504, S-505, S-506, S-507, S-508, S-509, S-510
  - Rule 6-2: removed A-101.4, A-101.5; added G-101, G-104
  - Rule 7-1: removed A-101; added L-104
  - Rule 7-2: added P-601
  - Rule 8-3: added E-105
  - Rule 8-5: added E-103, E-104, E-602
  - Rule 8-5 (one-line electrical diagram): removed E-302; added E-601, E-602
  - Rule 8-5 (site plan): removed I-602; added G-103
  - Rule 8-5 (elevations): added E-104



- Rule 9-1: removed A-402.1; added G-101, P-101
- Rule 9-1 (shaded water tanks): removed A-402.1; added P-101
- Rule 9-8: added P-102, P-902
- Rule 9-9: added P-102
- Rule 11-4: removed G-105
- Structural Calculations
  - Moved to Appendix B
- Interconnection Application Form
  - Filled out in accordance with new panel selection
- Appendices
  - Appendix A
    - Added Section 01 54 19 Temporary Cranes
  - Added Appendix B Structural Calculations
  - Added Appendix C Solar Decathlon 2015 Rules
  - Added Appendix D Solar Decathlon 2015 Building Code
  - Added Appendix E Reference Sheets

### March 26, 2015 Revision

- Interconnection Application
  - Array size calculation added
- Construction Documents
  - Division 26
    - Updated according to NEC 2014
    - Added:
      - Section 26 05 19
      - Section 26 05 33
      - Section 26 24 16
      - Section 26 27 26
      - Section 26 51 00

### August 17, 2015 Revision

- Detailed Water Budget
  - Updated to as-built house specifications
- Quantity Takeoff of Competition Prototype House
  - All quantities and materials updated to as-built house specifications

## Rules Compliance Checklist

| Rule     | Rule Description                 | Location Description  | Location  |
|----------|----------------------------------|---|---|
| Rule 4-2 | Construction Equipment           | Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site   | O-101, O-102  |
| Rule 4-2 | Construction Equipment           | Specifications for heavy machinery  | 01 54 19  |
| Rule 4-3 | Ground Penetration               | Drawing(s) showing the locations and depths of all ground penetrations on the competition site  | S-101, S-505  |
| Rule 4-4 | Impact within the Solar Envelope | Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope   | S-101   |
| Rule 4-5 | Generators                       | Specifications for generators (including sound rating)  | TBD   |
| Rule 4-6 | Spill Containment                | Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event  | P-101, P-102,<br>P-501, P-601,<br>P-901, P-902  |
| Rule 4-6 | Spill Containment                | Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event  | 11 30 00,<br>22 40 00,<br>33 16 20,<br>44 40 10   |
| Rule 4-7 | Lot Conditions                   | Calculations showing that the structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists  | Appendix B  |
| Rule 4-7 | Lot Conditions                   | Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot   | S-101, S-501,<br>S-505  |
| Rule 5-2 | Solar Envelope Dimensions        | Drawing(s) showing the location of all house and site components relative to the solar envelope   | G-102, L-102  |
| Rule 5-2 | Solar Envelope Dimensions        | List of solar envelope exemption requests accompanied by justifications and drawing references  | N/A   |
| Rule 6-1 | Structural Design Approval       | List of, or marking on, all drawing and project manual sheets that will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual | S-101, S-102,<br>S-103, S-501,<br>S-502, S-503,<br>S-504, S-505,<br>S-506, S-507,<br>S-508, S-509,<br>S-510 |
| Rule 6-2 | Finished Square Footage          | Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically  | A101, G-101,<br>G-104   |

|          |                           |   |                     |
|----------|---------------------------|---|---------------------|
| Rule 6-2 | Finished Square Footage   | Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week   | N/A                 |
| Rule 6-3 | Entrance and Exit Routes  | Drawing(s) showing the accessible public tour route   | G-103, G-105        |
| Rule 7-1 | Placement                 | Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system  | L-104               |
| Rule 7-2 | Watering Restrictions     | Drawing(s) showing the layout and operation of greywater irrigation systems   | P-601               |
| Rule 8-1 | PV Technology Limitations | Specifications for photovoltaic components  | 48 14 00            |
| Rule 8-3 | Batteries                 | Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices  | N/A                 |
| Rule 8-3 | Batteries                 | Specifications for all primary and secondary batteries and stand-alone, PV-powered devices  | N/A                 |
| Rule 8-4 | Desiccant Systems         | Drawing(s) describing the operation of the desiccant system   | N/A                 |
| Rule 8-4 | Desiccant Systems         | Specifications for desiccant system components  | N/A                 |
| Rule 8-5 | Village Grid              | Completed interconnection application form  | Page 13             |
| Rule 8-5 | Village Grid              | Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means   | E-103, E-104, E-602 |
| Rule 8-5 | Village Grid              | Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means  | 48 14 00            |
| Rule 8-5 | Village Grid              | One-line electrical diagram   | E-601, E-602        |
| Rule 8-5 | Village Grid              | Calculation of service/feeder net computed load per NEC 220   | Page 14-15          |
| Rule 8-5 | Village Grid              | Site plan showing the house, decks, ramps, tour paths, and terminal box   | G-103               |
| Rule 8-5 | Village Grid              | Elevation(s) showing the meter housing, main utility disconnect, and other service equipment  | E-104               |
| Rule 9-1 | Container Locations       | Drawing(s) showing the location of all liquid containers relative to the finished square footage  | G-101, P-101        |
| Rule 9-1 | Container Locations       | Drawing(s) demonstrating that the primary supply water tank(s) is fully shaded from direct solar radiation between 9 a.m. and 5 p.m. PDT or between 8 a.m. and 4 p.m. solar time on October 1 | P-101               |

|           |                         |   |   |
|-----------|-------------------------|---|---|
| Rule 9-2  | Team-Provided Liquids   | Quantity, specifications , and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation | N/A   |
| Rule 9-3  | Greywater Reuse         | Drawing(s) showing the layout and operation of greywater reuse systems  | P-601   |
| Rule 9-4  | Rainwater Collection    | Drawing(s) showing the layout and operation of rainwater collection systems   | N/A   |
| Rule 9-6  | Thermal Mass            | Drawing(s) showing the locations of liquid-based thermal mass systems   | N/A   |
| Rule 9-6  | Thermal Mass            | Specifications for components of liquid-based thermal mass systems  | N/A   |
| Rule 9-7  | Greywater Heat Recovery | Drawing(s) showing the layout and operation of greywater heat recovery systems  | N/A   |
| Rule 9-8  | Water Delivery          | Drawing(s) showing the complete sequence of water delivery and distribution events  | P-101, P-102, P-901, P-902                      |
| Rule 9-8  | Water Delivery          | Specifications for the containers to which water will be delivered  | 11 30 00,<br>22 40 00,<br>33 16 20,<br>44 40 10 |
| Rule 9-9  | Water Removal           | Drawing(s) showing the complete sequence of water consolidation and removal events  | P-101, P-102, P-601, P-901, P-902               |
| Rule 9-9  | Water Removal           | Specifications for the containers from which water will be removed  | 11 30 00,<br>22 40 00,<br>33 16 20,<br>44 40 10 |
| Rule 11-4 | Public Exhibit          | Interior and exterior plans showing entire accessible tour route  | G-103   |

## Structural Calculations

Refer to Appendix B.

## Detailed Water Budget

| Contest             | Amount Drawn (Gal.) | Number of Draws (Gal.) | Total (Gal.)  | Notes  |
|---------------------|---------------------|------------------------|---------------|--|
| Clothes Washer      | 14                  | 8                      | 112           | Amount specified according to competition rules and Energy Star standards.                           |
| Dishwasher          | 4                   | 5                      | 20            | Amount specified according to competition rules and Energy Star standards.                           |
| Cooking             | 1.6                 | 6                      | 9.6           | Amount specified according to competition rules.   |
| Hot Water           | 15                  | 16                     | 240           | Amount specified according to competition rules.   |
| Dinner/Movie        | 10                  | 1                      | 10            | Assumed amount of water used for both events.  |
| Hydroponics         | 100                 | 1                      | 100           | Assumed amount of water hydroponics and tower gardens, considering plant use and evaporation refill. |
| Initial System Fill | 80                  | 1                      | 80            | Initial fill for 80 gallon hot water tank.   |
| Fire Protection     | 270                 | 1                      | 270           | Estimate pending final system design.  |
| Testing             | 50                  | 1                      | 50            | Assumed amount for testing.  |
| Safety Factor       | 200                 | 1                      | 200           | Safety factor for spills and other discrepancies.  |
| <b>TOTAL</b>        |                     |                        | <b>1091.6</b> |  |

## Summary of Unlisted Electrical Components

There are no unlisted electrical components in the Nest Home.

## Summary of Reconfigurable Features

### Demonstration of Reconfigurable Features for Jury Tours

For public and jury tours, team members will demonstrate the fold-up bar feature of the Nest Home that has been outlined below.

#### Fold-up Bar

The Nest Home features a manually operated fold-up bar that is constructed in such a way that it can be folded down to provide an extra working plane, or folded up out of view for extra space. During public and jury tours, a decathlete will lower and raise the bar to demonstrate its usability. The operation of this and details can be view in more detail in the Construction Documents. Specific references include A4/A-404.



## Interconnection Application Form

Missouri S&T Solar House Design Team, Lot 108

### PV Systems

| Module Manufacturer | Short Description of Array  | DC Rating of Array (sum of the DC ratings) |
|---------------------|---|--|
| LG                  | 24 LG Solar LG3001C-B3 Panels connected in a 4x6 array in two branches of 12 panels wired in parallel | 7.2kW                                      |

Total DC power of all arrays is **7.14 kW**.

### Inverters

| Inverter Manufacturer | Model Number | Voltage | Rating | Quantity |
|-----------------------|--------------|---------|--------|----------|
| LG                    | LM305UE-G1   | 240V    | 305W   | 24       |

Total AC power of all inverters is **6.84 kW**.

### Required Information

|  | Location                            |
|--|-------------------------------------|
| One-Line Electrical Schematic  | E302, E601                          |
| Calculations of service/feeder net computed load and neutral load (NEC 220)  | Electrical Calculations (pg. 14-15) |
| Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center | I602                                |

### Electrical Contact

The Team's electrical engineer is Tyler Jackson. His contact information is provided in the "Team Officer Contact Info" database on the Yahoo Groups as required per Rule 3-2.

### Energy Analysis Results and Discussion

The Team conducted several different energy analyses throughout the design of The Nest Home using several different computer simulations to evaluate the size of the array and its anticipated production. These simulations helped the team to determine the necessary size of the solar array for the Nest Home.

## NREL System Advisor Model (SAM)

The SAM software was used to estimate the total production of the array, to more effectively determine an array size that would be suitable for the Nest Home. It allowed us to evaluate the overall production of different array sizes and panels, to determine how much energy we could expect to produce.

## PVWatts

The PVWatts website was used in addition to SAM to verify the array output approximations, and to compare the two different estimations for the production of the array. Both programs returned similar results, making the team confident that a 7kW array would produce all the energy the home will require.

## Electrical Calculations

Total Contest Week Consumption = (8 days)\*(Estimated Consumption)\* (Estimated Daily Use)\*(Quantity)

| Mechanical Load Estimates |   |                             |                             |                                     |
|---------------------------|---|-----------------------------|-----------------------------|-------------------------------------|
| Item                      | # | Estimated Consumption (kWh) | Estimated Daily Use (hours) | Total Contest Week Consumption (kW) |
| Pump                      | 3 | 0.4                         | 12                          | 115.2                               |
| Chiller                   | 1 | 0.1                         | 8                           | 6.4                                 |
| ERV                       | 1 | 0.1                         | 3                           | 2.4                                 |
| TOTAL                     |   |                             |                             | 124                                 |

| Appliance Load Estimations |   |                             |                             |                                     |
|----------------------------|---|-----------------------------|-----------------------------|-------------------------------------|
| Item                       | # | Estimated Consumption (kWh) | Estimated Daily Use (hours) | Total Contest Week Consumption (kW) |
| Fridge/Freezer             | 1 | 0.25                        | 7                           | 14                                  |
| (Frost Free)               | 0 | 0.5                         | 6                           | 0                                   |
| Oven                       | 1 | 3                           | 1                           | 24                                  |
| Sm. Surf. Burner           | 2 | 1                           | 0.5                         | 8                                   |
| Lf. Surf. Burner           | 2 | 1.5                         | 0.5                         | 12                                  |
| Microwave                  | 1 | 1                           | 0.5                         | 4                                   |
| Washer                     | 1 | 0.35                        | 1.5                         | 4.2                                 |
| Dryer                      | 1 | 2.1                         | 1.5                         | 25.2                                |
| Dish Washer                | 1 | 1.2                         | 1                           | 9.6                                 |
| TV (40in)                  | 1 | 0.15                        | 8                           | 9.6                                 |
| PC w/Monitor               | 1 | 0.23                        | 8                           | 14.72                               |
| Stereo                     | 1 | 0.05                        | 8                           | 3.2                                 |
| Garbage Disposal           | 1 | 0.45                        | 0.1                         | 0.36                                |

|              |   |     |              |              |
|--------------|---|-----|--------------|--------------|
| Toaster      | 1 | 1   | 0.1          | 0.8          |
| Coffee Maker | 1 | 0.9 | 0.1          | 0.72         |
|              |   |     | <b>TOTAL</b> | <b>130.4</b> |

| Other              |    |                             |                             |                                     |
|--------------------|----|-----------------------------|-----------------------------|-------------------------------------|
| Item               | #  | Estimated Consumption (kWh) | Estimated Daily Use (hours) | Total Contest Week Consumption (kW) |
| Lighting (LED)     | 10 | 0.025                       | 4                           | 8                                   |
| Ceiling Fan        | 5  | 0.075                       | 4                           | 12                                  |
| Electrical Vehicle | 1  | 17.6                        | N/A                         | 17.6                                |
|                    |    |                             | <b>TOTAL</b>                | <b>37.6</b>                         |

Array Size Estimate = (Overall Consumption Estimate)/ (8 days)/(6 hrs production)=**6.0883kW**

|                              |                |
|------------------------------|----------------|
| Overall Consumption Estimate | <b>292 kWh</b> |
|------------------------------|----------------|

## Quantity Takeoff of Competition Prototype House

|                             | Description   | Qty  | Unit |
|-----------------------------|---|------|------|
| <b>A10 FOUNDATIONS</b>      |   |      |      |
| A1020 SPECIAL FOUNDATIONS   | Lateral strut; W6x15  | 1    | tons |
|                             | Screw jack support base   | 53   | ea   |
| <b>B10 SUPERSTRUCTURE</b>   |   |      |      |
| B1010 FLOOR CONSTRUCTION    | Steel beam W6x15  | 1.5  | tons |
|                             | Steel C channel; 10", 2.855 flange, 25 lbs/ft   | 9.6  | tons |
|                             | (2L) 3/4" plywood sub floor   | 667  | sf   |
|                             | 3" closed cell spray foam insulation  | 1055 | sf   |
| B1020 ROOF CONSTRUCTION     | Roof joist; 2x6   | 701  | sf   |
|                             | 3/4" Plywood roof sheathing   | 701  | sf   |
|                             | SIP roof panels   | 667  | sf   |
|                             | Steel C channel; 8", roof structure   | 2.1  | tons |
|                             | 10" steel built boxed header beam   | 0.6  | tons |
| <b>B20 EXTERIOR CLOSURE</b> |   |      |      |
| B2010 EXTERIOR WALLS        | Exterior wall assembly's; 3-1/2" metal studs, batt insulation, 2x2 furring strip, 5/8" plywood, 3" spray foam | 2124 | sf   |
|                             | Reclaimed wood pallet siding  | 2124 | sf   |
|                             | Cargo container; 20'x8'x9'6", braced, prepped   | 1    | ea   |
|                             | Cargo container; 25'x8'x9'6", braced, prepped   | 1    | ea   |
|                             | Cargo container; 35'x8'x9'6", braced, prepped   | 1    | ea   |
|                             | Steel angle HSS3x3x3/8  | 0.5  | tons |
|                             | Steel angle L3x3x3/8  | 1    | tons |
| B2020 EXTERIOR WINDOWS      | Storefront  | 104  | sf   |
|                             | D5; 48" Circular window, aluminum framed  | 1    | ea   |
|                             | Sun Shade   | 20   | lf   |
|                             | Windows; aluminum framed  | 185  | sf   |
|                             | Louver  | 9    | sf   |
| B2030 EXTERIOR DOORS        | 6'0"x7'0" Exterior Doors  | 1    | ea   |
|                             | 3'0"x7'0" Exterior Doors; glazed w/ Transom   | 2    | ea   |
| <b>B30 ROOFING</b>          |   |      |      |
| B3010 ROOF COVERINGS        | Roofing at main living area; standing seam and 10" insulation   | 674  | sf   |
|                             | Roofing at storage compartments; thermoplastic polyoefin w/5.5" insulation                                    | 701  | sf   |
|                             | Solar panel assembly, sloped  | 489  | sf   |
|                             | Fascia  | 350  | lf   |

| <b>C10 INTERIOR CONSTRUCTION</b> |   |      |    |
|----------------------------------|---|------|----|
| C1010 PARTITIONS                 | Interior wall assembly - W2; 2x2 furring, batt insul, 1/2" gyp type x one side              | 816  | sf |
|                                  | Wall assembly - W3; 3.5" metal stud, batt insul, (1) layer 5/8" gyp, (1) layer 5/8" plywood | 134  | sf |
|                                  | Wall assembly - W8; 3-1/2" meta stud, 1/2" gyp 2 sides                                      | 254  | sf |
| C1020 INTERIOR DOORS             | 4'-0 x 7'-0" bifold, 4 panel door, closet   | 1    | ea |
|                                  | 3'-0"x7'-0" sliding barn door, office and bedroom   | 2    | ea |
|                                  | 2'-6"x7'-0" single pocket door, master closet   | 1    | ea |
|                                  | 5'-0"x7'-0" Panel folding door; master bedroom  | 1    | ea |
|                                  | 3'-0"x7'-0" single flush door, bath   | 1    | ea |
| C1030 FITTINGS                   | Base cabinets   | 15   | lf |
|                                  | Upper cabinets  | 3    | lf |
|                                  | Built-in bench seating w/under storage; 12" W 5   | 5    | lf |
|                                  | Built-in dinette  | 12   | sf |
|                                  | Closet shelving   | 17   | lf |
|                                  | Entertainment center cabinet; wall mounted  | 9    | sf |
|                                  | Entertainment center shelving   | 15   | lf |
|                                  | Entry/dining area shelving; 4 shelves, 24" W  | 8    | lf |
|                                  | Full height cabinet; pantry   | 2    | lf |
|                                  | Kitchen counter tops  | 33   | sf |
|                                  | Master bedroom built In night stands  | 2    | ea |
|                                  | Master bedroom shelving   | 2    | lf |
|                                  | Master bedroom counter tops   | 6    | sf |
|                                  | Office counter tops   | 20   | sf |
|                                  | Office shelving   | 8    | lf |
|                                  | Secretary counter tops  | 20   | sf |
| Secretary shelving               | 6   | lf   |    |
| <b>C30 INTERIOR FINISHES</b>     |   |      |    |
| C3010 WALL FINISHES              | Paint   | 2825 | sf |
|                                  | Paint at mech and storage; assumed  | 504  | sf |
|                                  | Ceramic wall tile; subway tile  | 188  | sf |
|                                  | Upcycled pottery border in bath   | 25   | lf |
| C3020 FLOOR FINISHES             | Carpet  | 399  | sf |
|                                  | Ceramic tile  | 58   | sf |
|                                  | Cork flooring, Mechanical room  | 56   | sf |
|                                  | Cork flooring   | 383  | sf |
|                                  | Bath base   | 25   | lf |
|                                  | Bed 2 base  | 60   | lf |

|                                   |                                   |      |    |
|-----------------------------------|-----------------------------------|------|----|
|                                   | Kitchen base                      | 29   | lf |
|                                   | Living area base                  | 65   | lf |
|                                   | Master bed base                   | 46   | lf |
|                                   | Master closet base                | 21   | lf |
|                                   | Mech rm base                      | 32   | lf |
|                                   | Office base                       | 34   | lf |
|                                   | Secretary base                    | 12   | lf |
|                                   | Storage base                      | 27   | lf |
| C3030 CEILING FINISHES            | Paint exposed deck                | 1105 | sf |
|                                   | Painted gyp. Board                | 1055 | sf |
| <b>D20 PLUMBING</b>               |                                   |      |    |
| D2010 PLUMBING FIXTURES           | Domestic water pump               | 1    | ea |
|                                   | Solar tube collector              | 2    | ea |
|                                   | Collector controls                | 1    | ls |
|                                   | Expansion tank                    | 1    | ea |
|                                   | Kitchen sink & faucet             | 1    | ea |
|                                   | Vanity sink & faucet              | 1    | ea |
|                                   | Shower/tub & mixing valve         | 1    | ea |
|                                   | Water closet                      | 1    | ea |
|                                   | 500-gallon gray water tank        | 1    | ea |
|                                   | Dishwasher connection             | 1    | ea |
|                                   | Washer connection                 | 1    | ea |
| D2020 DOMESTIC WATER DISTRIBUTION | Plumbing supply pipe; PEX         | 160  | lf |
|                                   | Misc valves & fittings            | 1    | ls |
| D2030 SANITARY WASTE              | Waste & vent piping; PVC          | 110  | lf |
| <b>D30 MECHANICAL</b>             |                                   |      |    |
| D3040 DISTRIBUTION SYSTEMS        | Refrigeration piping              | 1    | ls |
|                                   | Rigid ductwork                    | 150  | lf |
|                                   | Flex duct                         | 25   | lf |
| D3050 TERMINAL & PACKAGE UNITS    | Air handler                       | 1    | ea |
|                                   | Heat pump; 2-ton outdoor unit     | 1    | ea |
|                                   | GRD's                             | 20   | ea |
|                                   | Energy recovery ventilator        | 1    | ea |
|                                   | Outside grille for intake/exhaust | 2    | ea |
| D3060 CONTROLS & INSTRUMENTATION  | Collector controls                | 1    | ls |
|                                   | Temperature control               | 1    | ls |
| <b>D40 FIRE PROTECTION</b>        |                                   |      |    |
| D4010 SPRINKLERS                  | Fire protection                   | 1055 | sf |
| <b>D50 ELECTRICAL</b>             |                                   |      |    |

|   |   |      |    |
|---|---|------|----|
| D5010 ELECTRICAL SERVICE & DISTRIBUTION | 200A Panel; including AFCI circuit breakers             | 1    | ea |
|   | Electrical meter  | 1    | ea |
|   | Service entrance conductors; (3) 2/0 THHN (1) #4 ground | 15   | lf |
|   | 200A SE Cable   | 50   | lf |
|   | Grounding allowance                                     | 1    | ls |
| D5020 LIGHTING & BRANCH WIRING          | Duplex  | 27   | ea |
|   | Ground fault interrupter                                | 10   | ea |
|   | Weatherproof ground fault interrupter                   | 2    | ea |
|   | 30A Dryer outlet  | 1    | ea |
|   | 50A Range outlet  | 1    | ea |
|   | 30A Vehicle charging station                            | 1    | ea |
|   | Loxone Lighting Control System                          | 1    | ea |
|   | Open Motics controller                                  | 1    | ea |
|   | Branch 14-2 NM Cable                                    | 1140 | lf |
|   | 12-2 NM Cable   | 280  | lf |
|   | 12-3 NM Cable   | 40   | lf |
|   | 10-3 NM Cable   | 80   | lf |
|   | 6-3 NM Cable  | 50   | lf |
| <i>Lighting</i>                         | 6" LED Recessed Can                                     | 20   | ea |
|   | LED Wall Sconce   | 4    | ea |
|   | LED Vanity  | 1    | ea |
|   | LED Pendant Light                                       | 3    | ea |
|   | Ceiling Fan w/ light kit                                | 2    | ea |
|   | LED T8 lamp; (2) T8 LED lamps                           | 1    | ea |
| <i>Mech</i>                             | Air handler   | 1    | ea |
|   | Heat pump; 2-ton outdoor unit                           | 1    | ea |
|   | Energy recovery ventilator                              | 1    | ea |
|   | Pump  | 3    | ea |
|   | Electric water heater; 40-gallon                        | 1    | ea |
|   | Dishwasher connection                                   | 1    | ea |
| <i>Branch</i>                           | 12-2 NM Cable   | 40   | lf |
|   | 12-3 NM Cable   | 200  | lf |
|   | 10-3 NM Cable   | 100  | lf |
| D5030 COMMUNICATIONS & SECURITY         | Voice Opening   | 5    | ea |
|   | Data Opening  | 5    | ea |
|   | TV Opening  | 5    | ea |
|   | Smoke detector  | 5    | ea |
| D5090 OTHER ELECTRICAL SYSTEMS          | LG, LG30001C-B3   | 24   | ea |

|  |  |     |      |
|--|--|-----|------|
|  | Enphase, M250                                      | 24  | ea   |
|  | LG, Transition Cable, male, 59 inch                | 2   | ea   |
|  | LG, Extension Cable, female, 63 inch               | 2   | ea   |
|  | LG, Extension Cable, male, 126 inch                | 2   | ea   |
|  | LG End Cap, Female                                 | 2   | ea   |
|  | PV rack system, roof, penetrating                  | 24  | ea   |
|  | LG Communications Gateway                          | 1   | ea   |
|  | Combiner Box and Fuse                              | 1   | ea   |
|  | Disconnect   | 1   | ea   |
| <b>E10 EQUIPMENT</b>                             |  |     |      |
| E1010 COMMERCIAL EQUIPMENT                       | Dishwasher   | 1   | ea   |
|  | Range  | 1   | ea   |
|  | Refrigerator                                       | 1   | ea   |
|  | Stacking washer & dryer                            | 1   | ea   |
|  | Tools  | 1   | ea   |
|  | Safety Equipment                                   | 1   | ea   |
|  | Range hood, assumed                                | 1   | ea   |
| <b>F10 SPECIAL CONSTRUCTION</b>                  |  |     |      |
| F1010 SPECIAL STRUCTURES                         | Deck structure; east entry                         | 181 | sf   |
|  | Deck structure; south entry                        | 129 | sf   |
|  | Access Ramp  | 242 | sf   |
|  | Railings at Ramp & deck                            | 142 | lf   |
|  | Sail Shade; at East Entry                          | 49  | sf   |
| <b>G20 SITE IMPROVEMENT</b>                      |  |     |      |
| G2040 SITE DEVELOPMENT                           | Deck Planters; exterior                            | 10  | sf   |
|  | Raised Planters; exterior, multi-level             | 69  | sf   |
|  | 25 ton crane                                       | 2   | days |
| G2050 LANDSCAPING (Interior plants are excluded) | Landscaping  | 1   | ea   |
|  | Box Hedges   | 2   | ea   |
|  | Greenwall; swiss chard, looseleaf, rosemary, basil | 72  | sf   |



## Construction Documents

See Construction Drawings of the Nest Home submitted to the Solar Decathlon Organizers on March 26, 2015.

Refer to Appendix A for Construction Specifications.

# **APPENDIX A**

# **CONSTRUCTION SPECIFICATIONS**

# **DIVISION 00**

## **PROCUREMENT AND CONTRACTING REQUIREMENTS**

## SECTION 00 31 00

### PART 1 GENERAL

#### 1.1 PRELIMINARY BUILDING SCHEDULE BY PHASE

- |                                      |                               |
|--------------------------------------|-------------------------------|
| A. Schematic Design Phase            | January 2014 – May 2014       |
| B. Design Development Phase          | May 2014 – October 2014       |
| C. Construction Documents Phase      | August 2014 – November 2014   |
| D. Construction Phase                | November 2015 – May 2015      |
| E. System and Building Testing Phase | June 2015 – August 2015       |
| F. Competition Phase                 | September 2015 – October 2015 |

#### 1.2 PROJECT BUDGET

- A. Construction Budget: \$250,000
- B. Total Project Budget: \$325,000

#### 1.3 CONSTRUCTION FACILITY

- A. The Nest Home will be constructed on an indoor site provided by Missouri S&T.
  - 1. 12405 County Road 3120, Rolla, MO 65401

**END OF SECTION 00 31 00**

# **DIVISION 01**

## **GENERAL REQUIREMENTS**

## SECTION 01 81 30 GREEN POWER REQUIREMENTS

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Green Power contracting requirements.

#### 1.2 DEFINITIONS

- A. Definitions pertaining to sustainable development: As defined in ASTM E2114 and as specified herein.
- B. Green Power: Electrical power generated using renewable resources such as solar or wind.
- C. Renewable resource: a resource that is grown, naturally replenished, or cleansed, at a rate which exceeds depletion of the usable supply of that resource.
  - 1. Rapidly renewable material: Material made from plants that are typically harvested within a ten-year cycle.

#### 1.3 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
  - 1. Renewable Energy:
    - a. Baseline Energy Usage: Submit calculations for estimated electricity use per the U.S. Department of Energy (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database or other program as acceptable to Owner.
    - b. Green Power Certification: Submit copy of certification for Green Power in accordance with the Center for Resource Solutions Green-e Standard for Electricity Products. Indicate type and percentage mix of renewable energy provided.

#### 1.4 QUALITY ASSURANCE

- A. Green Power: Arrange for Green Power sufficient to provide minimum **100** percent of the project's total energy needs.
- B. Comply with renewable energy requirements in accordance with the Center for Resource Solutions (CRS) Green-e Standard for Electricity Products.

#### 1.5 MAINTENANCE

- A. Green Power: Provide service contract for 2 years with options for annual renewal thereafter.
  - 1. Comply with the Center for Resource Solutions (CRS) Green-e Standard for Electricity Products for the duration of the contract. Comply with requirements of the CRS Green-e Annual Verification Protocol.
    - a. Immediately notify Owner if electricity product fails to comply with Green-e certification criteria during contract period.
  - 2. On an annual basis for during contract period, submit:
    - a. Annual report that includes data on the resources used to generate the past year's electricity purchased.
    - b. Disclosure statement lists the resources or fuel sources from which the electricity in the product will be generated in the following year.

## **PART 2 PRODUCTS**

### **2.1 EQUIPMENT**

- A. Photovoltaic Module with built in Microinverter
  - 1. AC Unison PM250MA0
    - a. Power Output = 225W
    - b. Nominal Voltage = 240V
    - c. Normal Frequency = 60Hz
    - d. Nominal Output Current = 0.9375

## **PART 3 EXECUTION**

### **3.1 SITE ENVIRONMENTAL PROCEDURES**

- A. Resource Management:
  - 1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

**END OF SECTION**

## **SECTION 01 54 19 TEMPORARY CRANES**

### **PART 1 GENERAL**

#### **1.1 SUMMARY**

- A. Structural Performance: Temporary cranes will withstand structural loads and lifts incurred in lifting, placing, and handling of all modular components

### **PART 2 PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Manufacturer: Grove TMS

#### **2.2 TEMPORARY CRANES**

- A. Type: 25 Ton Rated Hydraulic Boom
  - 1. Boom extension: 32'-80'

### **PART 3 EXECUTION**

#### **3.1 INSTALLATION**

- A. Prepare ground by cleaning, removing projections, clearing obstructions, and cordoning off safe working zone, and as otherwise recommended in temporary crane manufacturer's written instructions.
- B. Ground crane securely in place, per operational specifications
- C. Allow only licensed operators to operate machinery, manage lifts, and issue signals and commands.
- D. Ensure placement of modular components complies with foundational spacing and loading requirements.
- E. Coordinate operations with structural requirements per specifications of structural engineer and crane operator.
- F. Correct deficiencies in or remove and reinstall temporary cranes that do not comply with requirements.

**END OF SECTION**



# **DIVISION 05**

## **METALS**

## SECTION 05 10 00 STRUCTURAL STEEL

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
1. Structural steel.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
- B. Certifications and Registrations:
1. Environmental Management System (EMS): Submit evidence of an EMS for the steel manufacturers providing material for work of this section. **[For each steel manufacturing facility, submit copy of registration as per ISO 14001.]**
  2. Chain-of-custody certification: Submit manufacturer's certification that no open hearth furnaces were utilized in the production of structural steel to be incorporated into the Work. Submit evidence of energy efficiency for steel manufacturers providing material for work of this section. Acceptable certification includes:
    - a. Bill of Lading indicating source of manufactured steel as North American facility; or,
    - b. Manufacturer's certification that structural steel complies with CO<sub>2</sub> limitations for crude steel production. **[Indicate method for calculating CO<sub>2</sub> emissions.];** or,
    - c. Manufacturer's certification that structural steel complies with energy efficiency requirements for steel production. **[Include description of energy efficient processes utilized.]** ; or,

d. **Participation in CO<sub>2</sub> Breakthrough Program: Manufacturer's certification of participation in CO<sub>2</sub> Breakthrough Program.]**

**1.3 QUALITY ASSURANCE**

A. Toxicity/IEQ:

1. Carbon Dioxide Emissions: Not to exceed 1.6 tons of CO<sub>2</sub> per 1 ton of crude steel produced.
2. Energy Efficiency:
  - a. Integrated Steel Making: Not to exceed **19** GJ/ton.
  - b. Steel produced from scrap: Not to exceed **7**GJ/ton.

**PART 2 PRODUCTS**

**2.1 MATERIALS**

A. Structural Steel:

1. Recycled Content:
  - a. BOF steel: Minimum [percent post-consumer recycled content and minimum 10 percent pre-consumer recycled content.
  - b. EAF steel: Minimum 55 percent post-consumer recycled content and minimum 30 percent pre-consumer recycled content.

**2.2 CASTELLATED or CELLULAR STRUCTURAL STEEL BEAMS**

- A. Design: Design in accordance with the *AISC Manual of Steel Construction, Allowable Stress Design*, Ninth Ed. or *Load and Resistance Factor Design*, Second Ed. and per the design procedures outlined in "The Design of Welded Structures" by Omar W. Blodgett

**2.3 FACTORY FINISHING**

A. Finishing System:

1. Toxicity: Solvent coating systems are not permitted. Electroplated coating systems are not permitted.
2. Anti-Corrosive Paint: Comply with GS-11.

**PART 3 EXECUTION**

**3.1 SITE ENVIRONMENTAL PROCEDURES**

- A. Waste Management: As specified in Section 01 74 19 (01351) – Construction Waste Management.

**END OF SECTION**

# **DIVISION 06**

## **WOOD, PLASTICS, AND COMPOSITES**

## SECTION 06 05 73 WOOD TREATMENT

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
  - 1. Wood Treatment.
  - 2. Natural Decay and Insect Resistant Wood.
- B. Related Sections:
  - 1. 06 10 00 (06100) – Rough Carpentry.
  - 2. 06 16 00 (06160) – Sheathing.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
  - 1. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  - 2. VOC data:
    - a. Adhesives:
  - 3. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
  - 4. Submit Green Seal Certification to GS-36 and description of the basis for certification.
  - 5. **Submit manufacturer's certification that products comply with SCAQMD #1168.**
    - a. Engineered Wood Products: Provide documentation that composite wood and agrifiber products **are third-party certified as meeting ANSI standard requirements for formaldehyde emissions**
  - 6. ANSI A208.1 – 1999, Particleboard
  - 7. ANSI A208.2 – 2002, Medium Density Fiberboard (MDF) for Interior Applications
- B. Letter of Certification(s) for Sustainable Forestry:
  - 1. Forest Stewardship Council (FSC): Provide letter of certification signed by lumber supplier. Indicate compliance with FSC "Principles for Natural Forest Management" and identify certifying organization.
    - a. Submit FSC certification numbers; identify each certified product on a line-item basis.
    - b. Submit copies of invoices bearing the FSC certification numbers.
- C. Letter of Certification for Pressure Treatment: Submit Certification from treating plant stating chemicals and process used and net amount of preservatives retained are in conformance with specified standards.

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Preservative Pressure Treatment:
  - 1. Toxicity/IEQ: Products containing chromium will not be permitted. Products containing arsenic will not be permitted
  - 2. Waterborne Wood Preservatives:
    - a. Wood products shall be treated with waterborne wood preservatives listed in Section 4 of AWPA Standards U1, excluding those which contain arsenic and/or chromium.
    - b. Pressure treatment of wood products shall conform to the requirements of AWPA Standards U1 and T1.
    - c. Retention of preservatives as prescribed in AWPA Standard U1 for the following Use Categories (material conforming to a higher AWPA Use Category may be specified):
      - UC1: Interior construction - above ground, dry conditions.
      - UC2: Interior construction - above ground, damp conditions.
      - UC3A: Exterior construction - above ground, coated and with rapid water runoff.
      - UC3B: Exterior construction - above ground, uncoated or poor water runoff.
      - UC4A: General purpose soil or fresh water contact - heavy duty above ground.
      - UC4B: Heavy duty soil or fresh water contact - critical or difficult to replace components.
      - UC4C: Extreme duty soil or fresh water contact - critical structural components.
  - 3. Boron-based preservatives:
    - a. Impregnate lumber with preservative treatment conforming to AWPA Standard U1.
- B. Fire Retardant Treatment:
  - 1. Toxicity/IEQ: Fire-retardant-treated wood products shall be free of halogens, sulfates, ammonium phosphate and formaldehyde.
  - 2. Fire Retardant Formulations:
    - a. Wood products shall be treated with fire retardants listed in AWPA Standard U1.
    - b. Fire retardant treatment of wood products shall conform to the requirements of AWPA Standard U1, Commodity Specification H and AWPA Standard T1, Section H.
- C. Natural Decay and Insect Resistant Wood:
  - 1. Resource Management: Provide sustainably harvested; certified or labeled in accordance with **FSC** guidelines. Naturally Durable Wood is the heartwood of the following species with the exception that an occasional piece with corner sapwood is permitted if 90 percent or more of the width of each side on which it occurs is heartwood. Acceptable species include:
    - a. Decay resistant. Redwood, South American ipe, bald cypress, cedar, black locust and black walnut.
    - b. Termite resistant. Redwood and Eastern red cedar.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

- A. As specified in Division 01 (1) and Section 06 10 00 (06100) – Rough Carpentry.

**END OF SECTION**

## SECTION 06 20 00 FINISH CARPENTRY

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
  - 1. Exterior Millwork, including: standing and running trim.
  - 2. Interior Millwork, including: standing and running trim, cabinets and countertops.
- B. Related Sections:
  - 1. 06 05 73 (06070) - Wood Treatment.
  - 2. 06 10 00 (06100) – Rough Carpentry.
  - 3. 06 16 00 (06160) – Sheathing.
  - 4. 06 90 00 (06700) – Alternative Agricultural Products.
  - 5. 09 65 16.13 (09654) – Linoleum.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
  - 1. Recycled Content:
    - a. Engineered Wood Products:
  - 2. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
  - 3. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
  - 4. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
  - 5. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
    - a. Salvaged Lumber: Provide documentation certifying products are from salvaged lumber sources.
    - b. Recovered Lumber: Provide documentation certifying products are from recovered lumber sources.
  - 6. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  - 7. VOC data:
    - a. Adhesives:

8. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
9. Submit Green Seal Certification to GS-36 and description of the basis for certification.
10. **Submit manufacturer's certification that products comply with SCAQMD #1168.**
  - a. Engineered Wood Products: Provide documentation that composite wood and agrifiber products **are third-party certified as meeting ANSI standard requirements for formaldehyde emissions**
    - i. ANSI A208.1 – 1999, Particleboard
    - ii. ANSI A208.2 – 2002, Medium Density Fiberboard (MDF) for Interior Applications
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.
- C. Letter of Certification(s) for Sustainable Forestry:
  1. Forest Stewardship Council (FSC): Provide letter of certification signed by lumber supplier. Indicate compliance with FSC "Principles for Natural Forest Management" and identify certifying organization.
    - a. Submit FSC certification numbers; identify each certified product on a line-item basis.
    - b. Submit copies of invoices bearing the FSC certification numbers.

### 1.3 QUALITY ASSURANCE

- A. Sustainably Harvested Wood: Certification Organizations shall be accredited by the **Forest Stewardship Council**.
- B. Recycled Content Materials: Where recycled lumber materials are used for structural applications, include lumber certification and quality grading.
- C. VOC emissions: Provide low VOC products.
  1. Adhesives and sealants: Comply with California's South Coast Air Quality Management District (SCAQMD) #1168
  2. Aerosol adhesives: Comply with Green Seal GS-36
  3. Clear wood finishes: Comply with SCAQMD #1113
  4. Engineered Wood Products: Provide products with no added urea formaldehyde.
    - a. Determine formaldehyde concentrations in air from wood products under test conditions of temperature and relative humidity in accordance with ASTM D6007 or E1333.
    - b. Determine Volatile Organic Compounds (VOC), excluding formaldehyde, emitted from manufactured wood-based panels in accordance with ASTM D6330.

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Lumber: As specified in Section 06 10 00 (06100) – Rough Carpentry and Section 06 05 73 (06070) – Wood Treatment.
  1. Finger Jointed Lumber:
    - a. Recycled Content: Minimum 5 percent post-consumer recycled content, or minimum 20 percent pre-consumer recycled content at contractor's option.
- B. Sheathing and Panel Products: As specified in Section 06 16 00 (06160) - Sheathing.
  1. Sustainable Hardwood Wood Veneer Plywood: **1/40** inch thick veneer panels made from certified sustainably harvested lumber veneer, over a formaldehyde-free substrate.



- C. Alternative Agricultural Products: As specified in Section 06 90 00 (06700) – Alternative Agricultural Products.
  - 1. Strawboard Panels.
  - 2. Biocomposite Panels. Color and style as selected by Architect from manufacturer’s standards.
- D. Linoleum: As specified in Section 09 65 16.13 (09654) - Linoleum.
- E. Glass-Cement Composite: Material shall be polished and sealed. Color and style as selected by Architect from manufacturer’s standards.
  - 1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor’s option.

## 2.2 ACCESSORIES

- A. As specified in Section 06 10 00 (06100) – Rough Carpentry.
- B. Plastic Fabrications: As specified in Section 06 60 00 (06600) – Plastic Fabrications.

## 2.3 FABRICATION

- A. Exterior Millwork:
  - 1. Fascia, Trim, Trellis, Fence, Lattice and miscellaneous millwork:
    - a. Dimensional lumber of rot resistant species.
- B. Interior Millwork:
  - 1. Base, casing, trim, interior rail and wall caps and miscellaneous millwork: Select from the following, unless otherwise indicated:
    - a. Hardwood derived from certified sustainable sources.
    - b. Salvaged lumber.
    - c. Finger jointed pine or any western softwood species.
    - d. Low-emission Medium Density Fiberboard.
  - 2. Veneer panels:
    - a. Substrate: Select from the following, unless otherwise indicated:
  - 3. *Cellulose honeycomb core.*
  - 4. *Medium Density Fiberboard.*
  - 5. *Compressed straw particleboard.*
  - 6. Veneer:
    - a. *Veneer: Select from the following, unless otherwise indicated:*
      - i. *Certified sustainably harvested lumber.*
      - ii. *Biocomposite.*
  - 7. Countertops:
    - a. Biocomposite.
    - b. Linoleum.
    - c. Glass-cement composite.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

- A. As specified in Section 06 10 00 (06100) – Rough Carpentry.

**END OF SECTION**

# **DIVISION 07**

## **THERMAL AND MOISTURE PROTECTION**

## SECTION 07 20 00 THERMAL PROTECTION

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Insulation.
    - a. Cotton Batt (Denim).
    - b. Spray Foam Insulation.
  2. Insulation accessories.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. VOC data:
    - a. Adhesives:
  4. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
  5. Submit Green Seal Certification to GS-36 and description of the basis for certification.
  - 6. Submit manufacturer's certification that products comply with SCAQMD #1168.**
  7. Biobased materials:
    - a. Indicate type of biobased material in product.
    - b. Indicate the percentage of biobased content per unit of product.
    - c. Indicate relative dollar value of biobased content product to total dollar value of product included in project.

- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.
- C. Operating And Maintenance Manuals Submittals:
  - a. Verify that plastic products, including plastic components in assemblies, to be incorporated into the Project are labeled in accordance with ASTM D1972. Where products are not labeled, provide product data indicating polymeric information in Operation and Maintenance Manual.
    - i. Products made from compositions containing a single filler, reinforcing, or other modifying material in a concentration of more than one percent by mass shall be marked with the abbreviated term for the polymer, followed by a dash, then the abbreviated term or symbol for the additive, with its percentage by mass, arranged as shown in the example and set off with brackets. For example, a polypropylene containing 30 mass percentage of mineral powder use would be labeled: >PP-MD30<
- D. Documentation of manufacturer's **take-back program** for insulation materials. Coordinate with construction waste management. Include the following:
  - 1. Appropriate contact information.
  - 2. Overview of procedures.
  - 3. Limitations and conditions, if any, applicable to the project.

## PART 2 PRODUCTS

### 2.1 INSULATION MATERIALS

- A. Cotton Batt (Denim):
  - 1. Recycled content: Minimum **80** percent total recycled content.
- B. Spray foam insulation:
  - 1. Biobased Content:
    - a. Plastic Insulating Foam for Residential and Commercial Construction: Spray-in-place plastic foam products designed to provide a sealed thermal barrier for residential or commercial construction applications. Provide minimum 7% biobased content.
  - 2. Toxicity:
    - a. Provide clear hazard communication for all SPF users
    - b. Restrict work site to only those wearing appropriate personal protective equipment during SPF installation.
    - c. Provide guidance on re-entry time.

### 2.2 ACCESSORIES

- A. Adhesive
  - 1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, GS-36 for Commercial Adhesive, **South Coast Air Quality Management District Rule 1168**, and as specified.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES



- A. Waste Management: As specified in Section 01 74 19 (01351) – Construction Waste Management and as follows:
1. Coordinate with **manufacturer** for **take-back program**. Set aside scrap to be returned to manufacturer for recycling into new product.

**END OF SECTION**

# **DIVISION 08**

## **OPENINGS**

## SECTION 08 50 00 WINDOWS

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Aluminum or Wood windows.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. VOC data:
    - a. Adhesives for **site installation**:
    - b. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
    - c. Submit Green Seal Certification to GS-36 and description of the basis for certification.
    - d. **Submit manufacturer's certification that products comply with SCAQMD #1168**
    - e. Engineered Wood Products: Provide documentation that composite wood and agrifiber products **are third-party certified as meeting ANSI standard requirements for formaldehyde emissions**
      - i. ANSI A208.1 – 1999, Particleboard
      - ii. ANSI A208.2 – 2002, Medium Density Fiberboard (MDF) for Interior Applications
  4. Energy Efficiency: Submit documentation for Energy Star qualifications for products provided under work of this Section.
- B. Letter of Certification(s) for Sustainable Forestry:

1. Forest Stewardship Council (FSC): Provide letter of certification signed by lumber supplier. Indicate compliance with FSC "Principles for Natural Forest Management" and identify certifying organization.
    - a. Submit FSC certification numbers; identify each certified product on a line-item basis.
    - b. Submit copies of invoices bearing the FSC certification numbers.
  2. Sustainable Forestry Board: Provide letter of certification signed by lumber supplier. Indicate compliance with the Sustainable Forestry Board's "Sustainable Forestry Initiative" (SFI) and identify certifying organization.
    - a. Submit SFI certification numbers; identify each certified product on a line-item basis.
    - b. Submit copies of invoices bearing the SFI certification numbers.
  3. Canadian Standards Association (CSA): Provide letter of certification signed by lumber supplier. Indicate compliance with the CSA and identify certifying organization.
    - a. Submit CSA certification numbers; identify each certified product on a line-item basis.
    - b. Submit copies of invoices bearing the CSA certification numbers.
- C. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.
- D. Operating And Maintenance Manuals Submittals:
1. Verify that plastic products, including plastic components in assemblies, to be incorporated into the Project are labeled in accordance with ASTM D1972. Where products are not labeled, provide product data indicating polymeric information in Operation and Maintenance Manual.
  2. Products made from compositions containing a single filler, reinforcing, or other modifying material in a concentration of more than one percent by mass shall be marked with the abbreviated term for the polymer, followed by a dash, then the abbreviated term or symbol for the additive, with its percentage by mass, arranged as shown in the example and set off with brackets. For example, a polypropylene containing 30 mass percentage of mineral powder use would be labeled: >PP-MD30<

### 1.3 QUALITY ASSURANCE

- A. Sustainably Harvested Wood: Certification Organizations shall be accredited by the **Forest Stewardship Council**.
- B. VOC emissions: Provide low VOC products.
  1. Adhesives and sealants: Comply with California's South Coast Air Quality Management District (SCAQMD) #1168
  2. Aerosol adhesives: Comply with Green Seal GS-36
  3. Clear wood finishes: Comply with SCAQMD #1113
  4. Engineered Wood Products: Provide products with no added urea formaldehyde.
    - a. Determine formaldehyde concentrations in air from wood products under test conditions of temperature and relative humidity in accordance with ASTM D6007 or E1333.
    - b. Determine Volatile Organic Compounds (VOC), excluding formaldehyde, emitted from manufactured wood-based panels in accordance with ASTM D6330.

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Lumber:
  1. Resource Management:
    - a. Virgin Lumber: **Lumber fabricated from old growth timber is not permitted.** Provide sustainably harvested; certified or labeled in accordance with FSC guidelines.



- b. Salvaged Lumber: Lumber from deconstruction or demolition of existing buildings or structures. Unless otherwise noted, salvaged lumber shall be delivered clean, denailed, and free of paint and finish materials, and other contamination.
  - c. Recovered Lumber: Previously harvested lumber pulled from riverbeds or otherwise abandoned. Unless otherwise noted, recovered lumber shall be delivered clean and free of contamination.
- B. Engineered Wood Products:
- 1. Toxicity/IEQ: Products shall contain no added urea-formaldehyde.
- C. Metal or Plastic
- 1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.

## 2.2 ACCESSORIES

- A. Adhesives for **site installation**:
- 1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, GS-36 for Commercial Adhesive, **South Coast Air Quality Management District Rule 1168**, and as specified.
- B. Fasteners:
- 1. Recycled Content: Fabricated from 100 percent re-melted steel.

## 2.3 FABRICATED PRODUCTS

- A. Windows:
- 1. Energy Efficiency:
    - a. Thermal Transmittance: Provide windows and curtain walls with a U-factor maximum in accordance with NFRC 100.
    - b. U-Value: (W/sq. m x K).
    - c. **Solar Heat-Gain Coefficient: Provide windows with a whole-window SHGC maximum of [TBD] determined according to NFRC 200 procedures.**
    - d. Visible transmittance:
    - e. Exterior reflectivity:
    - f. Color of tint:
    - g. Energy Efficiency: Provide Energy Star labeled products as appropriate to climate zone.
  - 2. Toxicity/IEQ:
    - a. Sound Transmission Class: Provide glazed windows rated for not less than **26** STC when tested for laboratory sound transmission loss according to ASTM E90 and determined by ASTM E413.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Resource Management:
- 1. Energy Efficiency: Verify products are properly installed, connected, and adjusted. Verify that products are performing as specified.

**END OF SECTION**

# **DIVISION 09**

## **FINISHES**

## SECTION 09 29 00 GYPSUM BOARD

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
1. Interior gypsum wallboard.
  2. Exterior gypsum board panels for ceilings and soffits.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. VOC data: Submit manufacturer's product data for joint compounds. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

### PART 2 PRODUCTS

#### 2.1 MATERIALS

- A. Gypsum Board:
1. Recycled Content: Minimum **10** percent post-consumer recycled content, or minimum **40** percent pre-consumer recycled content at contractor's option.

#### 2.2 ACCESSORIES

- A. Reinforcing Tape:

1. Toxicity/IEQ: Sheetrock Joint Tape. Paper; fiberglass joint tape not permitted.
- B. Joint-Treatment Materials:
  1. Toxicity/IEQ: Lime compound. All purpose joint and texturing compound containing inert fillers and natural binders. Pre-mixed compounds shall be free of antifreeze, vinyl adhesives, preservatives, biocides and other slow releasing compounds

## **PART 3 EXECUTION**

### **3.1 SITE ENVIRONMENTAL PROCEDURES**

- A. Indoor Air Quality:
  1. Temporary ventilation: Provide temporary ventilation for work of this Section.
  2. Multi-layer gypsum board: Screw attach. Adhesive attachment will not be permitted.
- B. Waste Management: As specified in Section 01 74 19 (01351) – Construction Waste Management and as follows:
  1. Select panel sizes and layout panels to minimize waste; reuse cutoffs to the greatest extent possible.
  2. Scrap gypsum: Coordinate with Section 32 90 00 (02900) - Planting to identify requirements for gypsum soil amendment and to prepare scrap gypsum board for use as soil amendment. Do not use products containing glass fiber.

**END OF SECTION**

## SECTION 09 30 00 TILE

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
1. Ceramic tile.
  2. Porcelain tile.
  3. Quarry tile.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. VOC data:
    - a. Adhesives:
  4. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
  5. Submit Green Seal Certification to GS-36 and description of the basis for certification.
  6. **Submit manufacturer's certification that products comply with SCAQMD #1168.**
    - a. Grout: Submit manufacturer's certification that products comply with SCAQMD #1168.
    - b. Finish flooring: Submit FloorScore certification.
    - c. **Finish Flooring Systems: Submit verification that all interior flooring products, including adhesives and floor finish materials, comply with California Department of Health Services Standard Practice for the Testing of Volatile Organic emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.**

- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

### 1.3 QUALITY ASSURANCE

- A. VOC emissions: Provide low VOC products. **Comply with California Department of Health Services Standard Practice for the Testing of Volatile Organic emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda or**
  - 1. Adhesives and sealants: Comply with California's South Coast Air Quality Management District (SCAQMD) #1168
  - 2. Aerosol adhesives: Comply with Green Seal GS-36
  - 3. Hard surface flooring: Comply with FloorScore
  - 4. Tile setting adhesives and grout: Comply with SCAQMD #1168

## PART 2 PRODUCTS

### 2.1 TILE

- A. Ceramic tile:
  - 1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.
- B. Porcelain tile:
  - 1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.
- C. Quarry tile:
  - 1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.

### 2.2 ACCESSORIES

- A. Adhesives: Water-resistant organic; ANSI A136.1.
  - 1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, GS-36 for Commercial Adhesive, **South Coast Air Quality Management District Rule 1168**, and as specified.
- B. Sealants:
  - 1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, Bay Area Air Quality Management District Reg. 8 Rule 51, and as specified.
- C. Prepared Grouts:
  - 1. Toxicity/IEQ: Cement based, petroleum-free and plastic-free grout; ANSI A118.4.

## PART 3 EXECUTION

**END OF SECTION**

## SECTION 09 72 00 WALLCOVERING

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
1. Wallcovering.

#### 1.2 QUALITY ASSURANCE

- A. VOC emissions: Provide low VOC products. Comply with:
1. Adhesives and sealants: Comply with California's South Coast Air Quality Management District (SCAQMD) #1168
  2. Aerosol adhesives: Comply with Green Seal GS-36
- B. Provide wallcovering compliant with NSF 342 **Conformant** level.

#### 1.3 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. VOC data:
    - a. Adhesives:
  4. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.
  5. Submit Green Seal Certification to GS-36 and description of the basis for certification.
  6. **Submit manufacturer's certification that products comply with SCAQMD #1168.**
  7. Biobased materials:
    - a. Indicate type of biobased material in product.

- b. Indicate the percentage of biobased content per unit of product.
  - c. Indicate relative dollar value of biobased content product to total dollar value of product included in project.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Polyethylene:
  1. Toxicity/IEQ: Provide vinyl-free, chlorine-free, plasticizer-free wallcovering
- B. Fabric:
  1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.
  2. Biobased content: Minimum [**TBD**] percent biobased wallcovering.
    - a. Sisal.
    - b. Cork.
    - c. Flax.
- C. Cellulose:
  1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.

### 2.2 ACCESORIES

- A. Adhesive:
  1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, GS-36 for Commercial Adhesive, **South Coast Air Quality Management District Rule 1168**, and as specified.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Indoor Air Quality: Provide temporary ventilation as specified in Section 01 57 19.11 (01352) – Indoor Air Quality (IAQ) Management. .
- B. Waste Management: As specified in Section 01 74 19 (01351) – Construction Waste Management and as follows:
  1. Biobased Content scrap material may be shredded and composted on site.

**END OF SECTION**



## SECTION 09 90 00 PAINTING & COATING

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
1. Interior paint, except clear finishes and stains.
  2. Exterior paint, except clear finishes and stains.
  3. Specialty coatings.
    - a. Anti-Corrosive Paint

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section
1. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - a. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - b. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - c. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. VOC data: Submit Green Seal Certification to GS-11 and description of the basis for certification.
  4. Biobased materials:
    - a. Indicate type of biobased material in product.
    - b. Indicate the percentage of biobased content per unit of product.
    - c. Indicate relative dollar value of biobased content product to total dollar value of product included in project.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

#### 1.3 QUALITY ASSURANCE

- A. VOC Content: Determine VOC (Volatile Organic Compound) content of solvent borne and waterborne paints and related coatings in accordance with EPA Method 24 or ASTM D3960. Provide low VOC products. Comply with:

1. Interior architectural paints: Comply with Green Seal GS-11
2. Anti-corrosive paints: Comply with Green Seal GS-11
3. Clear wood finishes: Comply with SCAQMD #1113

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Paints and primers:
  1. Recycled Content: Minimum **20** percent post-consumer recycled content for light colors; minimum **50** percent post-consumer recycled content for dark colors.
  2. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, and as specified. Paints and coatings must meet or exceed the VOC and chemical component limits of Green Seal requirements.
    - a. Interior paint: Comply with GS-11.
    - b. Exterior paint: Comply with GS-11.
- B. Specialty Coatings:
  1. Anti-Corrosive Paint: Comply with GS-11.
- C. Wood and Concrete Sealers
  1. Biobased content:
    - a. Membrane Concrete Sealers: Products that are penetrating liquids formulated to protect wood and/or concrete, including masonry and fiber cement siding, from damage caused by insects, moisture, and decaying fungi and to make surfaces water resistant. Concrete sealers that are formulated to form a protective layer on the surface of the substrate. Provide minimum 11% biobased content.
    - b. Penetrating Liquids: Products that are penetrating liquids formulated to protect wood and/or concrete, including masonry and fiber cement siding, from damage caused by insects, moisture, and decaying fungi and to make surfaces water resistant. Wood and concrete sealers that are formulated to penetrate the outer surface of the substrate. Provide minimum 79% biobased content.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Indoor Air Quality: Provide temporary ventilation as specified in Section 01 57 19.11 (01352) – Indoor Air Quality (IAQ) Management.
- B. Waste Management: As specified in Section 01 74 19 (01351) – Construction Waste Management and as follows:
  1. Coordinate with manufacturer for **take-back program**. Set aside scrap to be returned to manufacturer for recycling into new product. Close and seal all partially used containers of paint to maintain quality as necessary for reuse.

**END OF SECTION**

# **DIVISION 11**

## **EQUIPMENT**

## SECTION 11 30 00 RESIDENTIAL EQUIPMENT

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes:
1. Refrigerators.
  2. Clothes Washers.
  3. Dishwashers.
  4. Freezers

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  3. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:
    - a. Clothes washers.
    - b. Dishwashers.
  4. Energy Efficiency:
    - a. Submit documentation for Energy Star qualifications for equipment provided under work of this Section.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.
- C. Documentation of manufacturer's **maintenance agreement** for each type of equipment. Include the following:

1. Appropriate contact information.
2. Overview of procedures.
  - a. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.
3. Limitations and conditions, if any, applicable to the project.

### 1.3 MAINTENANCE

- A. Operational Service: Provide manufacturer's **maintenance agreement** service for each type of equipment installed in project. Service shall reclaim materials for recycling and/or reuse. Service shall not landfill or burn reclaimed materials.

## PART 2 PRODUCTS

### 2.1 EQUIPMENT

- A. Refrigerator:
  1. Energy Efficiency: Provide Energy Star labeled products **and comply with FEMP performance requirements as indicated below.**

| FEMP Performance Requirement for Federal Purchases |                      |                      |
|--|----------------------|----------------------|
| Refrigerator Type                                  | Total Volume         | Annual Energy Use    |
| Single-Door Manual                                 | ≤ 2.4 cu. ft.        | 255 kWh/year or less |
| Single-Door Manual                                 | 2.5 to 4.4 cu. ft.   | 275 kWh/year or less |
| Single-Door Manual                                 | 4.5 to 6.4 cu. ft.   | 295 kWh/year or less |
| Single-Door Manual                                 | ≥ 6.5 cu. ft.        | 315 kWh/year or less |
| Single-Door Automatic                              | ≤ 2.4 cu. ft.        | 305 kWh/year or less |
| Single-Door Automatic                              | 2.5 to 4.4 cu. ft.   | 325 kWh/year or less |
| Single-Door Automatic                              | 4.5 to 6.4 cu. ft.   | 345 kWh/year or less |
| Single-Door Automatic                              | ≥ 6.5 cu. ft.        | 365 kWh/year or less |
| Bottom-Mount Freezer                               | ≤ 18.4 cu. ft.       | 475 kWh/year or less |
| Bottom-Mount Freezer                               | 18.5 to 20.4 cu. ft. | 485 kWh/year or less |
| Bottom-Mount Freezer                               | ≥ 20.4 cu. ft.       | 495 kWh/year or less |
| Top-Mount Freezer                                  | ≤ 10.4 cu. ft.       | 340 kWh/year or less |
| Top-Mount Freezer                                  | 10.5 to 12.4 cu. ft. | 360 kWh/year or less |
| Top-Mount Freezer                                  | 12.5 to 14.4 cu. ft. | 380 kWh/year or less |
| Top-Mount Freezer                                  | 14.5 to 16.4 cu. ft. | 400 kWh/year or less |
| Top-Mount Freezer                                  | 16.5 to 18.4 cu. ft. | 420 kWh/year or less |
| Top-Mount Freezer                                  | 18.5 to 20.4 cu. ft. | 440 kWh/year or less |
| Top-Mount Freezer                                  | 20.5 to 22.4 cu. ft. | 460 kWh/year or less |
| Top-Mount Freezer                                  | 22.5 to 24.4 cu. ft. | 480 kWh/year or less |
| Top-Mount Freezer                                  | ≥ 24.5 cu. ft.       | 500 kWh/year or less |
| Side-by-Side Freezer                               | ≤ 20.4 cu. ft.       | 560 kWh/year or less |
| Side-by-Side Freezer                               | 20.5 to 22.4 cu. ft. | 580 kWh/year or less |
| Side-by-Side Freezer                               | 22.5 to 24.4 cu. ft. | 600 kWh/year or less |
| Side-by-Side Freezer                               | ≥ 25.5 cu. ft.       | 620 kWh/year or less |

- B. Clothes Washer:

1. Energy Efficiency: Provide Energy Star labeled products **and comply with FEMP performance requirements as indicated below.**
2. Water Efficiency: Provide Energy Star labeled products **and comply with FEMP performance requirements as indicated below.**

| FEMP Performance Requirement for Federal Purchases |                        |              |
|--|------------------------|--------------|
| Washer Capacity                                    | Modified Energy Factor | Water Factor |
| 1.6 to 3.5 cu. ft.                                 | 1.72 or more           | 8.0 or less  |

C. Dishwasher:

1. Energy Efficiency: Provide Energy Star labeled products **and comply with FEMP performance requirements as indicated below.**

| FEMP Performance Requirements for Federal Purchases |                 |                   |
|---|-----------------|-------------------|
| Dishwasher Type                                     | Energy Factor   | Annual Energy Use |
| Standard  | 0.65 or greater | 339 kWh or less   |
| Compact   | 0.88 or greater | 252 kWh or less   |

D. Freezer:

1. Energy Efficiency: Provide Energy Star labeled products **and comply with FEMP performance requirements as indicated below.**

| FEMP Performance Requirement for Federal Purchases |                      |                                |
|--|----------------------|--------------------------------|
| Freezer Type–Defrost                               | Total Volume         | Annual Energy Use <sup>a</sup> |
| Chest–Manual                                       | ≤ 6.4 cu. ft.        | 230 kWh/year or less           |
| Chest–Manual                                       | 6.5 to 8.4 cu. ft.   | 260 kWh/year or less           |
| Chest–Manual                                       | 8.5 to 10.4 cu. ft.  | 290 kWh/year or less           |
| Chest–Manual                                       | 10.5 to 12.4 cu. ft. | 320 kWh/year or less           |
| Chest–Manual                                       | 12.5 to 14.4 cu. ft. | 350 kWh/year or less           |
| Chest–Manual                                       | 14.5 to 16.4 cu. ft. | 380 kWh/year or less           |
| Chest–Manual                                       | 16.5 to 18.4 cu. ft. | 410 kWh/year or less           |
| Chest–Manual                                       | 18.5 to 20.4 cu. ft. | 440 kWh/year or less           |
| Chest–Manual                                       | ≥ 20.5 cu. ft.       | 470 kWh/year or less           |
| Upright–Manual                                     | ≤ 6.4 cu. ft.        | 305 kWh/year or less           |
| Upright–Manual                                     | 6.5 to 8.4 cu. ft.   | 330 kWh/year or less           |
| Upright–Manual                                     | 8.5 to 10 cu. ft.    | 355 kWh/year or less           |
| Upright–Manual                                     | 10.5 to 12.4 cu. ft. | 380 kWh/year or less           |
| Upright–Manual                                     | 12.5 to 14.4 cu. ft. | 405 kWh/year or less           |
| Upright–Manual                                     | 14.5 to 16.4 cu. ft. | 430 kWh/year or less           |
| Upright–Manual                                     | 16.5 to 18.4 cu. ft. | 455 kWh/year or less           |
| Upright–Manual                                     | 18.5 to 20.4 cu. ft. | 480 kWh/year or less           |
| Upright–Manual                                     | ≥ 20.5 cu. ft.       | 505 kWh/year or less           |
| Upright–Automatic                                  | ≤ 12.4 cu. ft.       | 530 kWh/year or less           |

|                   |                      |                      |
|-------------------|----------------------|----------------------|
| Upright–Automatic | 12.5 to 14.4 cu. ft. | 565 kWh/year or less |
| Upright–Automatic | 14.5 to 16.4 cu. ft. | 600 kWh/year or less |
| Upright–Automatic | 16.5 to 18.4 cu. ft. | 635 kWh/year or less |
| Upright–Automatic | 18.5 to 20.4 cu. ft. | 670 kWh/year or less |
| Upright–Automatic | ≥ 20.5 cu. ft.       | 705 kWh/year or less |

E. Room Air Conditioner:

1. Energy Efficiency: Provide Energy Star labeled products **and comply with FEMP performance requirements as indicated below.**

| FEMP Performance Requirement for Federal Purchases |              |
|--|--------------|
| Air Conditioner Type and Capacity                  | Required EER |
| with louvers; < 20,000 Btu/hr                      | 10.7 or more |
| with louvers; ≥ 20,000 Btu/hr                      | 9.4 or more  |
| without louvers; < 8,000 Btu/hr                    | 9.9 or more  |
| without louvers; ≥ 8,000 Btu/hr                    | 9.4 or more  |

**PART 3 EXECUTION**

**3.1 SITE ENVIRONMENTAL PROCEDURES**

A. Resource Management:

1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.
2. Coordinate with manufacturer for **maintenance agreement.**

**END OF SECTION**

**DIVISION 22**

**PLUMBING**



## SECTION 22 40 00 PLUMBING FIXTURES

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Faucets and aerators.
  2. Water closets.
  3. Urinals.
  4. Showerheads.
  5. Accessories.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  2. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:
    - a. Plumbing fixtures.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

#### 1.3 QUALITY ASSURANCE

- A. Water flow and consumption rates for plumbing fixtures:
1. Comply with requirements in Public Law 102-486, Energy Policy Act.
  2. Provide WaterSense labeled products for:
    - a. **High-Efficiency Lavatory Faucets.**
    - b. **High-Efficiency Toilets - Tank-Type** Single Flush.
    - c. **High-Efficiency Toilets - Tank-Type** Dual Flush.
    - d. Flushing Urinals.

### PART 2 PRODUCTS

#### 2.1 MATERIALS

- A. Fixtures:

1. Water management: Provide low flow fixtures and automatic, sensor operated faucets and flush valves. Provide automatic, sensor operated faucets and flush valves to comply with ASSE 1037 and UL1951.
  - a. Faucets and aerators: WaterSense labeled. Maximum 1.5 gal/min when measured at a flowing water pressure of 60 pounds per square inch; and, minimum flow rate shall not be less than 0.8 gpm (3.0 L/min) at a pressure of 20 psi at the inlet, when water is flowing.
  - b. Water closets: WaterSense labeled high-efficiency toilet with maximum effective flush volume of 1.28 gallons. For single flush toilets, the effective flush volume is the average flush volume per ASME A112.19.2. For dual flush toilets, the effective flush volume is the composite, average flush volume of two reduced flushes and one full flush per ASME A112.19.2 and ASME 112.19.14. **[Gravity tank type water closets not allowed.]**
  - c. Urinals: **[WaterSense labeled flushing urinal with maximum 0.5 gallons/flush.]**  
**[Waterless operation; provide with urine trap and 100 percent biodegradable sealant liquid as approved by manufacturer.]**
  - d. Showerheads: 2.2 gal/min when measured at a flowing water pressure of 80 pounds per square inch.
2. Toxicity/IEQ:
  - a. Traps: Provide traps with removable access panels for easy clean-out at sinks and lavatories.
  - b. Water filter systems: Provide filters for chlorine at sinks, lavatories, and showerheads.
  - c. Low corrosion flux for copper pipe: Comply with ASTM B813.

## 2.2 ACCESSORIES

- A. Labels: Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:
  1. The identification of the sensor and its operation with description.
  2. Range of sensor.
  3. For battery operated units, the battery replacement schedule.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Resource Management:
  1. Water Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.
    - a. Adjust automatic sensor operated faucets and valves in accordance with manufacturer's instructions. Comply with ASHRAE 90.1 for energy efficiency.

**END OF SECTION**

# **DIVISION 23**

## **HEATING, VENTILATION, AND AIR CONDITIONING**

## SECTION 23 30 00 HVAC AIR DISTRIBUTION

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Ductwork.
  - 2. Filters
- B. Related Sections:
  - 1. 01 57 19.11 (01352) – IAQ Management.
  - 2. 01 91 00 (01810) – Commissioning.
  - 3. 23 70 00 (15700) – Central HVAC Equipment.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
  - 1. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  - 2. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

#### 1.3 QUALITY ASSURANCE

- A. Energy Efficiency: Meet or exceed ASHRAE 90.1.
- B. Indoor Environmental Quality:
  - 1. Ventilation: Meet or exceed ASHRAE 62 and all published addenda.
  - 2. Filtration: Meet or exceed filter media efficiency as tested in accordance with ASHRAE 52.2 – 1999 (or most recent version).
  - 3. Thermal Comfort: Meet or exceed ASHRAE 55.
  - 4. Maintain positive pressure within the building.

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### A. Ductwork:

1. Recycled Content: Minimum **5** percent post-consumer recycled content, or minimum **20** percent pre-consumer recycled content at contractor's option.
2. Toxicity/IEQ:
  - a. Mold/mildew growth management: **[Unfaced fiberglass and mineral fiber insulation will not be permitted in contact with airstream.] [Duct liner will not be permitted.] [Provide duct liner with durable surface in contact with airstream.]**
  - b. Acoustical performance: Provide **[one-third] [full]** octave bands of airflow generated noise for each rate and direction of airflow of design performance in accordance with **[ASTM E477] [ARI 260 (ducted equipment) [ARI 300 (terminal equipment)]]**. Indicate pressure drop across the silencing element for each airflow rate.

#### B. Filters:

1. Toxicity/IEQ: Provide filtration media with a Minimum Efficiency Reporting Value (MERV) of **6** as determined by ASHRAE 52.2.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

A. Commissioning: The project will have selected building systems commissioned. Coordinate with commissioning as specified in Section 01 91 00 (01810) - Commissioning.

#### B. Indoor Air Quality:

1. Temporary ventilation: as specified in Section 01 57 19.11 (01352) – Indoor Air Quality (IAQ) Management, and as follows:
  - a. Degrease sheet metal air ducts.
  - b. Seal air ducts to prevent HVAC system air leakage.
  - c. Install duct insulation so that unfaced fiberglass and mineral fiber insulation are not in contact with airstream.
  - d. Clean ductwork in accordance with manufacturer's recommendations **[and the NAIMA Guide on Cleaning Fibrous Glass Insulated Air Duct Systems]**.

#### C. Resource Management:

1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

**END OF SECTION**

**DIVISION 26**

**ELECTRICAL**

## SECTION 26 05 00 COMMON WORK RESULTS FOR ELECTRICAL

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NEC 2014, by qualified testing agency and marked for intended location and application
- B. Comply with NEC 2014 and all applicable local codes.

### PART 2 PRODUCTS

#### 2.1 CONDUCTORS 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.

#### 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 other 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 ½ 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.

#### 2.4 SUPPORT AND ANCHORAGE COMPONENTS

- A. Raceway and Cable Supports: As describe 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 insulation wedging.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plated shapes and bars, black and galvanized.
- E. Mounting, Anchoring and Attachment Components:

1. Mechanical-Expansion Anchors: TBD
2. Clamps for Attachment to Steel Structural Elements: TBD
3. Through Bolts: TBD
4. Toggle Bolts: TBD
5. Hanger Rods: TBD

## **2.5 SLEEVES FOR RACEWAYS AND CABLES**

- A. Steel Piper Sleeves: TBD
- B. Cast-Iron Pipe Sleeves: TBD
- C. Sleeves for Rectangular Openings: TBD
- D. Sleeve Seals: TBD

## **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 for 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 wire ways 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 the NECA 1.

### **3.2 RACEWAYS AND CABLE INSTALLATION**

- A. Conceal cables, unless otherwise indicated, within finished walls, ceiling and floors
- B. Install cables at least 6 inches away from parallel runs of water pipes. Locate horizontal raceway that runs above water piping.
- C. Connect motors and equipment subject to vibration, noise transmission, or movement with a 71-inch maximum length of flexible conduit.

### **3.3 WIRING METHODS**

- A. Service Entrance: TBD
- 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: TBD
- E. Class 2 Control Circuits: Power-limited cable, concealed in building finishes.

### **3.4 GROUNDING**

- A. Grounding Conductors: Install bar copper conductor, #4 AWG minimum.
- B. Pipe and equipment grounding conductor terminations: Bolted
- C. Connection to Structural Steel: 2 hole compression lug. All structural steel shall be grounded.



- D. Install ground rod driven into ground according to ground rod manufacturer's instructions.
- E. Making Connections without exposing steel or damaging coating.
- F. Install bonding straps and jumpers in locations accessible for inspection and maintenance, except where routed through short lengths conduit.
- G. Bond straps directly to basic structure, take care not to penetrate any adjacent parts.
- H. 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 panel boards 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 the exterior of the door cover
- 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 crew attachment
    - c. Elevated Components: Increase sized 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. Contractors
- A. Verify identity of each item before installing identification products
- B. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance.
- C. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- D. Install system identification color banding for raceways and cables at 50 foot maximum intervals in straight runs, and a 15 foot maximum intervals in congested areas.

- E. Color Coding for Phase Identification, 600V 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. INSTALLATION OF HANGERS AND SUPPORTS

- A. Fasten hangers and supports securely in place, with provision for thermal and structural movement. Install with concealed fasteners unless otherwise indicated.
- B. Separate dissimilar metals and metal products from contact with cement or wooden 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 sized of components so strength will be adequate to carry present and future static loads within specified loading limit. 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 item and their supports to building structural elements by the following methods unless otherwise indicated or required by Code:
  - 1. To wood: Fasten with lag screw 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 about finished floor level
- C. Size pipe sleeves to provide ½ 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-Penetrations Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applies 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**

## SECTION 26 05 19 CONDUCTORS

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work in this Section.
- B. This Section is a Division 26 "Basic Materials and Methods" section, and is part of each Division 26 section making reference to conductors.

#### 1.2 DESCRIPTION OF WORK

- A. Extent of electrical wire and electrical cable work is indicated by drawings and schedules. Types of wire, cable and connectors in this Section include the following:
  1. Conductors
  2. Power-limited circuit cable
  3. Service entrance cable

#### 1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of electric wire and cable products of types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer: Qualified with at least 3 years of successful installation experience on projects with electrical wiring work similar to that required for this project.

#### 1.4 REFERENCES

- A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wire, cable and connectors.
- B. UL Compliance: Comply with UL standards pertaining to wire cable and connectors.
- C. UL Labels: Provide electrical wires, cables and connectors which have been UL-listed and labeled.
- D. NEMA/ICEA Compliance: Comply with applicable portions of NEMA/Insulated Cable Engineers Association Standards pertaining to materials, construction and testing of wire and cable.
- E. ANSI/ASTM: Comply with applicable portions of ANSI/ASTM standards pertaining to construction of wire and cable.
- F. IEEE Compliance: Comply with applicable portions of IEEE standards pertaining to wire and cable.
- G. NECA Compliance: Comply with NECA's "Standard of Installation."

#### 1.5 SUBMITTALS

- A. Submit manufacturer's data on electric wire and cable.

### PART 2 PRODUCTS

#### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products of one of the following (for each type of wire, cable and connector):
  1. Wire and cable:

- a. Advance Wire and Cable, Inc.
  - b. Cerro Wire and Cable, Co.
  - c. Electrical Conductors, Inc.
  - d. General Cable Corp.
  - e. Hitemp Wires, Inc.
  - f. Rome Cable Corp.
  - g. Southwire Company
  - h. The Okonite Company
2. Connectors:
- a. Amp, Inc.
  - b. Burndy Corp.
  - c. Eagle Electric Mfg. Co., Inc.
  - d. Gould, Inc.
  - e. Ideal Industries, Inc.
  - f. Joselyn Mfg. and Supply Co.
  - g. O-Z/Gedney Co.
  - h. Pyle National Co.
  - i. Thomas and Betts Co.

## 2.2 WIRE, CABLE, AND CONNECTORS

- A. General: Except as otherwise indicated, provide wire, cable and connectors of manufacturer's standard materials, as indicated by published product information; designed and constructed as recommended by manufacturer, and as required for the installation.
- B. Wire:
  - 1. All conductors shall be 600-volt and shall be copper, soft drawn, annealed, having a conductivity of not less than 98% pure copper with dual rated type THHN/THWN insulation unless otherwise specified or indicated on the drawings.
  - 2. No wire shall be smaller than No. 12 AWG, except wiring for signal and pilot control circuits, and pre-manufactured fixture whips for light fixtures.
  - 3. All wire No. 12 AWG shall be solid unless otherwise indicated within these specifications. All wire No. 10 AWG and larger shall be stranded.
  - 4. All wiring installed in light poles or other areas subject to vibration shall be stranded.
  - 5. Wire sizes shown are minimum based on code requirements, voltage drop and/or other considerations. Larger sizes may be installed at the Contractor's option to utilize stock size, provided conduit sizes are increased where necessary to conform to the National Electrical Code. Sizes of wires and cables indicated or specified are American Wire Gage (Brown and Sharpe).
  - 6. All feeder and branch circuit wiring shall be color-coded as follows:

| <u>PHASE</u> | <u>120/208 VOLT</u> | <u>277/480 VOLT</u> |
|--------------|---------------------|---------------------|
| A            | Black               | Brown               |
| B            | Red                 | Orange              |
| C            | Blue                | Purple              |
| Neutral      | *White              | *White              |
| Ground       | Green               | Green               |

\*Except as provided in paragraph 200.6 of the NEC.

### C. Connections

1. Wire connections shall be as follows unless otherwise indicated on the drawings.
  - a. Use pre-insulated connectors 3M Company "Scotchlok," or Ideal Industries, Inc. "super nut," for splices and taps in conductors No. 10 AWG and smaller. All other twist-on connectors must be reviewed by the Architect prior to installation. Use this type of connector for factory-made splices in fixtures or equipment.
  - b. Pressure indent type connectors must be submitted to the Architect for review.
  - c. Tape all splices and joints with vinyl plastic tape manufactured by Minnesota Mining and Manufacturing Company. Use sufficient tape to secure insulation strength equal to that of the conductors joined.
  - d. Keep splices in underground junction boxes to an absolute minimum. Where splices are necessary, use resin pressure splices and resin splicing kits manufactured by the 3M Company, St. Paul, Minnesota, to totally encapsulate the splice. Arrange the splicing kit to minimize the effects of moisture.
  - e. Connect wire No. 6 AWG and larger to panels and apparatus by means of approved lugs or connectors.
  - f. Connect wire No. 10 AWG and larger to panels, motors and electrical apparatus using OZ (or equivalent) type XL set screw type lugs. Lugs shall accommodate full wire capacity for stranded conductors. All connections and connectors shall be solderless.
  - g. Connectors of the porcelain cup type with or without metal inserts shall not be used, including all splices in fixtures which are made in advance by the fixture manufacturer. Splices in wire No. 8 AWG and larger shall be made with approved solderless lugs. If any type of pressure indent type connector is proposed for use on any size conductor, it shall be specifically submitted for approval prior to use.

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. General: Install electric cables, wires and connectors as indicated in compliance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices.
- B. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.
- C. Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes. Junction boxes may be utilized wherever required.
- D. Splicing: No splicing or joints will be permitted in either feeder or branch circuits except at outlet or accessible junction boxes.
- E. Wire shall not be installed in raceways until the concrete work and plastering is completed and all conduits in which moisture has collected have been swabbed out. Insulation resistance to ground shall not be less than that approved by NEC. Eliminate splices wherever possible.
- F. Use pulling compound or lubricant where necessary. Compound must not deteriorate conductor insulation.
- G. Prior to energization, check cable and wire for continuity of circuitry, and for short circuits. Correct malfunctions when detected.
- H. Bury a continuous, pre-printed, bright colored plastic ribbon cable marker with each underground cable, regardless of whether conductors are in conduit. Locate each directly over cables 12" below finished grade.

- I. **Conductor Installation:** Install all conductors in a single raceway at one time, insuring that conductors do not cross one another while being pulled into raceway. Leave sufficient cable at all fittings or boxes and prevent conductor kinks. Keep all conductors within the allowable tension and exceeding the minimum bending radius.
- J. **Conductor Support:** Provide conductor supports as required by the code and recommended by the cable manufacturer. Where required, provide cable supports in vertical conduits similar to OZ Type C.M.T., and provide the lower end of conduit with OZ Type KVF ventilators.
- K. **Conductor Termination:** Provide all power and control conductors, that terminate on equipment or terminal strips, with solderless lugs or fork and flanged tongue terminals. Provide T and B "sta-kon" tongue terminal. This type conductor termination is not required when the equipment is provided with solderless connectors.
- L. Many circuits are shown on the drawings to be provided with dedicated neutral and ground conductors. Carefully review circuiting and the electrical abbreviations and symbols legend and provide the number of conductors indicated.
- M. Unless otherwise indicated provide dedicated neutral conductors for all branch circuits. Neutral conductors shall not be shared between circuits. Where the drawings indicate shared neutral conductors, for a multi-wire branch circuit, group the breakers together in accordance with NEC requirements.

### 3.2 CONDUCTOR ARCPROOFING

- A. Cover two or more power feeder cables occurring in the same switchboard section, junction box or pull box (including pull boxes over switchboards) with arcproof and flameproof tape.
- B. Provide 3M Company "Scotch" No. 77 tape or Plymouth Rubber Co. Slipknot No. 30 tape, to provide an installation capable of withstanding a 200-amp arc for not less than 30 seconds.
- C. Apply tape in a single layer, one-half lapped, or as recommended by the manufacturer to conform to the above requirements. Apply with the coated side next to the cable and hold in place with a random wrap of 1/2 inch wide, pressure-sensitive, glass cloth electrical tape, 3M Company "Scotch" No. 69. Tape to be color coded as specified previously.

**END OF SECTION**



## SECTION 26 05 33 RACEWAYS

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.
- B. This Section is a Division 26 "Basic Materials and Methods" section, and is part of each Division 26 section making reference to electrical raceways specified herein.

#### 1.2 DESCRIPTION OF WORK

- A. Extent of raceways is indicated by drawings and schedules.
- B. Types of raceways in this Section include the following:
  - 1. Electrical metallic tubing.
  - 2. Flexible metal conduit.
  - 3. Intermediate metal conduit.
  - 4. Liquid-tight flexible metal conduit.
  - 5. Rigid metal conduit.
  - 6. Rigid nonmetallic conduit.
  - 7. Surface metal raceways.

#### 1.3 REFERENCES

- A. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.
- B. UL Compliance and Labeling: Comply with provisions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL-listed and labeled. Each length of raceway shall bear the Underwriters Laboratories label.
- C. NEC Compliance: Comply with NEC requirements which are applicable to the construction and installation of raceway systems.
- D. NECA Compliance: Comply with NECA's "Standard of Installation".

#### 1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations, for each type of raceway required.

### PART 2 PRODUCTS

#### 2.1 STEEL CONDUIT

- A. Steel Conduit: Rigid steel conduit, intermediate metal conduit and steel electrical metallic tubing shall be hot-dipped, galvanized or sheradized as manufactured by Youngstown Sheet and Tube Company, National Electric, General Electric, or equal.
- B. Joints: Raintight non-insulated throat type compression fittings (connectors and couplings) shall be provided for electrical metallic tubing systems. All fittings shall be of the steel type with steel locknuts equal to Appleton 95 Series.

- C. Expansion Joints: Provide expansion fittings, O.Z. Type AX with bonding jumper for rigid conduit and O.Z. Type TX with bonding jumper for electrical metallic tubing. Where embedded raceways cross building expansion joints, provide combination deflection/expansion fittings, O.Z. Type AXDX, or equal.

## 2.2 RIGID NON-METALLIC (PVC) CONDUIT

- A. PVC (polyvinyl chloride) Conduit: Heavy wall rigid PVC conduit shall be composed of high impact PVC and shall conform to industry NEMA Standards and to Federal Specification WC-1094. Conduits shall be Carlon Schedule 40 type, or approved equal.

## 2.3 FLEXIBLE METAL CONDUIT

- A. Flexible metal conduit shall conform to UL1. It shall be formed from continuous length of spirally-wound, interlocked zinc-coated strip steel.

## 2.4 LIQUID-TIGHT, FLEXIBLE METAL CONDUIT

- A. Liquid-tight flexible metal conduit shall be constructed of a single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; and coated with an oil-resistant, liquid-tight thermoplastic jacket.

## 2.5 WIREWAYS

- A. General: Provide electrical wireways of types, grades, sizes, weights (wall thicknesses), and number of channels for each type service indicated. Provide complete assembly of wireways including, but not necessarily limited to couplings, offsets, elbows, expansion joints, adapters, hold down straps, end caps, and other components and accessories as needed for a complete system. Where types and grades are not indicated, provide proper selection as determined by the Installer to fulfill wiring requirements and comply with applicable provisions of NEC for electrical raceways.
- B. Surface Metal Raceways: Provide surface metal raceways of sizes and channels indicated; in compliance with FS W-C-582. Construct of galvanized steel with snap-on covers, with 1/8" mounting screw knockouts in base approximately 8" o.c. Provide fittings indicated which match and mate with raceway. Finish with manufacturer's standard prime coating suitable for painting. Provide all necessary devices as shown on the drawings for a complete installation.
- C. Manufacturers: Subject to compliance with requirements, provide surface metal raceways of one of the following:
  1. B-Line Systems, Inc.
  2. Midland-Ross Corporation
  3. Power-Strut Division; Youngstown Sheet and Tube Company
  4. Square D Company
  5. Versa-Tech Corporation
  6. Walker/Parkersburg Division; Textron, Inc.
  7. Wiremold Company

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Install electric raceways where indicated; in accordance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation" and complying with recognized industry practices.



- B. Raceways embedded in concrete or in earth below floor slabs shall be rigid steel conduit, intermediate metal conduit or rigid schedule 40 PVC conduit. Rigid PVC conduit shall be provided with rigid metal or intermediate metal conduit elbows when the raceway system exits the concrete topping or earth.
- C. Electrical metallic tubing shall not be embedded in concrete or installed in earth.
- D. Rigid heavy wall Schedule 40 PVC conduit shall be installed in earth and concrete only.
- E. Raceways in walls installed outside or in refrigerated areas shall be rigid steel conduit, or intermediate metal conduit. "Walls installed outside" does not include building envelope walls.
- F. Provide rigid steel conduit or intermediate metal conduit for exposed raceways from floor to eight feet above the floor in mechanical rooms and in areas designated on the plans.
- G. Rigid galvanized steel conduit or galvanized intermediate metal conduit shall be used where conduit is exposed to weather.
- H. Conduits in hazardous locations shall conform to the National Electrical Code. Rigid galvanized steel conduit or intermediate metal conduit shall be used in hazardous locations. PVC conduit shall not be used in hazardous areas.
- I. Rigid metal, intermediate metal, electric metallic tubing or PVC conduit where allowed in other section 3.1 paragraphs shall be used for feeders and branch circuits.
- I. Flexible metal conduit may be used to connect light fixtures in accordance with NEC requirements. Provide flexible metal conduit for connections to motors, transformers, generators, and other equipment subject to vibration. Length of flexible conduit shall be a minimum of one foot for conduit diameters up to 1-1/2". A minimum of 3" of flexible conduit shall be added for every 1/2" increase in conduit diameter. Flexible metal conduit installation shall be kept to a minimum in connecting other electrical equipment items. Sealtight, flexible conduit shall be used where the flexible conduit may be subject to moist or humid atmosphere, corrosive atmosphere, subject to water spray and subject to dripping oil, grease or water. Flexible metal conduits shall not be permitted for any other applications, unless specifically approved by the Owner
- J. Conduits shall be 3/4" diameter, minimum. Raceway sizes shown on the drawing are based on type THHN/THWN conductors.
- K. Type Material: Except as noted otherwise all conduit shall be steel.

### 3.2 INSTALLATION

- A. All raceways shall be installed concealed except where shown or noted otherwise.
- B. Concealed raceways may not be embedded in concrete unless indicated as such on the drawings or approved by the Owner and Engineer.
- C. Continuity: Provide metallic raceways continuous from outlet to outlet, and from outlets to cabinets, junction or pull boxes. Enter and secure conduit to all boxes to provide electrical continuity from the point of service to outlets. Provide double locknut and bushing on terminals of metallic conduits.
- D. A nylon or polypropylene pull string shall be installed in all empty conduits to facilitate future installation of cabling.
- E. Provide accessible "seal-off" fittings for all raceways entering or leaving hazardous areas, entering or leaving refrigerated areas and as otherwise required by the National Electrical Code.
- F. Where conduits penetrate the roof seal, they shall be installed in curbs provided for mechanical equipment. When this is not possible, suitable pitch pockets, lead flashing, or approved fittings shall be provided. Details for special conduit installations shall be as shown on the drawings.
- G. Reinforced Concrete: No reinforcing steel shall be displaced to accommodate the installation of raceways and outlet boxes. Outlet boxes shall not be installed in beams or joists. In general, all embedded conduits shall be located in the physical center of the particular section of concrete. Unless otherwise indicated, raceways embedded in reinforced concrete shall conform to the following usual types of conditions. Particular attention is called to the fact that there are many extenuating conditions where the Contractor may be instructed in

writing during the course of the project not to place embedded conduits in certain areas, generally due to the possibility of unsightly cracking or for structural reasons. This instruction shall not entitle the Contractor to extra compensation. Any condition not covered by the following usual conditions shall require special clarification.

| Location               | Maximum Allowance  |
|------------------------|--|
| 1. Columns             | Displacement of 4 percent of plan area of column.  |
| 2. Floors and Walls    | Displacement of 1/3 of thickness of concrete spaced not less than three diameters on center. |
| 3. Beams and Joists    | Displacement of 1/3 of least dimension, spaced not less than three diameters on center.      |
| 4. Sleeves thru Floors | 2" maximum pipe size, not less than and Walls three diameters on center.                     |

- H. Plain Concrete: Raceways shall not be placed in plain concrete, such as cement toppings on structural floors without special instructions.
- I. Furred Spaces: Raceways installed in furred spaces shall be installed in accordance with the requirements of the National Electrical Code. Do not anchor or strap conduits to the ceiling furring channels or attach to furred ceiling hanger wires. Raceways may be attached to the suspension system (wire hangers) of drop ceilings if installed in such a manner that the ceiling panels may be removed without interference with the raceway, and the wire hangers are sized to carry the additional raceway load.
- J. Stub Ups: Extend conduit stubs at least one foot above slab or fill, before connection is made to electrical metallic tubing.
- K. Exterior Conduits: Install raceways a minimum of 42" below finished grade unless noted otherwise on the drawings.
- L. Provide marking of conduit and junction boxes to indicate which distribution system they are serving. The markings could be colored tape on conduit at or near junction boxes with different colored tapes indicating different distribution systems. Concealed junction boxes shall be legibly marked with a magic marker to indicate the panel and circuit number that junction box serves.
  - 1. The distribution systems shall be color coded as follows:
    - a. Fire Alarm - Red
    - b. Paging System - Blue
    - c. 120/208 Volt - Green
    - d. 277/480 Volt - Orange
    - e. Cable TV System - Black
    - f. Telephone System - White
- M. Steel Conduit (galvanized rigid steel, IMC or EMT):

1. Cutting: Cutting shall be done with hand or power hacksaws. All cut ends shall be reamed to remove burrs and sharp edges.
  2. All threaded joints shall be made up wrench-tight and all compression joints shall be made up mechanically secure and snug so as to make continuous current-carrying electrical contact.
  3. All metallic conduits buried or otherwise in contact with earth shall be painted using one heavy continuous coat of asphalt varnish after assembly of conduit and fittings.
  4. Expansion joints shall be installed in steel conduit systems in structures as follows expansion joints are specified elsewhere in the specification):
    - a. Where conduit run crosses a building expansion joint.
    - b. In any conduit run exceeding 100 feet in length.
    - c. Where shown on the drawings.
- N. Threads: Clean all threads of rigid or intermediate metal conduit. Coat all male threads of all steel conduit installed in concrete with red or white lead immediately before being coupled together.
- O. Running Threads: Use "Erickson" type couplings in lieu of running threads.
- P. PVC Conduit:
1. Joints: Conduits shall be joined by using couplings and solvent cement furnished or recommended by the raceway manufacturer. Finished joints shall be secure and watertight.
  2. Cutting: Cutting shall be done with hacksaws and ends shall be reamed to remove burrs and sharp edges.
  3. Expansion Joints: Expansion joints shall be installed:
    - a. Where conduit run crosses a building expansion joint.
    - b. As recommended by the manufacturer or as shown on the drawings.
  4. Bends for PVC conduit sizes 2" and smaller may be made "hot" in the field. Inside dimension shall be thereby undistorted. For PVC sizes larger than 2", provide only factory bends.

**END OF SECTION**

## SECTION 26 24 16 PANELBOARDS

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract including General and Supplementary Conditions and Division 1 specification sections, apply to the work of this Section.
- B. This Section is a Division 26 "Basic Materials and Methods" section, and is a part of each Division 26 section making reference to panelboards specified herein.

#### 1.2 DESCRIPTION OF WORK

- A. Extent of panelboard and enclosure work, including cabinets and cutout boxes is indicated on the drawings and by schedules.
- B. Types of panelboards and enclosures in this Section include the following:
  - 1. Distribution Panels
  - 2. Lighting and Appliance Panels
- C. Refer to other Division 26 sections for cable/wire, connectors and electric raceway work required in conjunction with panelboards and enclosures; not work of this Section.

#### 1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of panelboards and enclosures, of types, size and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer: A firm of at least three (3) years of successful installation experience on projects with electrical installation work similar to that required for this project.

#### 1.4 REFERENCES

- A. Special Use Markings: Provide panelboards, constructed for special use, with UL markings indicating that special type usage. Panels identified or shown on the drawings for use as main service entrance equipment shall be labeled at the factory with "SERVICE ENTRANCE" type UL label.
- B. UL Compliance: Comply with applicable UL safety standards pertaining to panelboards, accessories, and enclosures. Provide units which have been UL listed and labeled. UL standards are as follows:
  - 1. Panelboards - UL67
  - 2. Cabinets and Boxes - UL50
- C. NEC Compliance: Comply with the NEC as applicable to the installation of panelboards, cabinets, and cutout boxes.
- D. NEMA Compliance: Comply with NEMA Stds. Pub. No. 250 "Enclosures for Electrical Equipment (1000 volt maximum)", Pub. No. 1 "Panelboards" and Pub. No. PB1.1, "Instruction for Safe Installation, Operation, and Maintenance of Panelboards Rates 600 Volts and Less".
- E. NECA Compliance: Comply with NECA's "Standard of Installation".

#### 1.5 SUBMITTALS

- A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations for each panelboard required. Include data substantiating that units comply with specified requirements.

- B. Shop Drawings: Submit dimensioned drawings of panelboards and enclosures showing accurately scaled layouts of enclosures and required individual panelboard devices, including but not limited to circuit breakers, fusible switches, fuses, ground fault circuit interrupters, and accessories.

## **PART 2 PRODUCTS**

### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Subject to compliance with requirements provide products of one of the following:
  - 1. Square D Company
  - 2. General Electric
  - 3. Cutler Hammer
  - 4. Siemens

### **2.2 FEEDER PROTECTIVE DEVICE COORDINATION**

- A. All overcurrent protective devices feeding the emergency system(s) shall be selectively coordinated in accordance with N.E.C 2011, 700.27. Selective coordination is required to the 0.10 second level. At least one manufacturer's equipment has been evaluated during design to ensure selective coordination. If an equipment manufacturer has a conflict with selective coordination they shall bring this to the attention of the design engineer a minimum of 10 business days prior to the bid date. The panelboard manufacturer and generator system manufacturer shall fully coordinate the overcurrent protective device selection to ensure selectivity between equipment.

### **2.3 GENERAL**

- A. Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials, and which are designed and constructed in accordance with published product information. Provide solderless lugs, or connectors, in the correct number and size for conductors on mains, on the load side of each branch, circuit, and on ground and neutral bars. Provide tin plated copper busses. Provide an insulated neutral bus (rated at 200% of phase bussing) and a bonded equipment ground bus mounted at the opposite end of the structure from the mains, and having numbered screw or lug terminals for connection of wires. Equip panels with the number of unit devices as required for a complete installation. Where more than one type of component meets the indicated requirements, selection is installer's option. Where types, sizes or ratings are not indicated, comply with NEC, UL and established industry standards for applications indicated.
- B. Provide ground fault circuit interrupting type circuit breakers for all devices noted with a "GFI" subscript on the panelboard schedules for this project.
- C. Provide UL listed HACR type circuit breakers for all devices which serve heating, ventilating, or air conditioning equipment.
- D. Panelboards shall be provided with covers for surface or flush mounting as shown on the drawings, or as required for actual project conditions.
- E. Panelboards shall be constructed for top or bottom feeder service, as required by actual project conditions.

### **2.4 LIGHTING AND APPLIANCE PANELS**

- A. Lighting and appliance panelboards shall be Square D type NF (or equal) for 277/480 volt or Square D type NQOB (or equal) 120/208 volt applications. All branch circuit breakers are to be quick-make, quick-break, trip indicating and common trip on all multi-pole breakers, and shall be bolt-on type. Trip indication shall be

- clearly shown by breaker handle located between the "ON" and the "OFF" positions. Panelboards shall have distributed phase copper bussing throughout.
- B. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.
  - C. Provide fully rated main circuit breaker type panelboards, where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.
  - D. Provide fully rated main lug only type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.
  - E. Panelboard boxes shall be 5.75" deep, maximum and shall have 6-inch minimum gutters. Fronts are to be complete with door and cylinder lock, with all locks keyed alike. Fronts shall have adjustable trim clamps, directory frames, and shall be equipped with a typewritten directory that identifies each circuit breaker by number and the equipment that the breaker serves. One additional blank directory card for each panel shall be furnished to the Owner.
  - F. Two section panels (as required by Code) shall be equipped with boxes of equal dimensions.
  - G. Panelboards shall be Underwriters' Laboratory listed and shall bear the UL label. The size of the panelboard main disconnect device or main lugs, the rating and number of branch circuits, and the type of mounting shall be as shown on the drawings.
  - H. All factory installed devices shall be re-torqued prior to energizing.

## 2.5 DISTRIBUTION PANELS

- A. Distribution panels shall be Square D I-Line (or equal) panels as indicated on the plans. Provide appropriate type of panels to meet specific project requirements. Panelboards shall have distributed phase copper bussing throughout.
- B. Circuit breakers shall be as specified for lighting panels unless indicated otherwise. Power panels shall have combination card holder and name-plate and shall be equipped with typewritten directories that identify all loads served and all spare circuits. Provide a copper ground bus in all power panels.
- C. Power panels shall be Underwriters' Laboratory approved and shall bear the UL label. Main lugs and gutters shall be suitable for copper and aluminum wire. The size of the panelboard main protective device or main lugs, the size, type and the number of branch circuits and the type of mounting shall be as shown on the drawings.
- D. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.
- E. Provide fully rated main circuit breaker type panelboards, where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.
- F. Provide fully rated main lug only type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.

## 2.6 FEEDER PROTECTIVE DEVICES

- A. The following paragraphs list the general feeder protective device requirements. For circuit breakers that are part of the emergency distribution system electronic circuit breakers may be required to achieve selective coordination in accordance with N.E.C. 2011, 700.27.



1. Feeder protective devices as shown shall be molded case air circuit breakers, built, tested and UL labeled per UL 489.
2. In general 100 ampere through 400-ampere frames shall be thermal-magnetic trip with inverse time current characteristics. Breakers with 225 ampere through 400- ampere frames shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.
3. In general breakers with 600 ampere frames and above shall be Square D Powerpact or approved equivalent with solid-state trip complete with built in current transformers, solid-state trip unit and flux transfer shunt trip. Breakers shall have easily changed trip-rating plugs with trip ratings as indicated on the drawings. Rating plugs shall be interlocked so they are not interchangeable between frames and interlocked such that breakers cannot be latched with rating plug removed. Breaker shall have built-in test points for testing long delay, instantaneous and ground fault (where shown). Functions of the breaker shall be tested by means of a 120 volt operated test kit. Provide one test kit capable of testing all breakers 600 ampere and above.
4. Solid state instantaneous element shall be continuously adjustable from approximately 4 to 8 times the trip rating, with short time adjustment from instantaneous to 10-cycle delay for coordination purposes. Provide short delay override feature providing for instantaneous tripping on high magnitude faults.
5. Molded case breakers shall have a minimum UL listed interrupting capacity as listed on the drawings.
6. Breakers 2000 thru 3000A frame on the drawings shall be UL listed and labeled for 100 percent application per the N.E.C.

## 2.7 CUSTOMER METERING

- A. Where indicated on the drawings, provide a BACNET compatible digital electronic power meter with the following monitoring and metering capabilities:
  1. Current, per phase and neutral.
  2. Voltage, phase-to-phase and phase-to neutral.
  3. Real power (kW), per phase and three-phase total.
  4. Reactive power (kVAR), per phase and three phase total.
  5. Apparent power (kVA), per phase and three phase total.
  6. Power factor (true), per phase and three phase total.
  7. Frequency.
  8. Demand current, per phase and neutral, present and peak.
  9. Real power demand (kWd), three phase total, present and peak.
  10. Reactive power demand (kVARd), three phase total, present and peak.
  11. Apparent power demand (kVAd), three phase total, present and peak.
  12. Real energy (kWh), three phase total.
  13. Reactive energy (kVARh), three phase total.
  14. Apparent energy (kVAh) three phase total.
  15. Energy accumulation modes, signed, absolute, energy in, energy out.
  16. Total harmonic distortion (THD), voltage and current, per phase.
  17. Date and time stamping, peak demands, power up/restart and resets.
- B. The power meter shall be accurate to 0.25% of the reading plus 0.05% of the full scale for voltage and current sensing, and 0.5% of the reading plus 0.05% of the full scale for power and energy, accurate through the 31st
- C. Provide necessary current transformers to support current inputs to the power meter. Provide potential transformers, control power transformers, and fusing as required. harmonic.



## **PART 3 EXECUTION**

### **3.1 INSTALLATION**

- A. General: Install panelboards and enclosures where indicated, in accordance with the manufacturers' written instructions, applicable requirements of the NEC and NECA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.
- B. Coordinate the installation of panelboards and enclosures with cable and raceway installation work.
- C. Provide all required electrical connections within the enclosure.
- D. Fill out typewritten panelboard circuit directory cards upon completion of the installation work.

**END OF SECTION**



## **SECTION 26 27 26 WIRING DEVICES**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.
- B. This section is a Division 26 "Basic Materials and Methods" section, and is a part of each Division 26 section making reference to wiring devices specified herein.

#### **1.2 DESCRIPTION OF WORK**

- A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems which are intended to carry, but not utilize electrical energy.
- B. Types of electrical wiring devices in this Section include the following:
  1. Receptacles
  2. Switches
  3. Wall Plates
  4. Dimmer Controls
  5. Floor Outlets
  6. Service Pedestals

#### **1.3 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in manufacture of wiring devices of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer: Qualified with at least 2 years of successful installation experience on projects with electrical installation work similar to that required for this project.

#### **1.4 REFERENCES**

- A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring devices.
- B. UL Compliance and Labeling: Provide electrical wiring devices which have been UL listed and labeled.
- C. NEMA Compliance: Comply with NEMA standards for general and specific purpose wiring devices.
- D. NECA Compliance: Comply with NECA's "Standard of Installation."

#### **1.5 SUBMITTALS**

- A. Product Data: Submit manufacturer's data on electrical wiring devices.

### **PART 2 PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Subject to compliance with requirements, provide products of one of the following:
  1. Pass and Seymour Corporation
  2. Hubbell, Inc.
  3. Leviton, Inc.

4. Crouse Hinds
5. Wiremold
6. Walker Duct
7. Lutron

## 2.2 WIRING DEVICES

- A. General: Where shown on the drawings, furnish and install wiring devices indicated by the appropriate symbols. Wiring devices shall be products of Pass and Seymour Corporation, or equal. Catalog numbers shown below are P & S hard use specification grade. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable.
- B. Switches: Branch circuit switches shall be flush tumbler type as follows:
  1. Single Pole CS20AC1 Series - Gray
  2. Two Pole CS20AC2 Series - Gray
  3. Three-Way CS20AC3 Series - Gray
  4. Four-Way CS20AC4 Series - Gray
  5. Single Pole SW with Lighted Toggle PS20AC1-CSL Series - Clear
- C. Switches located in laboratory spaces on normal power shall be the same as
  1. listed above but **GRAY** in color. Laboratory spaces include all areas indicated or
  2. referenced on Sheet LF0.12 – Lab Area Callouts
- D. Switches located in non-laboratory spaces on normal power shall be the same as
  1. listed above but **WHITE** in color.
- E. Switches fed by a generator circuit (standby or life safety) shall be the same as
  1. listed above but **RED** in color.
- F. Dimmer Switches: Provide dimmer switches according to the following (all catalog numbers are Lutron Nova T series, unless otherwise noted). At minimum, all dimmer switches shall be rated to accommodate the load shown to be switched on the Drawings.

| <u>Incandescent Dimmers</u>      | <u>Catalog No.</u> |
|----------------------------------|--------------------|
| 120 Volt, 600 Watt, Single Pole  | NT-600             |
| 120 Volt, 1000 Watt, Single Pole | NT-1000            |
| 120 Volt, 1500 Watt, Single Pole | NT-1500            |
| 120 Volt, 2000 Watt, Single Pole | NT-2000            |

| <u>Fluorescent Dimmers</u> | <u>Catalog No.</u> |
|----------------------------|--------------------|
| 277 Volt, Single Pole      | NTF-10-277         |

1. Wall Mounted Line Voltage Automatic Wall Switches: Watt Stopper type DW-100-I-120/277. Provide time delay setting of 15 minutes unless directed otherwise by the University.
2. Wall Mounted Line Voltage Digital Time Switches: Watt Stopper type TS-400-I-120/277- with adjustments set as directed by the University.
3. Low Voltage, Dual Technology Occupancy Sensors: Watt Stopper type DT-200 complete with isolated relay for connection to HVAC control system and BZ-150 box mounted power pack. Provide sensor adjustments as directed by the University.
4. Other occupancy sensor types: See the Electrical Abbreviations and Symbols Legend for additional occupancy sensor types and information.

## 2.3 RECEPTACLES

- A. All receptacles shall be side and back wired, self-grounding of the type indicated on the drawings, or as follows. Catalog numbers shown below are Pass & Seymour specification grade unless otherwise indicated. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable:
1. Duplex Convenience Receptacles                      CRB5362S Series  
    20A-125V (Grounding Type)
  2. Weatherproof Duplex Receptacles                      CRB5362S WP Series  
    20A-125V (Grounding Type)                      Weatherproof Plate
  3. Duplex GFI Receptacle                                      2094 20A-125V
  4. Weatherproof Duplex                                      2094 – with GFI Receptacle  
    20A-125 Volt    Weatherproof Wall Plate
  5. TVSS Duplex Receptacle                                  5362ISP 20A-125V
- B. Receptacles located in laboratory spaces on normal power shall be the same as listed above but **GRAY** in color. Laboratory spaces include all areas indicated or referenced on Sheet LF0.12 – Lab Area Callouts
- C. Receptacles located in non-laboratory spaces on normal power shall be the same as listed above but **WHITE** in color.
- D. Receptacles fed by a generator circuit (standby or life safety) shall be the same as listed above but **RED** in color.

## 2.4 PLATES

- A. Furnish and install wall plates for all wiring devices. Where switches and/or receptacles are shown adjacent to each other, provide a common cover plate for each group of devices
1. Plates in laboratory spaces as indicated or referenced on Sheet LF0.12 – Lab Area Callouts:
    - a. Plates shall be Pass and Seymour Type 302 stainless steel. Oversize plates are not acceptable.
    - b. Cover plates for all electrical devices in laboratories shall be engraved with panel and circuit no. designation. Engraving shall be 1/8" high, block style letters, with black filler on front side of cover plates.
  2. Plates in non-laboratory spaces:
    - a. Plates shall be Pass and Seymour "RP" Series high impact thermoplastic, and shall be **WHITE** in color. Oversize plates are not acceptable.
    - b. Cover plates for all electrical devices in non-laboratory spaces shall be labeled with an adhesive label 1/8" high, block style letters, with black lettering on a clear background. Label shall be approved by engineer and owner's representatives.
  3. Weatherproof switch plates shall be Appleton WCT1 type. Weatherproof receptacle plates shall be Appleton WHDO1 type.

## 2.5 TWO PIECE SURFACE METAL RACEWAYS

- A. Where indicated on the drawings, provide Wiremold (or equivalent) Series ALA4800 two-piece, aluminum, surface metal raceway systems complete with all necessary electrical and telecommunications devices, bases, covers, dividers, wire clips, couples, inserts, end fittings, device mounting brackets, device covers, etc. to ensure a complete and functional installation.
- B. Cover plates for all power devices installed in two piece surface metal raceways shall be engraved with panel and circuit no. designation. Engraving shall be 1/8" high, block style letters, with black filler.

## 2.6 FLOOR OUTLETS

- A. Flush Mounted Floor Boxes and Floor Outlets. See plans for types. Unless noted otherwise on the plans provide one receptacle faceplate, and one blank faceplate (to support telecom devices) for each flush mounted floor convenience outlet. When carpet is indicated on the finish schedule, supply each floor box or outlet with an appropriate carpet flange.
- B. Poke-Thru Service Fittings and Service Pedestals: See plans for types. Provide all necessary faceplate types, conduit adapters for installation on counter tops and all other accessories as noted on the drawings, or as required to meet specified project needs.
- C. Where devices are installed on exposed fittings or boxes, the plates shall be galvanized and of a type designed to fit the box. Blank covers shall be installed on all boxes without devices or fixtures, of same type as installed on devices in the room or area.
- D. Test wiring devices to ensure electrical continuity of grounding connections and proper polarity.

## **PART 3 EXECUTION**

### **3.1 INSTALLATION**

- A. Install wiring devices as indicated in compliance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate with other work including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices and other work.
- C. Testing: Test wiring devices for electrical continuity and proper polarity of connections. Test wiring devices to demonstrate compliance with requirements.
- D. All outlets shall be located as shown on the drawings, except that where practicable; outlets shall be located in center of panels or trim or otherwise symmetrically located to conform to existing structural layout. Outlets incorrectly installed shall be corrected. Damaged items or damaged finishes shall be repaired or replaced at no expense to the Owner.
- E. Outlets shall be set plumb or horizontal and shall extend to the finished surface of the walls, ceiling or floor, as the case may be, without projecting beyond the same.
- F. Receptacles, switches, etc., shown on wood trim, cases or other fixtures shall be installed symmetrically; and, where necessary, shall be set with the long dimensions of the plate horizontal, or ganged in tandem.
- G. Where dimmer switches are shown adjacent to standard switches, both shall be installed in separate back boxes with adequate space between so that neither cover plate requires cutting.
- H. Where devices are shown near wall openings, coordinate location if corner guards are to be installed so that cover plates do not require cutting.
- I. Where devices are shown mounted adjacent to one another on the drawings, provide multi-gang faceplates to cover all devices.

**END OF SECTION**

## SECTION 26 50 00 LIGHTING

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Interior luminaires.
  - 2. Exterior luminaires.
  - 3. Lighting control devices.
  - 4. Accessories.
- B. Related Sections:
  - 1. 01 91 00 (01810) - Commissioning.

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
  - 1. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  - 2. Energy Efficiency:
    - a. Submit documentation for Energy Star qualifications for equipment provided under work of this Section.
    - b. Submit data indicating lumens per watt efficiency of light source.
    - c. Submit data indicating color rendition index of light source.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.
- C. Documentation of manufacturer's **maintenance agreement** for luminaires. Include the following:
  - 1. Appropriate contact information.
  - 2. Overview of procedures.
    - a. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.
  - 3. Limitations and conditions, if any, applicable to the project.

#### 1.3 QUALITY ASSURANCE

- A. Energy Efficiency: Comply with National Energy Policy Act requirements for lighting products.

#### 1.4 MAINTENANCE

- A. Operational Service: Provide manufacturer’s **maintenance agreement** service for luminaires installed in project. Service shall reclaim materials for recycling and/or reuse. Service shall not landfill or burn reclaimed materials.
1. Indicate procedures for compliance with regulations governing disposal of Mercury.

**PART 2 PRODUCTS**

**2.1 INTERIOR LUMINAIRES**

- A. Downlight Luminaires;

| FEMP Performance Requirement for Federal Purchases |  |
|--|--|
| Compact Fluorescent Lamps                          |  |
| Luminaire Type                                     | Required Luminaire Efficacy Rating (LER) |
| Open Optics  | 29 or higher                             |
| Baffled Optics                                     | 21 or higher                             |
| Lensed Optics                                      | 24 or higher                             |
| Metal Halide Lamps                                 |  |
| Luminaire Type                                     | Required Luminaire Efficacy Rating (LER) |
| Open Optics  | 35 or higher                             |
| Lensed Optics                                      | 30 or higher                             |

- B. Compact Fluorescent Lamps:

| FEMP Performance Requirement for Federal Purchases |                                 |                                 |                                    |
|--|---------------------------------|---------------------------------|------------------------------------|
| To Replace Incandescent Bulb Rate At:              | Typical CFL Replacement Wattage | Necessary Light Output (Lumens) | Required CFL Lumens per Watt (lpw) |
| Bare Bulbs   |                                 |                                 |                                    |
| 40 watts   | 11-14 watts                     | 495 or more                     | 45 lpw or more                     |
| 60 watts   | 15-19 watts                     | 900 or more                     | 60 lpw or more                     |
| 75 watts   | 20-25 watts                     | 1200 or more                    | 60 lpw or more                     |
| 100 watts  | ? 29 watts                      | 1750 or more                    | 60 lpw or more                     |
| Reflector Type Bulbs                               |                                 |                                 |                                    |
| 50 watts   | 17-19 watts                     | 550 or more                     | 33 lpw or more                     |
| 60 watts   | 20-21 watts                     | 675 or more                     | 40 lpw or more                     |
| 75 watts   | ? 22 watts                      | 875 or more                     | 40 lpw or more                     |

**2.2 EXTERIOR LUMINAIRES**

- A. Luminaire:
1. IESNA Classification: **LZ2 – low**.
  2. Photometric Performance of installed units: Maximum initial horizontal illumination does not exceed **[TBD]** footcandles at a point lighting level readings should be measured at **grade**.



## 2.3 LIGHTING CONTROL DEVICES

- A. Dimming Ballast Controls: Sliding-handle type with on/off control; compatible with ballast and having light output and energy input over the full dimming range.
- B. Light Level Sensor: Detect changes in ambient lighting level and provide dimming range of 20 to 100 percent in response to change. Sensor shall be capable of controlling 40 electronic dimming ballast, minimum. Adjustable Ambient Detection Range: **10 to 100** footcandles minimum. Sensor shall have a bypass function to electrically override sensor control.
- C. Occupancy Sensors: Comply with Green Seal GC-12. Provide adjustable sensitivity and off delay time range of 5 to 15 minutes.
- D. Time Switch: Astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at predetermined time between 8:30 p.m. and 2:30 a.m. or sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise.
  - 1. Provide switch rated [xxxx] volts, having automatically wound spring mechanism or capacitor, to maintain accurate time for a minimum of 15 hours following power failure.
  - 2. Provide time switch with a manual on-off bypass switch.
  - 3. Housing: [surface] [flush]-mounted, NEMA [1] [3] [xxxx] enclosure conforming to NEMA ICS 6.
- E. Photocell Switch: UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated [xxxx] volts ac, 60 Hz with [single-throw contacts] [single pole double-throw contacts] for control of mechanically held contactors, rated [1000] [xxxx] W.
  - 1. Switch shall turn on at or below 32 lux (3 footcandles) and off at 22 to 107 lux (92 to 10 footcandles).
  - 2. A time delay shall prevent accidental switching from transient light sources.
  - 3. Provide switch:

## 2.4 ACCESSORIES

- A. Labels: Provide labels luminaires. Include the following information on each label:
  - 1. All luminaires shall be clearly marked for operation of specific lamps and ballasts and according to proper lamp type in accordance with UL 1570 or UL 1572 requirements, as applicable.
  - 2. For maintenance purposes, the following lamp characteristics should be noted, as applicable, in the format "Use Lamps Only":
    - a. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
    - b. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
    - c. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
    - d. ANSI ballast type (M98, M57, etc.) for HID luminaires.
    - e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.
  - 3. All markings related to lamp type shall be clear and located to be readily visible to service personnel, but invisible from normal viewing angles when lamps are in place.
  - 4. Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

## PART 3 EXECUTION

### 3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.
  - a. Electronic Dimming Ballast: Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.
  - b. Occupancy Sensor: Test sensors for proper operation. Observe for light control over entire area being covered.
2. Coordinate with manufacturer for **maintenance agreement**.

**END OF SECTION**



## SECTION 26 51 00 INTERIOR LIGHTING

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections apply to the work of this Section.
- B. Division 26 "Basic Materials and Methods" sections apply to the work in this Section.

#### 1.2 DESCRIPTION OF WORK

- A. Types of interior and exterior lighting fixtures in this Section include the following:
  - 1. High Intensity Discharge
    - a. Metal-Halide
    - b. High-Pressure-Sodium
  - 2. Fluorescent
  - 3. LED

#### 1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacturer of interior and exterior light fixtures of types and ratings required, whose products have been in satisfactory use in similar service for not less than three years.
- B. Installer: Qualified with at least three years of successful installation experience on projects with interior and exterior lighting fixture work similar to that required for this project.

#### 1.4 REFERENCES

- A. NEC Compliance: Comply with the NEC as applicable to the installation and construction of lighting fixtures.
- B. NEMA Compliance: Comply with applicable requirements of NEMA Standard Pub. Nos. LE-1 and LE-2 pertaining to lighting equipment.
- C. ANSI/UL Compliance: Comply with ANSI/UL Standards pertaining to interior and exterior lighting fixtures for hazardous locations.
- D. UL Compliance: Provide light fixtures that have been UL listed and labeled.
- E. CBM Labels: Provide fluorescent lamp ballasts that comply with Certified Ballast Manufacturers Association Standards and carry the CBM label.
- F. NECA Compliance: Comply with NECA's "Standard of Installation".

#### 1.5 SUBMITTALS

- A. Product Data: Submit manufacturer's product data on lighting fixtures.
- B. SHOP DRAWINGS
  - 1. Furnish shop drawing portfolios (collated bound sets) containing the following information:
    - a. Name of manufacturer
    - b. Descriptive cut sheets
    - c. Complete photometric information
    - d. Coefficient of utilization tables
    - e. Fixture voltage
    - f. The number, type and wattage of the fixture lamps
    - g. Lens types

- h. Fixture options
  - i. Fixture mounting details
  - j. Fixture door types
  - k. Construction of fixture housing and/or door
  - l. Fixture ballast manufacturer and type
2. All lighting fixtures required to be used on this project shall be submitted in one single submittal so that all fixtures can be reviewed at one time. Those fixtures not receiving a shop drawing action of "Reviewed" or "Reviewed and Noted" on the first submittal shall be resubmitted for review. A light fixture receiving a shop drawing action of "Resubmit" or "Rejected" after the third review for any reason, shall be furnished as originally specified.
3. The portfolios shall be made from standard manufacturer's specification sheets. Each fixture shall be identified by the letter or number indicated on the fixture schedule. The combining of more than one fixture type of fixture on a single sheet shall not be acceptable.

## 1.6 EXTRA MATERIALS

- A. At substantial completion of the project, furnish the following extra materials that match specified and installed products to the Owner for future use after completion of project warranty periods. Extra materials shall be delivered and stored at a location or locations directed by the Owner. Products shall be packaged with protective covering for storage and shall be suitably labeled by product type.
  1. Provide ten extra lamps for every 100 lamps (of each rating and type) installed on the project. Provide a minimum of at least one extra lamp for each lamp type and rating used.
  2. Provide one extra lens and one extra louver for every 100 units (of each type) installed on the project. Provide a minimum of at least one extra lens and one extra louver for each type used.
  3. Provide one extra ballast for every 100 units (of each type) installed on the project. Provide a minimum of at least one extra ballast for each type used.

## PART 2 PRODUCTS

### 2.1 MANUFACTURER

- A. Manufacturers of lighting fixtures are noted on the drawings by notes and/or by the light fixture schedule.

### 2.2 FLUORESCENT BALLASTS

- A. Multi-level switching scenarios are indicated on the lighting plans by circuiting where 2, 3, or 4 lamp fluorescent fixtures are shown within a room or area to be controlled by two switches (or two sets of 3-way switches), connect the outside lamps of each fixture to one switch and connect the inside lamp(s) of each fixture to the second switch. Provide quantity of ballasts necessary to achieve multi-level switching scenarios indicated on the plans..
- B. Ballasts for fluorescent lamps shall be of the high frequency electronic type, operating lamps at a frequency of 42 kHz or higher with no detectable flicker. Ballasts for fluorescent lamps shall be manufactured by Osram Sylvania, Advance, Universal Lighting Technologies or General Electric unless otherwise noted or specified herein. The warranty period for fluorescent ballasts shall be five years from the date of substantial completion of the project, including all parts and labor. Ballasts shall be specifically designed for the type and quantity of lamps indicated on the drawings, and shall be designed to provide full light output (except for emergency fluorescent power packs). All fluorescent ballasts shall be UL listed and CSA certified. Ballasts shall have an audible noise rating of Class 'A'.

- C. Ballasts for T2, T4, or T5 lamps shall contain dynamic end of lamp life sensing circuiting to protect against overheated bases and sockets.
- D. Universal input voltage (120-277 VAC) ballasts shall be provided for all T5 and T8 programmed rapid start and T4 compact fluorescent applications. All other ballasts shall have a nominal line voltage of 120 or 277 VAC as indicated on the drawings or as required for proper system operation.
- E. Ballasts shall have an input current total harmonic distortion content of less than 10 percent (based on the full light output current level). The lamp current crest factor for any ballast shall not exceed 1.7. Ballasts shall have a power factor of 98 percent or greater for primary lamp, and shall contain no PCB's.
- F. Ballasts shall have a minimum ballast factor for primary lamp application as follows: 0.75 for Low Watt, 0.85 for Normal Light Output, and 1.20 for High Light.
- G. Ballasts shall comply with all applicable State, Federal and industry performance and safety standards. Ballasts shall comply with FCC requirements governing electromagnetic and radio frequency interference. Ballasts shall comply with IEEE standards for line voltage transient protection, and shall meet or exceed ANSI and IEEE standards for harmonic distortion. Ballasts shall have internal electronic protection to prevent catastrophic failures.
- H. For T8 lamp applications, provide programmed rapid start ballasts equivalent to Advance Optanium to properly heat lamp filaments and minimize glow current during the starting process.
- I. For T5 and T5HO lamp applications, provide programmed rapid start ballasts equivalent to Advance Optanium
- J. For TT5 lamp applications, provide programmed rapid start ballasts equivalent to Osram Sylvania Quicktronic Prostart Professional Series.
- K. For T4 compact fluorescent lamp applications, provide programmed rapid start ballasts equivalent to Osram Sylvania Quicktronic CF – Universal Professional Series (universal voltage 120 – 277 VAC and multi lamp compatibility).
- L. Ballasts for Dimming: Provide a fluorescent dimming system consisting of electronic dimming ballasts (equivalent to Lutron Hi-Lume Series) and controls made by the same manufacturer. Ballasts and controls shall be produced by the same manufacturer who shall have a minimum of ten-(10) years experience with electronic dimming ballasts. Dimming shall be smooth and continuous without flicker down to one percent light output. Ballasts shall be capable of striking lamps at any light level without first flashing to full light. Different lamp lengths of the same type shall dim evenly when controlled by the same dimmer. One- and two-lamp ballasts shall dim evenly when controlled by the same dimmer. Ballasts shall be inaudible in a 27dB room ambient throughout the dimming range. Ballasts must comply with FCC Part 18 regulations and shall not interfere with other properly installed electrical equipment. Ballasts shall be UL listed, Class P and shall meet ANSI C62.41 (IEEE Publication 587, Category A) standards for surge protection.

### 2.3 HIGH INTENSITY DISCHARGE BALLASTS

- A. Ballasts for HID lamps shall be manufactured by Venture Lighting, Universal Lighting Technologies, Osram Sylvania or Advance.
- B. Provide multi-tap, single lamp, protected, high power factor CWA type ballasts for high intensity discharge lamps, unless indicated or specified otherwise. Ballasts shall be designed and constructed in accordance with all applicable ANSI specifications and requirements. Ballasts shall be designed with class “H” (180 degrees C) or higher insulation systems and shall be vacuum impregnated with a 100% solid based resin. Ballasts shall be designed to provide reliable lamp starting down to minus 40 degrees C for high-pressure sodium applications and minus 30 degrees C for standard metal halide applications. Ballasts shall be suitable for 150 degrees F interior applications. Ballasts shall be designed and constructed to operate for at least 180 cycles of 12 hours on and 12 hours off, with the lamp circuit in an open or shortcircuited condition and without undue

reduction in ballast life. Ballast capacitors shall be provided with a self-contained internal bleeder resistor. Oil-filled capacitors shall be housed in corrosion resistant steel cans and shall contain quick disconnect terminals. Ignitors shall be epoxy-filled with either a plastic or aluminum external housing. Ignitors shall be designed and constructed to provide six months of lamp open circuit operation without failure. Provide lamp and ballast combinations that are designed and constructed to ensure compatibility and proper system operation.

- C. All ballasts shall be guaranteed for a minimum of twelve months from date of acceptance and during this period, shall be replaced, upon failure, at no cost to the Owner.

## 2.4 LAMPS

- A. All fluorescent and H.I.D. lamps shall be manufactured by Osram/Sylvania, Philips, General Electric or Venture. Lamps of other manufacturers may be installed only after written approval is obtained from the Engineer. Failure to obtain written approval will result in the rejection of all installed lamps, and will require the installation of the lamps specified herein, at no expense to the Owner.
- B. Provide T8 fluorescent lamps that have full rated life when operating on Instant Start, Rapid Start or Programmed Rapid Start electronic ballasts. Provide lamps with a minimum average rated life of 20,000 hours, a minimum color rendering index of 85, minimum initial lumen output of 2950 (for F32T8 lamps) and a correlated color temperature of 3,500 degrees Kelvin, or as noted on the drawings. Provide low mercury type lamps that are designed and manufactured to pass the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste.
- C. Provide T5 and T5HO fluorescent lamps with a minimum average rated life of 20,000 hours, a minimum color rendering index of 82, minimum initial lumen output of 2,900 (for F28T5 lamps), minimum initial lumen output of 5,000 (for F54T5HO lamps), and a correlated color temperature of 3,500 degrees Kelvin, or as noted on the drawings.
- D. Provide 4-pin, T4, triple tube compact fluorescent lamps with a minimum efficacy of 75 lumens per watt, a minimum average rated life of 10,000 hours, a minimum color rendering index of 82, and a correlated color temperature of 3,500 degrees Kelvin, or as noted on the drawings. Provide low mercury type lamps that are designed and manufactured to pass the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste.
- E. Provide 4-pin, T4, quad tube compact fluorescent lamps with a minimum average rated life of 10,000 hours, a minimum color rendering index of 82, and a correlated color temperature of 3,500 degrees Kelvin, or as noted on the drawings. Provide low mercury type lamps that are designed and manufactured to pass the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste.
- F. Provide 4-pin, TT5, long compact fluorescent lamps that have full rated life when operating on Instant Start or Rapid Start electronic ballasts. Provide lamps with a minimum average rated life of 20,000 hours, a minimum color rendering index of 82, minimum initial lumen output of 3150 (for FT40 lamps) and a correlated color temperature of 3,500 degrees Kelvin, or as noted on the drawings.
- G. Provide ceramic, metal halide PAR lamps with a minimum average rated life of 9,000 hours, plus or minus 200 degrees Kelvin (maximum) color stability over the lifetime of the lamp, a minimum color rendering index of 81 (for 3000 degree Kelvin lamps), a minimum color rendering index of 92 (for 4,000 degree Kelvin lamps), and suitable for use in open or enclosed fixtures. Provide low mercury type lamps that are designed and manufactured to pass the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste.
- H. Provide ED-17, universal operating position, ceramic metal halide lamps with a minimum average rated life of 9,000 hours, plus or minus 200 degrees Kelvin (maximum) color stability over the lifetime of the lamp, a minimum color rendering index of 82 (for 3000 degree Kelvin lamps), a minimum color rendering index of

90 (for 4,000 degree Kelvin lamps), and suitable for use in open or enclosed fixtures. Provide low mercury type lamps that are designed and manufactured to pass the Federal Toxic Characteristic Leaching Procedure (TCLP) criteria for classification as non-hazardous waste.

1. All lamps shall be new and shall be delivered to the project in manufacturer's original sealed package. At the time of acceptance of this project by the Owner, all lamps shall be in working order, and all fixtures shall be fully lamped.
2. Fluorescent and H.I.D. lamps shall be guaranteed for a minimum of twelve months from the date of project substantial completion and during this period shall be replaced, upon failure, at no cost to the Owner.

## 2.5 FLUORESCENT FIXTURE LENSES

- A. Plastics: Where the fixtures specified require the use of acrylic plastic lenses, materials of the highest quality conforming to the following requirements must be supplied.
  1. Use 100 percent virgin acrylic thermoplastic.
  2. All raw material used shall meet ASTM D 788, Grade 8, and shall exceed IES-SPI-NEMA specifications by at least 100 percent.
  3. Lens thickness shall not be less than 0.125 inches over all. Penetrations shall not exceed 0.08 inches.

## 2.6 PLASTER FRAMES

- A. Standard plaster frames shall be provided for all recessed lighting fixtures installed in plaster or drywall finished walls or ceilings. Coordinate with architectural drawings.

## 2.7 THERMAL PROTECTION

- A. All recessed incandescent and H.I.D. light fixtures shall be provided with thermal protection per N.E.C requirements.

# PART 3 EXECUTION

## 3.1 INSTALLATION

- A. Install lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer's written instructions, applicable requirements of the NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.
- B. Coordinate with other electrical work as appropriate to properly interface installation of lighting fixtures with other work.
- C. Adjust and Clean: Clean lighting fixtures of dirt and debris upon completion of the installation. Protect installed fixtures from damage during the remainder of the construction period.
- D. Field Quality Control: Upon completion of the installation of lighting fixtures, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.
- E. Undercabinet and undercounter light fixtures shall be installed with 3/8" deep x 2" x 4" wood spacers painted black to provide an air space between the fixture and the top of the millwork.
- F. The lighting design for this project has included multi-level lighting in some rooms. Where 3 lamps fixtures are shown in a room, the outer 2 lamps will be switched from one switch and the center lamp will be switched from the other switch. Where 4 lamp fixtures are shown in a room, the outer 2 lamps will be switched from one switch and the center 2 lamps will be switched from the other switch. A similar multi-level lighting



arrangement will be provided where 4-3 way switches are shown. Two ballasts must be used when dual level switching is shown.

- G. Surface Mounted Fluorescent Fixtures: Where fixtures are indicated for installation on low density cellulose fiberboard (see room finish schedule on drawings), provide 1-1/2 inch ceiling spacers, unless UL approved for mounting directly to the ceiling material.
- H. Lighting fixture supports: Properly support and install fixtures in strict accordance with all applicable building codes and standards. Fully and completely coordinate the installation of fixtures with actual ceiling systems, and with all building trades. In general, provide fixture supports according to the following (unless applicable codes require more restrictive support details):
  - 1. All lighting fixtures installed in grid type suspended ceiling systems, shall be positively attached to the ceiling system with clips that are UL listed for the application. In addition, a minimum of four (4) ceiling support system rods or wires shall be provided for each light fixture and shall be installed not more than six (6) inches from fixture corners. Provide two (2) No. 12 gage hangers from each fixture housing to the building structure above (wires may be installed slack). Light fixtures that weigh more than 56 pounds shall be supported directly from the structure above by UL listed and approved hangers. Light fixtures that are smaller than the ceiling grid shall be installed at locations indicated on the reflected ceiling plans, or shall be installed in the center of the ceiling panel and shall be supported independently by at least two metal channels that span and are secured to the ceiling system.
  - 2. Suspended lighting fixtures shall be supported directly from the building structure without using suspended ceilings as support systems. Support systems shall be UL listed and approved for the specific installation. Where pendants or rods exceed 48 inches in length, brace support systems to limit swinging.
- I. Square and rectangular fixtures shall be mounted with sides parallel to building and ceiling lines, unless otherwise noted.
- J. Where special fixtures to be used in special ceilings are scheduled, verify all ceiling system details and coordinate fixture type and accessories prior to ordering fixtures. Coordinate and cooperate with ceiling system supplier in the preparation of ceiling system shop drawings.
- K. Install fluorescent fixtures as recommended by the manufacturer, or as necessary to provide exact horizontal alignment, preventing horizontal or vertical deflection, or angular jointing of fixtures suspended in continuous rows.
  - 1. Provide concrete bases for pole mounted fixtures as detailed on the drawings and as specified herein.
  - 2. Concrete shall be 3000 psi, minimum.
  - 3. Provide anchor bolts of the size and orientation recommended by the manufacturer. The recommendations of the manufacturer shall govern the installation of all anchor bolts irrespective of any conflicting information.
- L. Where conductors are strung within poles, take all steps necessary to insure that the conductor insulation will not wear by virtue of pole movement caused by wind or similar action. Consult the pole manufacturer for recommendations.
- M. Grounding of Pole Mounted Fixtures: Connect the green ground wire specified in Section 260526, "Grounding System", to the pole ground and luminaire ground.

## END OF SECTION

# **DIVISION 33**

## **UTILITIES**

## Section 33 16 20 RAINWATER HARVESTING

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes engineering, fabricating, furnishing, and installing:
  - 1. Rainwater Harvesting System.
    - a. Roof collection system.
- B. Related Sections:
  - 1. Divisions 31 – 33 (2) – landscaping and irrigation sections.
  - 2. Division 07 (7) – roofing section(s).
  - 3. Division 22 (15) – plumbing.

#### 1.2 DEFINITIONS

- A. Rainwater Harvesting System: An assembly that collects, stores, and distributes rain water for use in situ; including water treatment as appropriate to intended use.

#### 1.3 SUBMITTALS

- A. Product Data: Submit product data on all components of the rainwater harvesting system. Unless otherwise indicated, include the following for each type of product provided under work of this Section:
  - 1. Manufacturer's brochure indicating equipment model(s).
  - 2. Recycled Content:
    - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
    - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
    - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
    - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
  - 3. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
- B. Shop Drawings: **For roof collection system** include plans, sections, details, and attachments to other work, for the following:
  - 1. Pumps.
  - 2. Storage.
  - 3. Connection to roofing system.



4. Connection to irrigation system.
5. Connection to plumbing system.
- C. Calculations: **For roof collection system** submit the following:
  1. Maximum water capacity.
  2. Collection data: Include the following:
    - a. average rainfall rate (inches annually)
    - b. total collection area (s.f.)
    - c. potential collection (s.f.= gallons)
    - d. peak gallons @ 5"/hour
    - e. peak gallons @ 5 min. duration
    - f. available gallons
  3. Water Demand: Include the following:
    - a. Landscaping:
      - i. total estimated planted area (acres)
      - ii. application rate / week (high) gallons
      - iii. application rate /week (low) gallons
      - iv. gallons required
    - b. Fixture Demand:
      - i. Fixtures by type, water use per person/day
      - ii. Gallons potable water required
      - iii. Gallons non-potable water required
- D. Designer/Installer Qualifications.
- E. Regulatory Requirements Documentation:
- F. Operation and Maintenance Manuals Submittals: Provide the following:
  1. Operation and maintenance procedures, including variations of procedures appropriate for normal climatic conditions anticipated throughout an annual cycle of operations.
  2. Water testing laboratory contact information.
  3. Water testing requirements, schedule, kits, and equipment.
- G. Reports for Field Quality Control: Submit test reports and inspection reports to **[Owner]**
  1. System Inspections.
  2. Water Quality Tests.
- H. Closeout Submittals:
  1. Warranty.

#### 1.4 QUALITY ASSURANCE

- A. Designer/Installer Qualifications: For work of this Section, engage an experienced rainwater consultant who has specialized in systems similar to those required for this Project and with a record of successful in-service performance. Consultant shall:
  1. be a member in good standing of The American Rainwater Catchment Systems Association.
  2. have a minimum **1** years experience designing and constructing rainwater catchment systems similar to requirements for this Project.
  3. for potable systems, **[comply with agencies having jurisdiction]**
- B. Single-Source Responsibility: To the greatest extent possible, obtain the system components from one source and from a single manufacturer.

- C. Pre-Construction Meeting: After award of Contract and prior to the commencement of the Work of this Section, schedule and conduct meeting to discuss the Work of this Section and to coordinate with related Work. Convene pre-construction meeting to comply with requirements of Division 01 (1) and as follows:
1. Notify all attendees at least two weeks prior to the conference.
  2. Require attendance of parties directly affecting Work of this Section, including, but not limited to:
    - a. Owner,
    - b. Contractor,
    - c. Architect,
    - d. Civil Engineer
    - e. System Designer/Installer,
    - f. Landscape Architect and Irrigation Installer,
    - g. Roofing Membrane Provider/Installer,
    - h. Owner's insurer, and if applicable; testing and inspecting agency representative.
  3. Review methods and procedures related to installation and operation of Work of this Section, including coordination with related Work.
  4. Document proceedings, including corrective measures or actions required, and furnish copy of record to each participant.

## 1.5 SEQUENCING AND SCHEDULING

- A. Coordinate the Work with installation of associated roofing, waterproofing, flashings, and roof accessories specified under other sections as the Work of this Section proceeds.
- B. Coordinate the Work with installation of associated irrigation and plumbing systems specified under other sections as the Work of this Section proceeds.

## 1.6 WARRANTY

- A. Warranty: Warrant the system against defects including equipment failure and leakage, except for defects resulting from lack of adequate maintenance, neglect, or abuse by Owner, abnormal weather conditions unusual for warranty period.
1. Warranty Period: One year after date of Substantial Completion,

## PART 2 PRODUCTS

### 2.1 SYSTEM COMPONENTS

- A. Catchment Area:
1. Roofing as indicated.
- B. Conveyance:
1. Pump(s), sized as appropriate to water demands of facility.
    - a. Roof collection system: Gravity Fed
  2. Piping. Overflow pipe shall empty into a non-flooding area. Include separate inlet for intermittent treatment as is deemed necessary on basis of regular inspection/testing.
- C. Storage:
1. Tank(s), sized as appropriate to water demands of facility. Above ground design. System design shall indicate load requirements for tank foundation. Tanks shall be accessible for routine maintenance.
    - a. Potable systems: **[Tank shall be state-approved as a vessel for potable water storage.]**
    - b. Biobased content:

2. Water Tank Coatings: Coatings formulated for use in potable water storage systems. Provide minimum 59% biobased content.
  3. Cisterns. Below ground design; accessible for cleaning and maintenance. Provide screens for all openings.
  4. Ponds. Provide soil liner or synthetic liner.
    - a. Where on-site soils or clay provide an adequate seal, compaction of these materials may be sufficient to line the pond.
      - i. On-site soils may be used if they can be compacted to permeability of  $<108$  ft/sec ( $<10^{-6}$  cm/sec).
    - b. Synthetic liners: Asphalt liners are not permitted. Synthetic liners may be fabricated from synthetic butyl rubber or 0.5 to 10.0 mil high density polyethylene.
      - i. If the site soils contain angular stones, place sand bedding or geotextile cushions under the liner to prevent punctures.
      - ii. Cover the liner with 3 - 4 inches of soil to prevent the roots of the vegetation from penetrating the liner.
- D. Water Treatment:
1. Filtration. Include automatic catchment tank/pump system to prefilter water prior to entry to storage tank. Carbon is not permitted.
  2. Disinfection: Provide disinfection acceptable to agencies having jurisdiction. Provide disinfection necessary to attain [**Advanced Secondary Wastewater**] quality.
    - a. [**a. Chlorine: Where acceptable to agencies having jurisdiction, prohibit use of chlorine treatment. Verify acceptability of iodine.**]
    - b. [**b. Potable system shall include automatic ozonation treatment.**]
- E. Accessories:
1. Joint Sealants: Non-toxic and as specified in Division 07 (7).
  2. Fasteners: non-corrosive and compatible with materials being fastened.
- F. Lead components are not permitted.

## 2.2 FABRICATION

- A. Design prefabricated components and necessary field connections required for installation to permit easy assembly, repair and maintenance, and disassembly.
- B. Design and construct to comply with applicable regulatory requirements.
  1. Potable system(s): Provide piping and accessories necessary to operate as a potable water system capable of utilizing municipal water as a supplementary source.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions under which system will be installed, with Designer/Installer present, for compliance with requirements.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install in accordance with manufacturer's written instructions, approved shop drawings, and applicable regulatory requirements.

### 3.3 FIELD QUALITY CONTROL

- A. General: Comply with requirements of agencies having jurisdiction and as specified herein.
- B. System Inspection: System Designer/Installer shall inspect system installation and submit reports to Architect. Notify **Owner** 48 hours in advance of the date and time of inspection.
  - 1. Provide site inspection of system **two weeks prior to Occupancy**.
  - 2. Provide site inspection of system immediately after storm event that may be severe enough to affect the system; provide inspection services for minimum **12** months after Final Completion.
  - 3. Provide site inspection of system seasonally, and not less than once every three months; provide inspection services for minimum **12** months after Final Completion.
- C. Water Quality tests: Comply with requirements of agencies having jurisdiction and as specified herein. Comply with ASTM D4840 for chain of custody of water samples. **[Provide on-line monitoring consistent with ASTM D3864.]**
  - 1. Provide data on the following immediately after plants are established and **monthly** thereafter for minimum **6** months:
    - a. Biochemical oxygen demand (BOD<sub>5</sub>).
    - b. Total Suspended Solids (TSS).
    - c. Fecal coliform.
  - 2. Establish baseline water quality for rainwater harvesting systems for both influent and effluent.
  - 3. Provide comparison of test results with municipal water quality, and maintenance of system.
  - 4. Water testing shall be performed by a laboratory in compliance with agencies having jurisdiction.

**END OF SECTION**

# **DIVISION 44**

## **POLLUTION CONTROL EQUIPMENT**

## SECTION 44 40 10 WATER REUSE SYSTEMS

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This Section includes water reuse systems for:
  - 1. municipal-supplied reclaimed water
  - 2. in situ water reclamation
    - a. rain water
    - b. gray water
    - c. black water
- B. Related Sections:
  - 1. 01 41 00 (01411) Regulatory Requirements
  - 2. 33 16 20 (11201) Rainwater Harvesting

#### 1.2 DEFINITIONS

- A. Definitions pertaining to sustainable development: As defined in ASTM E2114 and as specified herein.
- B. Definitions pertaining to water reuse: As defined in ASTM E2635 and as specified herein.
- C. Black water: untreated wastewater from urinals and water closets.
- D. Gray water: untreated wastewater from bathtubs, showers, bathroom wash basins, clothes washing machines, and laundry tubs. It may also include condensation pan water from refrigeration equipment and air-conditioners, hot tub drain water, pond and fountain drain water, and cistern drain water.
- E. Reclaimed water: Water that is used more than one time before it passes back into the natural water cycle. Reclaimed water is considered nonpotable but may be highly treated and used for approved purposes other than drinking water.
- F. Recycled water: See reclaimed water.
- G. Water reuse: cycling water one or more times for beneficial use as reclaimed water.

#### 1.3 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
  - 1. Water efficiency:
    - a. Indicate water reuse rates in gallons per day (gpd) per unit for the following:
  - 2. municipal-supplied reclaimed water
  - 3. in situ water reclamation
    - a. Water Budget: Submit water budget statement. Indicate how approved water budget increases water efficiency over baseline; and, indicate how water reuse system(s) complies with approved water budget.
      - i. Baseline: Calculate baseline water budget using occupancy rate and **[EPAct 1992 standards for water fixtures]**.
- B. Designer/Installer Qualifications.

#### 1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Conform to **[the International Plumbing Code and]** applicable codes, rules, and regulations.

- B. Designer/Installer Qualifications: For work of this Section, engage an experienced licensed plumbing contractor who has specialized in systems similar to those required for this Project and with a record of successful in-service performance. Contractor shall:
  - 1. have a minimum **1** years experience designing, constructing, and installing water reuse systems similar to requirements for this Project.
- C. Pre-Installation Meetings:
  - 1. Convene a pre-installation meeting minimum one week prior to commencing work of this Section.
  - 2. Require attendance of parties directly affecting Work of this Section.
    - a. Coordinate with installation of plumbing fixtures, equipment, and piping.
    - b. Coordinate with rainwater harvesting system.
    - c. Coordinate with municipal supplier.
  - 3. Review conditions of operations, procedures and coordination with related Work.
  - 4. Agenda:
    - a. Tour, inspect, and discuss conditions of work.
    - b. Review installation schedule.
    - c. Review required permits and inspections.
    - d. Review monitoring and maintenance.
    - e. Review environmental procedures.
- D. Operation and Maintenance Manuals Submittals:
  - 1. Instructions indicating procedures for routine operation and maintenance of the water reuse system(s) as appropriate to:
    - a. municipal-supplied reclaimed water
    - b. in situ water reclamation utilizing:
      - 2. rain water
      - 3. gray water
      - 4. black water
  - 5. Instructions indicating procedures for normal and peak loading conditions, and periods of shutdown.
    - a. Peak loading conditions shall include peak hydraulic loading and pollutant loading conditions.
    - b. Periods of shutdown shall include: power failures, equipment failure, and normal maintenance shutdowns.
  - 6. Instructions indicating procedures for emergency response in the event of a failure of the system.

#### 1.4 MONITORING AND MAINTENANCE

- A. Provide regular maintenance for minimum one year from date of.
  - 1. Monitor system **monthly** to assess performance.
    - a. Verify components are adjusted and functioning properly.
    - b. Verify water quality is satisfactory for intended use. If in situ water reuse systems are used, monitor and test water quality in accordance with ASTM E2635.
    - c. Verify water reuse rate is consistent with water budget.
  - 2. Make minor adjustments, if any, as necessary.
  - 3. Document system performance including:
    - a. Rate and amount of water reuse.
    - b. Quality of reclaimed water. If in situ water reuse systems are used, document quality of reclaim water before and after treatment.
    - c. Adjustments, if any, to system.



4. Provide recommendations for improvements to the system.

## **PART 2 PRODUCTS**

### **2.1 WATER REUSE SYSTEM**

#### **A. General:**

1. Provide system design with easy access for effective monitoring program and for effective maintenance and process control program.
2. Provide dual distribution systems to prevent cross-connections of reclaimed water and potable water lines and the misuse of reclaimed water.
  - a. Marking: Clearly mark distribution piping and use lavender (light purple) pipes to distinguish it from potable water. Provide piping certified and labeled “NSF-rw” in accordance with NSF Pipe Certification for Reclaimed Water End Use protocols.
3. Provide backflow prevention devices on reclaimed water lines to preclude the likelihood of incidental human misuse.

#### **B. Municipal-supplied reclaimed water:**

1. Provide system design so that the pressure of reclaimed water 10 psi lower than potable water mains to prevent backflow and siphonage in case of accidental cross-connection.
2. Run reclaimed water mains at least 12 inches lower in elevation than potable water mains and horizontally at least five feet away.
3. Review the quality of reclaimed water to ensure there will be no harmful effects, such as salt buildup, to piping or equipment from long-term use. Adjust design as necessary.

#### **C. In situ water reclamation: Comply with requirements of ASTM E2635 and as follows:**

1. Water reclamation system shall be designed and implemented to provide for reliability and redundancy. System design shall take into account operations and treatment during normal and peak loading conditions, and periods of shutdown.
2. Source water: Water captured from one or more of the following:
  - a. rain water, including snowmelt and stormwater runoff.
  - b. gray water
  - c. black water

## **PART 3 EXECUTION**

### **3.1 FIELD QUALITY CONTROL**

- A. Water: Coordinate with work specified in Section 01 57 19.13 (01354) – Environmental Management to provide water monitoring for surface and groundwater.
- B. Field Inspection: Verify installation conforms with approved system design and applicable codes, rules, and regulations.
  1. Confirm the reclaim water is disinfected by an approved method that employs one or more disinfectants such as chlorine, iodine, or ozone.
  2. Confirm the distribution piping and reservoirs are identified as containing nonpotable water.

**END OF SECTION**



# **DIVISION 45**

## **INDUSTRY-SPECIFIC MANUFACTURING EQUIPMENT**

## SECTION 48 14 00 SOLAR ENERGY ELECTRICAL POWER GENERATION EQUIPMENT

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Solar Energy System(s).

#### 1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:
1. Local/Regional Materials:
    - a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
    - b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
    - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
    - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.
  2. Renewable Energy:
    - a. Submit manufacturer's product data for system.
    - b. Submit calculations indicating the energy produced by the system relative to the total energy demand for the building.
    - c. Submit Letter of Certification from system provider indicating that energy produced by the system represents minimum [1] [3] [5] [7] [9] [11] [13] [xxxx] of the total energy demand for the building.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

#### 1.3 QUALITY ASSURANCE

- A. Solar Energy Systems:
1. Photovoltaic Panels: Provide panels labeled with the PowerMark certification by PowerMark Corporation.
    - a. Weathering:
      - ASTM E1038-Standard Test Method for Determining Resistance of Photovoltaic Modules to Hail by Impact with Propelled Ice Balls
      - ASTM E1171- Standard Test Method for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
      - ASTM E1597- Standard Test Method for Saltwater Pressure Immersion and Temperature Testing of Photovoltaic Modules for Marine Environments
      - ASTM E1802-Standard Test Methods for Wet Insulation Integrity Testing of Photovoltaic Modules

- ASTM E2047- Standard Test Method for Wet Insulation Integrity Testing of Photovoltaic Arrays
- ASTM E1830- Standard Test Methods for Determining Mechanical Integrity of Photovoltaic Modules
- ASTM E781- Standard Practice for Evaluating Absorptive Solar Receiver Materials When Exposed to Conditions Simulating Stagnation in Solar Collectors With Cover Plates
- ASTM E782- Standard Practice for Exposure of Cover Materials for Solar Collectors to Natural Weathering Under Conditions Simulating Operational Mode
- ASTM E823- Standard Practice for Nonoperational Exposure and Inspection of a Solar Collector
- ASTM E881- Standard Practice for Exposure of Solar Collector Cover Materials to Natural Weathering Under Conditions Simulating Stagnation Mode
- b. Calibration:
  - ASTM E1362- Standard Test Method for Calibration of Non-Concentrator Photovoltaic Secondary Reference Cells
- c. Energy Performance:
  - ASTM E948- Standard Test Method for Electrical Performance of Photovoltaic Cells Using Reference Cells Under Simulated Sunlight
  - ASTM E1021- Standard Test Methods for Measuring Spectral Response of Photovoltaic Cells
  - ASTM E1040- Standard Specification for Physical Characteristics of Nonconcentrator Terrestrial Photovoltaic Reference Cells
  - ASTM E1462- Standard Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules
- 2. Solar Water Heating collectors: Submit OG 100 rating by Solar Rating and Certification Corporation for collector performance characteristics, and for rated systems submit OG 300 rating.

## **PART 2 PRODUCTS**

### **2.1 EQUIPMENT**

- A. Photovoltaic Module with Built-In Microinverter
  - 1. AC Unison PM250MA0
  - 2. Power Output = 225W
  - 3. Nominal Voltage = 240V
  - 4. Nominal Frequency = 60 Hz
  - 5. Nominal Output Current = 0.9375

## **PART 3 EXECUTION**

### **3.1 SITE ENVIRONMENTAL PROCEDURES**

- A. Resource Management:
  - 1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

2. Renewable Energy: Verify proper operation in all modes of system operation by testing. Verify proper operation under a wide range of conditions to verify energy delivery as calculated for those conditions.
  - a. Solar Energy Systems: Comply with ASTM E1799- Standard Practice for Visual Inspections of Photovoltaic Modules.

**END OF SECTION**

# **APPENDIX B**

# **STRUCTURAL CALCULATIONS**

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# 1. General

## 1.1 Architecture

### 1.1.1 Isometric View



Figure 1.1.1

### 1.1.2 Floor Plan

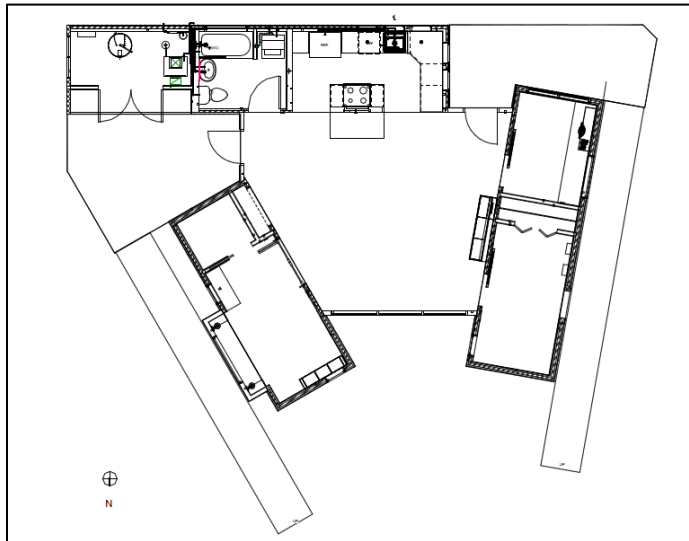


Figure 1.1.2

### 1.1.3 Roof Plan

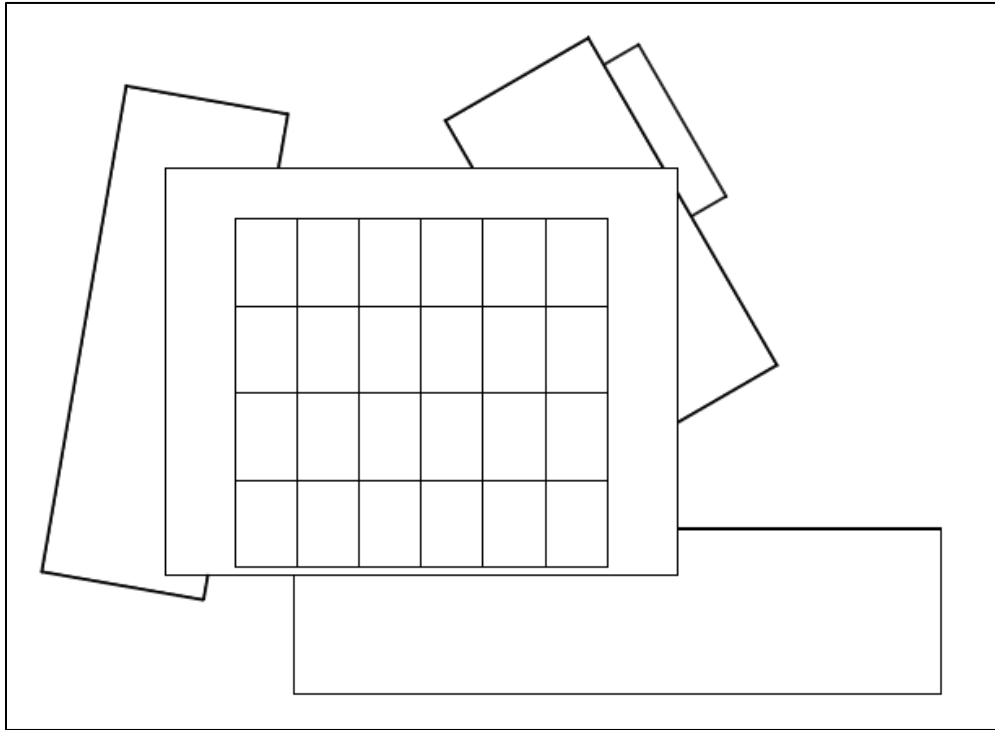


Figure 1.1.3

### 1.1.4 North Elevation

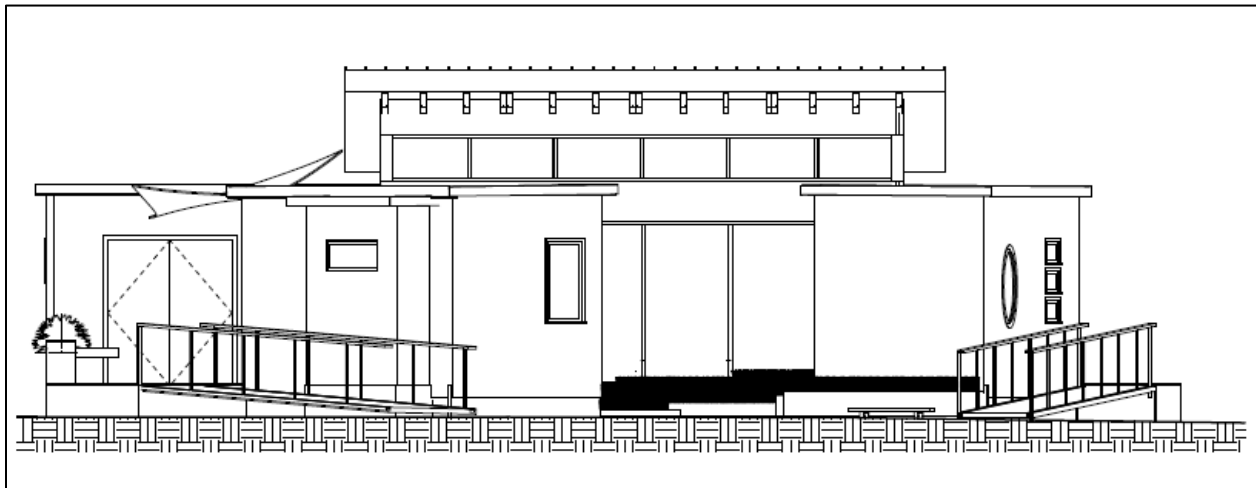


Figure 1.1.4



### 1.1.5 East Elevation

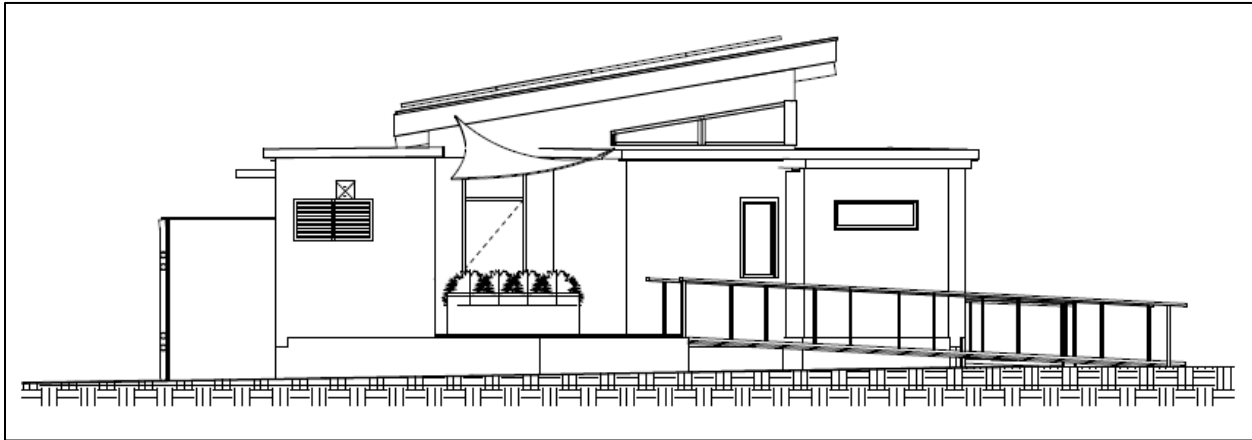


Figure 1.1.5

### 1.1.6 South Elevation

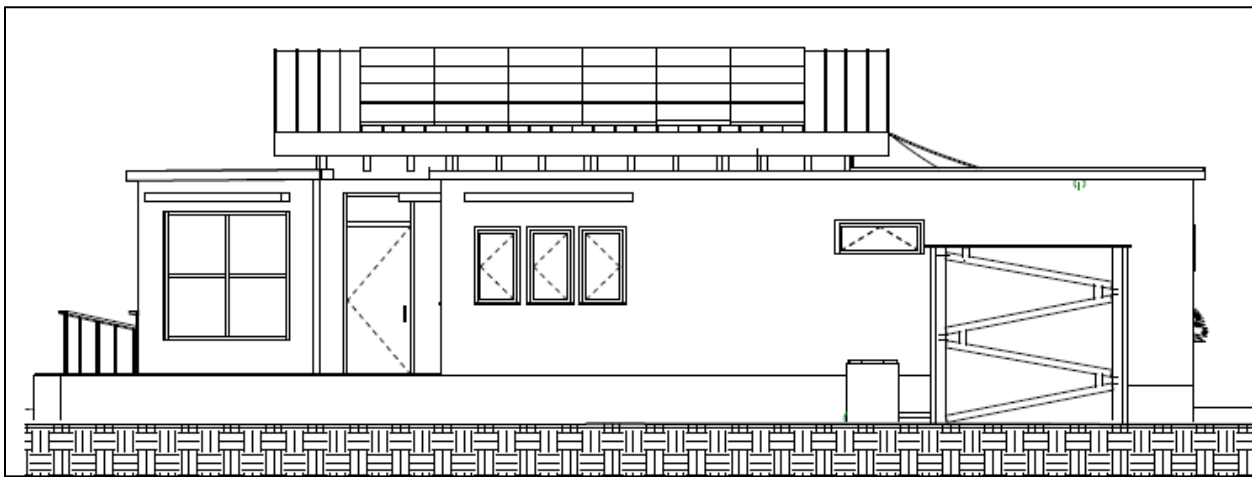


Figure 1.1.6

### 1.1.7 West Elevation

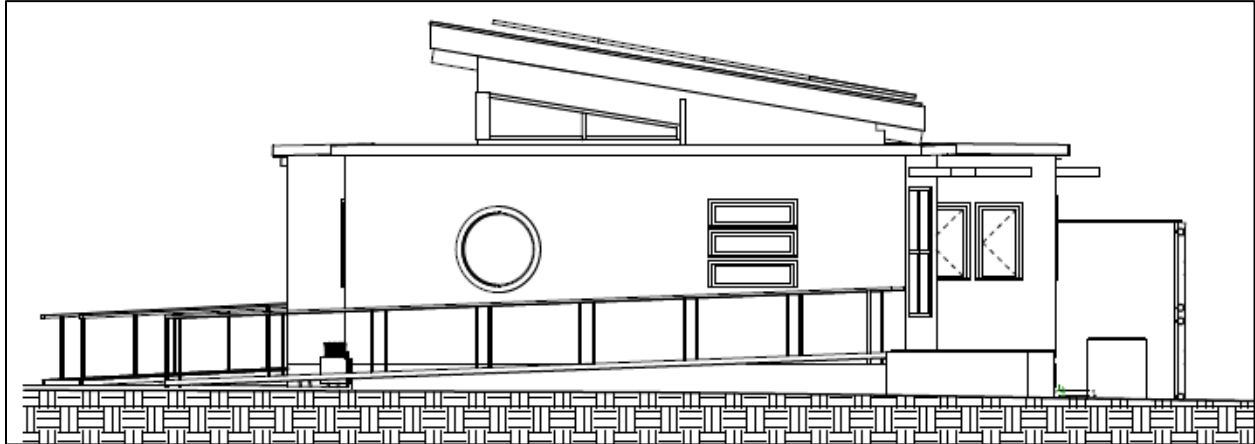


Figure 1.1.7

## 1.2 Loads

### 1.2.1 Item Loads

Table 1.2.1 is an itemized list of the expected weight and quantities of loads applied to the house.

Table 1.2.1

|       | Item                              | Quantity | Weight | Units | Load                                | Weight | Unit |
|-------|-----------------------------------|----------|--------|-------|-------------------------------------|--------|------|
| Roof  |                                   |          |        |       | Floor Live Loads                    | 50     | psf  |
|       | Standing Seam Metal Roof          |          | 3      | psf   | Tour Live Load                      | 50     | psf  |
|       | Panels                            | 24       | 39.68  | lbs   | Egress Components                   | 100    | psf  |
|       | Plywood Decking (1")              |          | 2.25   | psf   | Snow Roof Live Load                 | 20     | psf  |
|       | Drywall (5/8")                    |          | 2.5    | psf   | Roof Load                           | 20     | psf  |
| Walls | Casement Window (24"x42")         | 5        | 119    | lbs   | Wind Loads<br>85 mph 3 second gusts |        |      |
|       | Casement Windows (24"x48")        | 3        | 136    | lbs   |                                     |        |      |
|       | Awning Window (48"x18")           | 1        | 102    | lbs   |                                     |        |      |
|       | Awning Window (48"x14")           | 3        | 80     | lbs   |                                     |        |      |
|       | Picture Window (48" Diameter)     | 1        | 215    | lbs   |                                     |        |      |
|       | Picture Window (60"x18")          | 1        | 128    | lbs   |                                     |        |      |
|       | Single-Pocket Door (30"x84")      | 1        | 120    | lbs   |                                     |        |      |
|       | Sliding Barn Door (36"x84")       | 2        | 147    | lbs   |                                     |        |      |
|       | Single-flush Door (36"x84")       | 1        | 105    | lbs   |                                     |        |      |
|       | Bifold-4 Panel (48"x84")          | 1        | 140    | lbs   |                                     |        |      |
|       | Panel Folding Doors (60"x84")     | 1        | 175    | lbs   |                                     |        |      |
|       | Double-flush Door (72"x84")       | 1        | 210    | lbs   |                                     |        |      |
|       | Kitchen Cabinets                  |          | 40     | lbs   |                                     |        |      |
|       | Insulation Closed-cell (4")       |          | 0.5    | psf   |                                     |        |      |
|       | 3 1/2" Steel Stud Wall (16" O.C.) |          | 1.31   | psf   |                                     |        |      |
|       | 5 1/2" Steel Stud                 |          | 0.86   | plf   |                                     |        |      |
|       | Curtain Wall                      |          | 10.44  | psf   |                                     |        |      |
|       | Curtain Wall (72"x72")            |          | 375.93 | lbs   |                                     |        |      |
|       | Louver with trim (48"x24")        |          |        |       |                                     |        |      |
|       | Drywall (5/8")                    |          | 2.5    | psf   |                                     |        |      |
| Floor | Plywood Floor (1")                |          | 2.25   | psf   |                                     |        |      |
|       | Insulation Closed-cell (4")       |          | 0.5    | psf   |                                     |        |      |

\*Wind loads are based upon competition requirements specified in Appendix B.

## 1.2.2 Gravity Loads

### 1.2.2.1 Master Bedroom

Table 1.2.2.1 A

| DEAD LOADS: CRANE, TRUCK, AND COMPETITION |                 |               |                 |
|---|-----------------|---------------|-----------------|
| Master Bedroom Roof                       | Area            | 189.6         | ft <sup>2</sup> |
|   | Length          | 21.02         | ft              |
|   | Width           | 9.02          | ft              |
| <b>Item</b>                               | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| Roofing Material                          |                 | 3             | psf             |
| Plywood (1")                              |                 | 2.25          | psf             |
| 2x4 stud frame (24" O.C.)                 |                 | 1.65          | psf             |
| Shipping Container                        |                 | 5.16          | psf             |
| Master Bedroom North Wall                 | Area            | 79            | ft <sup>2</sup> |
|   | Length          | 8.17          | ft              |
|   | Height          | 9.67          | ft              |
| <b>Item</b>                               | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| Plywood (1")                              |                 | 2.25          | psf             |
| Exterior 2x2 Furring strips (12" O.C.)    |                 | 0.5           | psf             |
| Interior 2x2 Furring strips (12" O.C.)    |                 | 0.5           | psf             |
| Casement Window (24" x 48")               | 1               | 136           | lbs             |
| (2"x4") Wood Siding                       |                 | 3.5           | psf             |
| 1/2" gypsum board                         |                 | 4             | psf             |
| Shipping Container                        |                 | 5.16          | psf             |
| Master Bedroom South Wall                 | Area            | 79            | ft <sup>2</sup> |
|   | Length          | 8.17          | ft              |
|   | Height          | 9.67          | ft              |
| <b>Item</b>                               | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| Plywood (1")                              |                 | 2.25          | psf             |
| 1/2" gypsum board                         |                 | 4             | psf             |
| Interior 2x2 Furring strips (12" O.C.)    |                 | 0.5           | psf             |
| Shipping Container                        |                 | 5.16          | psf             |
| Master Bedroom East Wall                  | Area            | 116.04        | ft <sup>2</sup> |

|                      |           |
|----------------------|-----------|
| <b>Total</b>         | 12.06 psf |
| <b>Safety Factor</b> | 1.2       |
| <b>Factored</b>      | 14.47 psf |

|                      |           |
|----------------------|-----------|
| <b>Total</b>         | 17.63 psf |
| <b>Safety Factor</b> | 1.2       |
| <b>Factored</b>      | 21.16 psf |
| <b>UF - Dist</b>     | 170.5 plf |
| <b>Distributed</b>   | 204.6 plf |

|                      |            |
|----------------------|------------|
| <b>Total</b>         | 11.91 psf  |
| <b>Safety Factor</b> | 1.2        |
| <b>Factored</b>      | 14.29 psf  |
| <b>UF - Dist</b>     | 113.15 plf |
| <b>Distributed</b>   | 135.77 plf |



|  | Length   | 12     | ft              |
|--|----------|--------|-----------------|
|  | Height   | 9.67   | ft              |
| Item                                   | Quantity | Weight | Units           |
| Plywood (1")                           |          | 2.25   | psf             |
| Exterior 2x2 Furring strips (12" O.C.) |          | 0.5    | psf             |
| Interior 2x2 Furring strips (12" O.C.) |          | 0.5    | psf             |
| Casement Window (24" x 48")            | 1        | 136    | lbs             |
| (2"x4") Wood Siding                    |          | 3.5    | psf             |
| 1/2" gypsum board                      |          | 4      | psf             |
| Shipping Container                     |          | 5.16   | psf             |
| Master Bedroom West Wall               | Area     | 195.04 | ft <sup>2</sup> |
|  | Length   | 20.17  | ft              |
|  | Height   | 9.67   | ft              |
| Item                                   | Quantity | Weight | Units           |
| Plywood (1")                           |          | 2.25   | psf             |
| Exterior 2x2 Furring strips (12" O.C.) |          | 0.5    | psf             |
| Interior 2x2 Furring strips (12" O.C.) |          | 0.5    | psf             |
| Door (60" x 84")                       | 1        | 140    | lbs             |
| (2"x4") Wood Siding                    |          | 3.5    | psf             |
| 1/2" gypsum board                      |          | 4      | psf             |
| Shipping Container                     |          | 5.16   | psf             |
| Master Bedroom Pop-out Wall            | Area     | 119.26 | ft <sup>2</sup> |
|  | Length   | 12.33  | ft              |
|  | Height   | 9.67   | ft              |
| Item                                   | Quantity | Weight | Units           |
| Plywood (1")                           |          | 2.25   | psf             |
| 3 1/2" Steel stud                      |          | 1.31   | psf             |
| (2"x4") Wood Siding                    |          | 3.5    | psf             |
| 1/2" gypsum board                      |          | 4      | psf             |
| Picture Window (60" x 18")             | 1        | 128    | lbs             |

|               |            |
|---------------|------------|
| Total         | 17.08 psf  |
| Safety Factor | 1.2        |
| Factored      | 20.5 psf   |
| UF - Dist     | 165.18 plf |
| Distributed   | 198.22 plf |

|               |            |
|---------------|------------|
| Total         | 16.64 psf  |
| Safety Factor | 1.2        |
| Factored      | 19.968 plf |
| UF - Dist     | 158.08 plf |
| Distributed   | 189.7 plf  |

|               |            |
|---------------|------------|
| Total         | 12.13 psf  |
| Safety Factor | 1.2        |
| Factored      | 14.56 psf  |
| UF - Dist     | 149.6 plf  |
| Distributed   | 179.52 plf |

Table 1.2.2.1 B

| LIVE LOAD: COMPETITION                     |        |                   |          |                         |              |                 |               |        |
|--|--------|-------------------|----------|-------------------------|--------------|-----------------|---------------|--------|
| Master Bedroom<br>(135.48ft <sup>2</sup> ) |        | Longest Dimension |          |                         |              |                 |               |        |
|  |        | Length            | 21.29 ft |                         |              |                 |               |        |
|  |        | Width             | 9.29 ft  |                         |              |                 |               |        |
|  |        |                   |          | Area (ft <sup>2</sup> ) | Weight (psf) | Peak Load (plf) | Factored Load |        |
| Load Type                                  | Weight | Units             |          | Northeast               | 135.48       | 20              | 127.27        | 203.63 |
| Snow                                       | 20     | psf               |          | Southeast               | 135.48       | 20              | 127.27        | 203.63 |
| Roof load                                  | 20     | psf               |          | Northeast Overhang      | 28.07        | 20              | 57.09         | 91.35  |

Table 1.2.2.1 C

| FLOOR LOADS        |                |        |       |        |      |     |
|--------------------|----------------|--------|-------|--------|------|-----|
| Dead Loads         |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Container Floor    |                | 5.16   | psf   | DL     | 7.91 | psf |
| Insulation         | 4              | 0.5    | psf   | Factor | 1.2  |     |
| Plywood Floor      | 1              | 2.25   | psf   | F DL   | 9.49 | psf |
| Live Loads         |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units | LL     | 50   | psf |
| Tour Live Load     |                | 0      | psf   | F DL   | 9.49 | psf |
| Typical Floor Load |                | 50     | psf   | F LL   | 80   | psf |

1.2.2.2 Bedroom / Office

Table 1.2.2.2 A

| DEAD LOADS: CRANE, TRUCK, AND COMPETITION |          |        |                 |
|---|----------|--------|-----------------|
| Bedroom/Office Roof                       | Area     | 243.72 | ft <sup>2</sup> |
|   | Length   | 27.02  | ft              |
|   | Width    | 9.02   | ft              |
| Item                                      | Quantity | Weight | Units           |
| Roofing Material                          |          | 3      | psf             |
| Plywood (1")                              |          | 2.25   | psf             |
| 2x4 stud frame (24" O.C.)                 |          | 1.65   | psf             |
| Shipping Container                        |          | 5.16   | psf             |
| Bedroom/Office North Wall                 | Area     | 79     | ft <sup>2</sup> |
|   | Length   | 8.17   | ft              |
|   | Height   | 9.67   | ft              |
| Item                                      | Quantity | Weight | Units           |
| Plywood (1")                              |          | 2.25   | psf             |
| Exterior 2x2 Furring strips (12" O.C.)    |          | 0.5    | psf             |
| Interior 2x2 Furring strips (12" O.C.)    |          | 0.5    | psf             |
| (2"x4") Wood Siding                       |          | 3.5    | psf             |
| 1/2" gypsum board                         |          | 4      | psf             |
| Shipping Container                        |          | 5.16   | psf             |
| Bedroom/Office South Wall                 | Area     | 79     | ft <sup>2</sup> |
|   | Length   | 8.17   | ft              |
|   | Height   | 9.67   | ft              |
| Item                                      | Quantity | Weight | Units           |
| Plywood (1")                              |          | 2.25   | psf             |
| 1/2" gypsum board                         |          | 4      | psf             |
| Interior 2x2 Furring strips (12" O.C.)    |          | 0.5    | psf             |
| Shipping Container                        |          | 5.16   | psf             |
| Curtain wall (72"x72")                    |          | 375.93 | lbs             |
| Bedroom/Office East Wall                  | Area     | 261.28 | ft <sup>2</sup> |
|   | Length   | 27.02  | ft              |
|   | Height   | 9.67   | ft              |
| Item                                      | Quantity | Weight | Units           |
|   |          |        |                 |
| Total                                     |          |        | 12.06 psf       |
| Safety Factor                             |          |        | 1.2             |
| Factored                                  |          |        | 14.47 psf       |
| Total                                     |          |        | 15.91 psf       |
| Safety Factor                             |          |        | 1.2             |
| Factored                                  |          |        | 19.09 psf       |
| UF - Dist                                 |          |        | 153.85 plf      |
| Distributed                               |          |        | 184.62 plf      |
| Total                                     |          |        | 16.67 psf       |
| Safety Factor                             |          |        | 1.2             |
| Factored                                  |          |        | 20 psf          |
| UF - Dist                                 |          |        | 161.19 plf      |
| Distributed                               |          |        | 193.42 plf      |
| Total                                     |          |        | 17.9 psf        |

|  |                 |               |                 |                      |            |
|--|-----------------|---------------|-----------------|----------------------|------------|
| Plywood (1")                           |                 | 2.25          | psf             | Safety Factor        | 1.2        |
| Exterior 2x2 Furring strips (12" O.C.) |                 | 0.5           | psf             | Factored             | 21.48 psf  |
| Interior 2x2 Furring strips (12" O.C.) |                 | 0.5           | psf             | UF - Dist            | 173.13 plf |
| Awning Window (48"x14")                | 3               | 102           | lbs             | Distributed          | 207.76 plf |
| Casement Round Window (48" D)          | 1               | 215           | lbs             |                      |            |
| (2"x4") Wood Siding                    |                 | 3.5           | psf             |                      |            |
| 1/2" gypsum board                      |                 | 4             | psf             |                      |            |
| Shipping Container                     |                 | 5.16          | psf             |                      |            |
| <b>Bedroom/Office West Wall</b>        | <b>Area</b>     | 195.04        | ft <sup>2</sup> | <b>Total</b>         | 18.11 psf  |
|  | <b>Length</b>   | 27.02         | ft              | <b>Safety Factor</b> | 1.2        |
|  | <b>Height</b>   | 9.67          | ft              | <b>Factored</b>      | 21.74 psf  |
| <b>Item</b>                            | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    | <b>UF - Dist</b>     | 175.17 plf |
| Plywood (1")                           |                 | 2.25          | psf             | <b>Distributed</b>   | 210.2 plf  |
| Exterior 2x2 Furring strips (12" O.C.) |                 | 0.5           | psf             |                      |            |
| Interior 2x2 Furring strips (12" O.C.) |                 | 0.5           | psf             |                      |            |
| Casement Window (24"x48")              | 1               | 136           | lbs             |                      |            |
| Sliding Barn Door (36"x84")            | 2               | 147           | lbs             |                      |            |
| (2"x4") Wood Siding                    |                 | 3.5           | psf             |                      |            |
| 1/2" gypsum board                      |                 | 4             | psf             |                      |            |
| Shipping Container                     |                 | 5.16          | psf             |                      |            |

Table 1.2.2.2 B

| LIVE LOAD: COMPETITION                      |               |                          |                  |                              |                     |                        |
|---|---------------|--------------------------|------------------|------------------------------|---------------------|------------------------|
| <b>Bedroom / Office (212ft<sup>2</sup>)</b> |               | <b>Longest Dimension</b> |                  |                              |                     |                        |
|   |               | <b>Length</b>            | 27.83 ft         |                              |                     |                        |
|   |               | <b>Width</b>             | 9.29 ft          |                              |                     |                        |
|   |               |                          |                  | <b>Area (ft<sup>2</sup>)</b> | <b>Weight (psf)</b> | <b>Peak Load (plf)</b> |
| <b>Load Type</b>                            | <b>Weight</b> | <b>Units</b>             | <b>Northeast</b> | 212                          | 20                  | 152.35                 |
| Snow  | 20            | psf                      | Southeast        | 212                          | 20                  | 152.35                 |
| Roof load                                   | 20            | psf                      |                  |                              |                     | 243.77                 |



Table 1.2.2.2 C

| FLOOR LOADS        |                |        |       |        |      |     |
|--------------------|----------------|--------|-------|--------|------|-----|
| <b>Dead Loads</b>  |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Container Floor    |                | 5.16   | psf   | DL     | 7.91 | psf |
| Insulation         | 4              | 0.5    | psf   | Factor | 1.2  |     |
| Plywood Floor      | 1              | 2.25   | psf   | F DL   | 9.49 | psf |
| <b>Live Loads</b>  |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Tour Live Load     |                | 0      | psf   | LL     | 50   | psf |
| Typical Floor Load |                | 50     | psf   | F DL   | 9.49 | psf |
|                    |                |        |       | F LL   | 80   | psf |

1.2.2.3 Living Room

Table 1.2.2.3 A

| DEAD LOADS: CRANE, TRUCK, AND COMPETITION |          |         |                 |               |        |     |
|---|----------|---------|-----------------|---------------|--------|-----|
| <b>Living Room Roof</b>                   |          |         |                 |               |        |     |
|   | Area     | 676.2   | ft <sup>2</sup> |               |        |     |
|   | Length   | 29      | ft              |               |        |     |
|   | Width    | 23      | ft              |               |        |     |
| Item                                      | Quantity | Weight  | Units           |               |        |     |
| Standing Seam metal Roof                  |          | 2       | psf             | Total         | 12.63  | psf |
| Plywood (1")                              |          | 2.25    | psf             | Safety Factor | 1.2    |     |
| 8" C-channel joist                        | 16       | 76.59   | lbs             | Factored      | 15.16  | psf |
| Solar Panel                               | 24       | 39.68   | lbs             |               |        |     |
| <b>Living Room Lower North Wall</b>       |          |         |                 |               |        |     |
|   | Area     | 130.63  | ft <sup>2</sup> |               |        |     |
|   | Length   | 14.25   | ft              |               |        |     |
|   | Height   | 9.167   | ft              |               |        |     |
| Item                                      | Quantity | Weight  | Units           |               |        |     |
| Insulation Closed-cell (4")               |          | 0.5     | psf             | Total         | 13.13  | psf |
| 5 1/2" Steel Stud                         |          | 83.25   | lbs             | Safety Factor | 1.2    |     |
| 1/2" gypsum board                         |          | 4       | psf             | Factored      | 15.75  | psf |
| Curtain Wall                              |          | 1043.46 | lbs             | UF - Dist     | 120.32 | plf |
|   |          |         |                 | Distributed   | 144.38 | plf |

|                              |                 |               |                 |
|------------------------------|-----------------|---------------|-----------------|
| Living room Upper North Wall | Area            | 73.96         | ft <sup>2</sup> |
|                              | Length          | 25.33         | ft              |
|                              | Height          | 2.92          | ft              |
| <b>Item</b>                  | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| 12" Steel Boxed Header Beam  |                 | 217.87        | lbs             |
| 1/2" gypsum board            |                 | 4             | psf             |
| 5 1/2" Steel Stud            |                 | 111.19        | lbs             |
| Insulation Closed-cell (4")  |                 | 0.5           | psf             |
| Curtain Wall                 |                 | 554.19        |                 |
| Living Room South Wall       | Area            | 58.02         | ft <sup>2</sup> |
|                              | Length          | 6             | ft              |
|                              | Height          | 9.167         | ft              |
| <b>Item</b>                  | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| 10" Steel Boxed Header Beam  |                 | 190.5         | lbs             |
| 1/2" gypsum board            |                 | 4             | psf             |
| 5 1/2" Steel Stud            |                 | 111.19        | lbs             |
| Insulation Closed-cell (4")  |                 | 0.5           | psf             |
| Single-flush Door            |                 | 105           | lbs             |
| Living Room East Wall        | Area            | 99.56         | ft <sup>2</sup> |
| <b>Item</b>                  | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| 1/2" gypsum board            |                 | 4             | psf             |
| 5 1/2" Steel Stud            |                 | 116.82        | lbs             |
| Insulation Closed-cell (4")  |                 | 0.5           | psf             |
| Curtain Wall                 |                 | 136.35        | lbs             |
| Single-flush Door            |                 | 105           | lbs             |
| Living Room West Wall        | Area            | 43.41         | ft <sup>2</sup> |
| <b>Item</b>                  | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| 5 1/2" Steel Stud            |                 | 72.24         | lbs             |
| 1/2" gypsum board            |                 | 4             | psf             |
| Insulation Closed-cell (4")  |                 | 0.5           | psf             |
| Curtain Wall                 |                 | 136.35        | lbs             |

|                    |                  |
|--------------------|------------------|
| Total              | 15.68 psf        |
| Safety Factor      | 1.2              |
| Factored           | 18.82 psf        |
| UF - Dist          | 45.8 plf         |
| <b>Distributed</b> | <b>54.85 plf</b> |

|                    |                   |
|--------------------|-------------------|
| Total              | 11.51 psf         |
| Safety Factor      | 1.2               |
| Factored           | 13.81 psf         |
| UF - Dist          | 113.15 plf        |
| <b>Distributed</b> | <b>135.77 plf</b> |

|                 |                 |
|-----------------|-----------------|
| Total           | 8.1 psf         |
| Safety Factor   | 1.2             |
| <b>Factored</b> | <b>9.72 psf</b> |

|                 |                  |
|-----------------|------------------|
| Total           | 9.31 psf         |
| Safety Factor   | 1.2              |
| <b>Factored</b> | <b>11.17 psf</b> |

Table 1.2.2.3 B

| LIVE LOAD: COMPETITION            |        |                   |       |                         |              |                 |               |
|-----------------------------------|--------|-------------------|-------|-------------------------|--------------|-----------------|---------------|
| Living Room (677ft <sup>2</sup> ) |        | Longest Dimension |       |                         |              |                 |               |
|                                   | Length | 29 ft             |       |                         |              |                 |               |
|                                   | Width  | 23 ft             |       |                         |              |                 |               |
| Load Type                         | Weight | Units             |       | Area (ft <sup>2</sup> ) | Weight (psf) | Peak Load (plf) | Factored Load |
| Snow                              | 20     | psf               | North | 677                     | 20           | 466.9           | 747.03        |
| Roof load                         | 20     | psf               | South | 677                     | 20           | 466.9           | 747.03        |

Table 1.2.2.3 C

| FLOOR LOADS        |                |        |       |        |      |     |
|--------------------|----------------|--------|-------|--------|------|-----|
| Dead Loads         |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Container Floor    |                | 5.16   | psf   | DL     | 7.91 | psf |
| Insulation         | 4              | 0.5    | psf   | Factor | 1.2  |     |
| Plywood Floor      | 1              | 2.25   | psf   | F DL   | 9.49 | psf |
|                    |                |        |       | LL     | 100  | psf |
| Live Loads         |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Tour Live Load     |                | 50     | psf   | F DL   | 9.49 | psf |
| Typical Floor Load |                | 50     | psf   | F LL   | 160  | psf |

1.2.2.4 Kitchen / Bathroom / Mechanical Room

Table 1.2.2.4 A

| DEAD LOADS: CRANE, TRUCK, AND COMPETITION     |                 |               |                 |
|---|-----------------|---------------|-----------------|
| <b>Kitchen/Bathroom/Mechanical Roof</b>       | Area            | 329.23        | ft <sup>2</sup> |
|   | Length          | 36.5          | ft              |
|   | Width           | 9.02          | ft              |
| <b>Item</b>                                   | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| Roofing Material                              |                 | 3             | psf             |
| Plywood (1")                                  |                 | 2.25          | psf             |
| 2x4 stud frame (24" O.C.)                     |                 | 1.65          | psf             |
| Shipping Container                            |                 | 5.16          | psf             |
| <b>Kitchen/Bathroom/Mechanical North Wall</b> | Area            | 101.54        | ft <sup>2</sup> |
|   | Length          | 10.5          | ft              |
|   | Height          | 9.67          | ft              |
| <b>Item</b>                                   | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| Plywood (1")                                  |                 | 2.25          | psf             |
| Interior 2x2 Furring strips (12" O.C.)        |                 | 0.5           | psf             |
| 1/2" gypsum board                             |                 | 4             | psf             |
| Single-flush Door (36"x84")                   |                 | 105           | lbs             |
| Shipping Container                            |                 | 5.16          | psf             |
| <b>Kitchen/Bathroom/Mechanical South Wall</b> | Area            | 343.29        | ft <sup>2</sup> |
|   | Length          | 35.5          | ft              |
|   | Height          | 9.67          | ft              |
| <b>Item</b>                                   | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>    |
| Plywood (1")                                  |                 | 2.25          | psf             |
| 1/2" gypsum board                             |                 | 4             | psf             |
| Interior 2x2 Furring strips (12" O.C.)        |                 | 0.5           | psf             |
| Shipping Container                            |                 | 5.16          | psf             |
| Exterior 2x2 Furring strips (12" O.C.)        |                 | 0.5           | psf             |
| Casement Window (24"x42")                     | 3               | 119           | lbs             |
| Awning Window (48"x18")                       | 1               | 102           | lbs             |
| (2"x4") Wood Siding                           |                 | 3.5           | psf             |
| <b>Kitchen/Bathroom/Mechanical West Wall</b>  | Area            | 79            | ft <sup>2</sup> |
|   | Length          | 8.17          | ft              |
|   | Height          | 9.67          | ft              |

|                      |           |
|----------------------|-----------|
| <b>Total</b>         | 12.06 psf |
| <b>Safety Factor</b> | 1.2       |
| <b>Factored</b>      | 14.47 psf |

|                      |            |
|----------------------|------------|
| <b>Total</b>         | 12.373 psf |
| <b>Safety Factor</b> | 1.2        |
| <b>Factored</b>      | 14.85 psf  |
| <b>UF - Dist</b>     | 119.65 plf |
| <b>Distributed</b>   | 143.58 plf |

|                      |            |
|----------------------|------------|
| <b>Total</b>         | 17.25 psf  |
| <b>Safety Factor</b> | 1.2        |
| <b>Factored</b>      | 20.7 psf   |
| <b>UF - Dist</b>     | 166.78 plf |
| <b>Distributed</b>   | 200.13 plf |

| Item   | Quantity        | Weight        | Units                 | Total                | 15.07 psf         |
|--|-----------------|---------------|-----------------------|----------------------|-------------------|
| Plywood (1")                                 |                 | 2.25          | psf                   | Safety Factor        | 1.2               |
| Exterior 2x2 Furring strips (12" O.C.)       |                 | 0.5           | psf                   | Factored             | 18.09 psf         |
| Interior 2x2 Furring strips (12" O.C.)       |                 | 0.5           | psf                   | UF - Dist            | 145.75 plf        |
| Casement Window (24"x42")                    | 2               | 119           | lbs                   | <b>Distributed</b>   | <b>174.9 plf</b>  |
| (2"x4") Wood Siding                          |                 | 3.5           | psf                   |                      |                   |
| 1/2" gypsum board                            |                 | 4             | psf                   |                      |                   |
| 3 1/2" Steel stud                            |                 | 1.31          | psf                   |                      |                   |
| <b>Kitchen/Bathroom/Mechanical East Wall</b> | <b>Area</b>     | <b>79</b>     | <b>ft<sup>2</sup></b> | <b>Total</b>         | <b>15.91 psf</b>  |
|  | <b>Length</b>   | <b>8.17</b>   | <b>ft</b>             | <b>Safety Factor</b> | <b>1.2</b>        |
|  | <b>Height</b>   | <b>9.67</b>   | <b>ft</b>             | <b>Factored</b>      | <b>19.09 psf</b>  |
| <b>Item</b>                                  | <b>Quantity</b> | <b>Weight</b> | <b>Units</b>          | <b>UF - Dist</b>     | <b>153.85 plf</b> |
| Plywood (1")                                 |                 | 2.25          | psf                   | <b>Distributed</b>   | <b>164.62 plf</b> |
| Interior 2x2 Furring strips (12" O.C.)       |                 | 0.5           | psf                   |                      |                   |
| 1/2" gypsum board                            |                 | 4             | psf                   |                      |                   |
| Shipping Container                           |                 | 5.16          | psf                   |                      |                   |
| (2"x4") Wood Siding                          |                 | 3.5           | psf                   |                      |                   |
| Exterior 2x2 Furring strips (12" O.C.)       |                 | 0.5           | psf                   |                      |                   |

Table 1.2.2.4 B

LIVE LOAD: COMPETITION

| Kitchen / Bathroom / Mechanical Room (329ft <sup>2</sup> ) |        | Longest Dimension |          |                         |              |                 |               |
|--|--------|-------------------|----------|-------------------------|--------------|-----------------|---------------|
|  |        | Length            | 36.67 ft |                         |              |                 |               |
|  |        | Width             | 9.29 ft  |                         |              |                 |               |
| Load Type  | Weight | Units             |          | Area (ft <sup>2</sup> ) | Weight (psf) | Peak Load (plf) | Factored Load |
| Snow   | 20     | psf               | North    | 329                     | 20           | 179.44          | 287.1         |
| Roof load  | 20     | psf               | South    | 329                     | 20           | 179.44          | 287.1         |

Table 1.2.2.5 C

| FLOOR LOADS        |                |        |       |        |      |     |
|--------------------|----------------|--------|-------|--------|------|-----|
| <b>Dead Loads</b>  |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Container Floor    |                | 5.16   | psf   | DL     | 7.91 | psf |
| Insulation         | 4              | 0.5    | psf   | Factor | 1.2  |     |
| Plywood Floor      | 1              | 2.25   | psf   | F DL   | 9.49 | psf |
| <b>Live Loads</b>  |                |        |       |        |      |     |
| Item               | Thickness (in) | Weight | Units |        |      |     |
| Tour Live Load     |                | 0      | psf   | LL     | 50   | psf |
| Typical Floor Load |                | 50     | psf   | F DL   | 9.49 | psf |
|                    |                |        |       | F LL   | 80   | psf |

### 1.2.3 Lateral

#### 1.2.3.1 Earthquake

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

Table 1.2.3.1 A

| SEISMIC WEIGHT CALCULATIONS   |                         |             |              |
|-------------------------------|-------------------------|-------------|--------------|
| <b>Master Bedroom Section</b> |                         |             |              |
|                               | Area (ft <sup>2</sup> ) |             | Weight       |
| Floor                         | 180                     | First Floor | 16000.3 lbs  |
| Roof                          | 190                     | Roof        | 2749.3 lbs   |
| Total Building Weight         |                         |             | 18749.6 lbs  |
|                               |                         |             | 18.7496 k    |
| <b>Bedroom/Office Section</b> |                         |             |              |
|                               | Area (ft <sup>2</sup> ) |             | Weight       |
| Floor                         | 221                     | First Floor | 15037.87 lbs |
| Roof                          | 243                     | Roof        | 3516.21 lbs  |

|   |                         |              |             |
|---|-------------------------|--------------|-------------|
| Total Building Weight                           |                         | 18554.08 lbs |             |
|   |                         | 18.55408 k   |             |
| <b>Living Room Section</b>                      |                         |              |             |
|   | Area (ft <sup>2</sup> ) |              | Weight      |
| Floor   | 387                     | First Floor  | 5440.17 lbs |
| Roof  | 475                     | Roof         | 10251.2 lbs |
| Total Building Weight                           |                         | 15691.37 lbs |             |
|   |                         | 15.69137 k   |             |
| <b>Kitchen/Bathroom/Mechanical Room Section</b> |                         |              |             |
|   | Area (ft <sup>2</sup> ) |              | Weight      |
| Floor   | 278                     | First Floor  | 13938.2 lbs |
| Roof  | 324                     | Roof         | 4764 lbs    |
| Total Building Weight                           |                         | 18702.2 lbs  |             |
|   |                         | 18.7022 k    |             |

Table 1.2.3.1 B

|  |                |       |   |                          |
|--|----------------|-------|---|--------------------------|
| <b>Seismic Forces</b><br>ASCE 7-10 Seismic Design<br>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   | <b>Class =</b> | D     |   | Table 1: Site Parameters |
| Value of Coefficients based on SPA periods:                        |                |       |   |                          |
| Site Coefficient for Short Period                                  | $F_a =$        | 1.00  | g | Table 11.4-1             |
| Site coefficient for 1-Sec. Period                                 | $F_v =$        | 1.50  | g | Table 11.4-2             |
| Determine Maximum Considered Earthquake (MCE)<br>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 =</b>            | 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. | Table 12.8-2                  |
| Effective Height                                   | $h_n =$                      | 13.1  | ft.  | Figure 22-12; 12.8.2.1        |
| Determine Period for Base Shear:                   |                              |       |      |                               |
| Seismic Design Category                            | <b>Cat. =</b>                | D     |      | 11.6 & Tables 11.6-1 & 11.6-2 |
| Occupancy Importance Factor                        | <b>I =</b>                   | 1.0   |      | 11.5.1 & Table 11.5-1         |
| Coefficient for Upper Limit on Calculated Period   | $C_U =$                      | 1.4   |      | 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 $T_O$                                       | $T_O =$                      | 0.111 | sec. | 11.4.4                        |
| Period $T_S$                                       | $T_S =$                      | 0.557 | sec. | 11.4.5                        |
| Design Category                                    | <b>T =</b>                   | 0.557 | sec. | 12.8.2                        |
| Determine Base Shear:                              |                              |       |      |                               |
| Seismic Response Coefficient                       | $C_S =$                      | N/A   |      | 12.8-2                        |
| Seismic Response Coefficient                       | $C_S =$                      | 0.153 |      | 12.8-3                        |
| Seismic Response Coefficient                       | $C_S =$                      | N/A   |      | 12.8-4                        |
| Min. Allowable Seismic Response Coefficient        | $C_{S, \min\_Allow} =$       | 0.01  |      | 12.8-5                        |
|  | $C_{S, \min\_Allow} =$       | N/A   |      | 12.8-6                        |
|  | $C_S =$                      | 0.153 |      |                               |



|   |         |        |    |        |
|---|---------|--------|----|--------|
| Seismic Base Shear (Equivalent Lateral Force Procedure) | $C_s =$ | 0.153  | *W | 12.8-1 |
|   | $W =$   | 18.7   | k  |        |
|   | $V =$   | 2.8611 | k  |        |

Table 1.2.3.1 C

| Floor  | $w_i$ (lbs) | $w_i$ (lbs) | $h_i$ (lbs) | k | $w_i h_i^k$ (k-ft)   | $w_x h_x^k$ (k-ft) | $C_v$ | V (k) | $F_x$ (k)   |
|--------|-------------|-------------|-------------|---|----------------------|--------------------|-------|-------|-------------|
| 1      | 50422       | 50.42       | 1.46        | 1 | 73.62                | 73.62              | 0.21  | 10.97 | <b>2.28</b> |
| Roof 1 | 11030       | 11.03       | 11.14       | 1 | 122.87               | 122.87             | 0.35  | 10.97 | <b>3.81</b> |
| Roof 2 | 10251       | 10.25       | 15.33       | 1 | 157.148              | 157.15             | 0.44  | 10.97 | <b>4.88</b> |
|        |             |             |             |   | $\Sigma w_i h_i^k =$ | <b>353.61</b>      |       |       |             |

### 1.2.3.2 Wind

Wind was calculated at a wind velocity of 85 miles per hour in three second gusts, per the U.S. DOE Solar Decathlon Building Code in Appendix B.

Shipping container end walls can withstand a pressure of 370 psf. The side walls can withstand 169 psf of pressure. These figures are well over the minimum design standard. The load of the exterior steel stud walls will be transferred onto the containers.

## 2. Specific Design Items

### 2.1 Solar Panels

Manufacturer: LG

Product: Mono X AC e LG300A1C-B3

Watts: 300W panels, 4 rows of 6 panels

Angle of panel: 10 degrees

A PE stamp is necessary to ensure the ballast weight applied to the solar system is adequate in weight. Appendix E.1 provides further information on the solar array.

### 2.2 Shipping Containers

Three shipping containers are incorporated into the structural design of the house. The shipping containers are tested in accordance with the requirements of International Standard ISO 1496/1 which stipulates static and dynamic design load factors to be complied with.

The side walls are design to withstand pressure of 196 lbs/sq. ft. The end walls are design for 379lbs/sq.ft pressure.

The roof is able to support an imposed load of a minimum of 330 lbs/sq. ft. The roof of containers will be reinforced to prevent flexure shown in Figure 2.2 A.

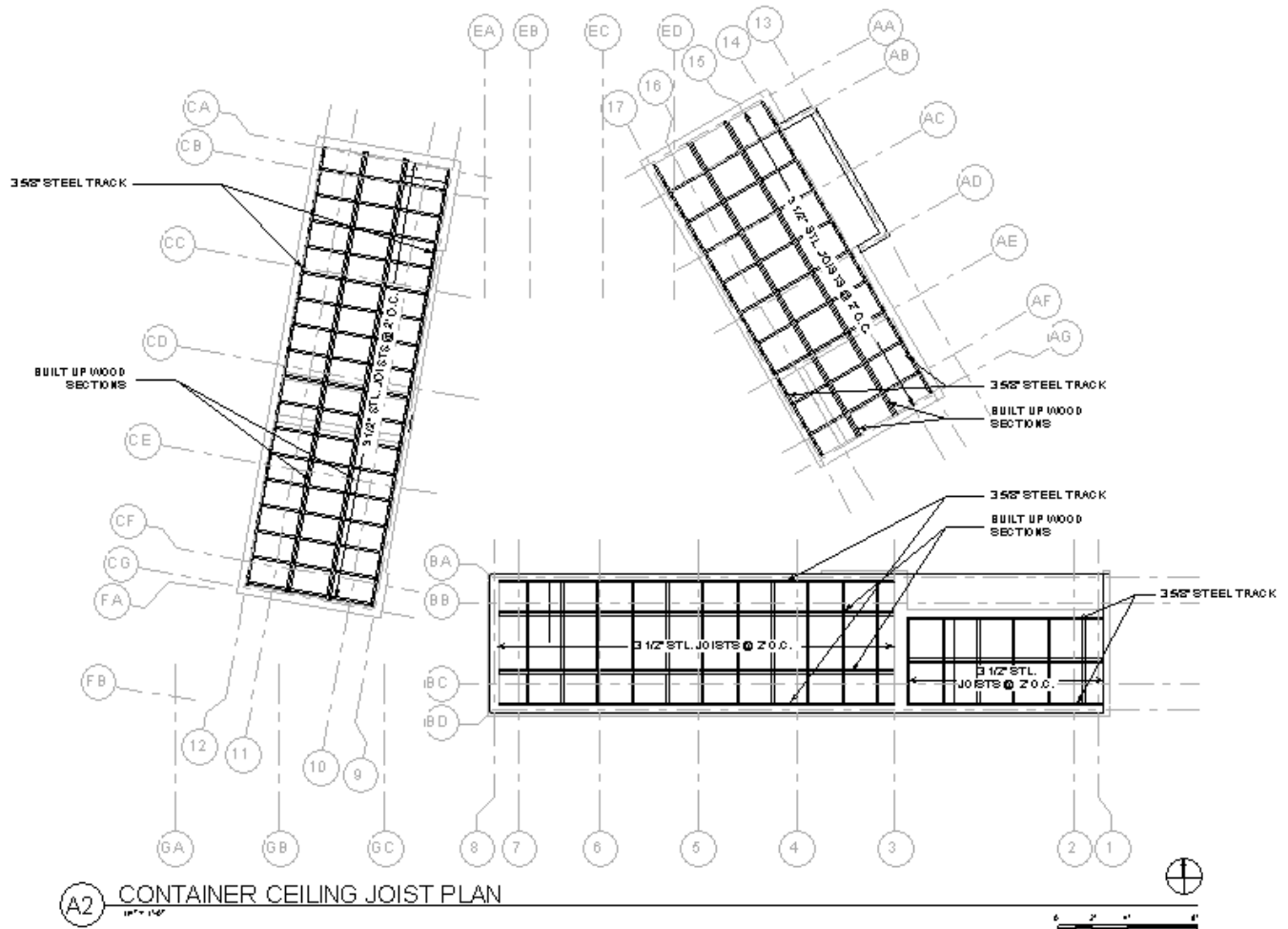


Figure 2.2A

The floor is design to pass a concentrated load test of 16,000 lbs over a footprint of 44 sq. inches.

### 2.3 Drop Ceilings

A drywall drop ceiling is incorporated in the design. However, a drop ceiling can be dangerous to occupants during a seismic event. Thus the ceiling must comply with seismic design codes.

The ceiling is designed to comply with ASTM E580 for the seismic design category D.

Lateral support will be provided by drywall beams. One main beam will run the length of the containers. Cross beams will run perpendicular the main beam and will be spaced at 4' intervals.

All vertical supports will be made of 12 gauge hanger wire. The wires will be spaced every 2' of the beams.

## 2.4 Wind Loads

### 2.4.1 Calculations

Based upon local Orange County building requirements and as well competition rules and building codes, 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 2.4.1. Calculations performed on wind loading were done per ASCE 7-10.

Table 2.4.1

| Basic Parameters                         |          |
|--|----------|
| Risk Category                            | II       |
| Basic Wind Speed, V                      | 85 mph   |
| Wind Directionality Factor, $K_d$        | 0.85     |
| Exposure Category                        | C        |
| Topographic Factor, $K_{zt}$             | 1.00     |
| Gust Effect Factor, G or $G_f$           | 0.836    |
| Enclosure Classification                 | Enclosed |
| Internal Pressure Coefficient, $GC_{pi}$ | +/- 0.18 |
| Terrain Exposure Constant, $\alpha$      | 9.5      |
| Terrain Exposure Constant, $z_g$         | 900 ft   |
| Wall Pressure Coefficients               |          |
| Windward Wall Width, B                   | 25 ft    |
| Side Wall Width, L                       | 19 ft    |
| L/B Ratio                                | 0.76     |
| Windward Wall Coefficient, $C_p$         | 0.80     |
| Leeward Wall Coefficient, $C_p$          | -0.50    |
| Side Wall Coefficient, $C_p$             | -0.70    |
| Roof Pressure Coefficients               |          |
| Roof Slope, $\theta$                     | 8.5°     |
| Median Roof Height, h                    | 15 ft    |
| Velocity Pressure Exposure Coef., $K_h$  | 0.85     |
| Velocity Pressure, $q_h$                 | 13.3 psf |

|                                  |                   |
|----------------------------------|-------------------|
| h/L Ratio                        | 0.79              |
| Windward Roof Area               | 0 ft <sup>2</sup> |
| Roof Area Within 8 ft of WW Edge | 0 ft <sup>2</sup> |

| Location   | Min/Max | Horiz Distance From Windward Edge |       |       |       |
|--|---------|-----------------------------------|-------|-------|-------|
|  |         | 0 ft                              | 8 ft  | 15 ft | 30 ft |
| Windward Roof Coefficient<br>Normal to Ridge, C <sub>p</sub> | Min     | -1.13                             | -1.13 | -0.62 | -0.53 |
|  | Max     | -0.18                             | -0.18 | -0.18 | -0.18 |
| Leeward Roof Coefficient<br>Normal to Ridge, C <sub>p</sub>  | Min     | -1.13                             | -1.13 | -0.62 | -0.53 |
|  | Max     | -0.18                             | -0.18 | -0.18 | -0.18 |
| Roof Coefficient<br>Parallel to Ridge, C <sub>p</sub>        | Min     | -1.13                             | -1.13 | -0.62 | -0.53 |
|  | Max     | -0.18                             | -0.18 | -0.18 | -0.18 |

**STRUCTURE PRESSURE SUMMARY (Add Internal Pressure q<sub>z</sub>GC<sub>pi</sub> or q<sub>h</sub>GC<sub>pi</sub> as Necessary)**

| Height, z | K <sub>z</sub> | q <sub>z</sub> | Walls   |          |          |          | Roof              |                   |                   | Internal         |          |         |
|-----------|----------------|----------------|---------|----------|----------|----------|-------------------|-------------------|-------------------|------------------|----------|---------|
|           |                |                | WW      | LW       | WW + LW  | Side     | Normal to Ridge   |                   | Parallel to Ridge | Positive         | Negative |         |
|           |                |                |         |          |          |          | WW                | LW                |                   |                  |          |         |
| 0 ft      | 0.85           | 13.3 psf       | 8.9 psf | -5.6 psf | 14.5 psf | -7.8 psf | Min:<br>-12.6 psf | Min:<br>-12.6 psf | Min:<br>-12.6 psf | 2.4 psf          | -2.4 psf |         |
| 2 ft      | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          |                   |                   |                   | 2.4 psf          |          |         |
| 3 ft      | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          |                   |                   |                   | 2.4 psf          |          |         |
| 5 ft      | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          |                   |                   |                   | 2.4 psf          |          |         |
| 6 ft      | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          |                   |                   |                   | 2.4 psf          |          |         |
| 8 ft      | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          | 2.4 psf           | Max:<br>-2.0 psf  | Max:<br>-2.0 psf  | Max:<br>-2.0 psf |          | 2.4 psf |
| 9 ft      | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          | 2.4 psf           |                   |                   |                  |          |         |
| 11 ft     | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          | 2.4 psf           |                   |                   |                  |          |         |
| 12 ft     | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          | 2.4 psf           |                   |                   |                  |          |         |
| 14 ft     | 0.85           | 13.3 psf       | 8.9 psf |          | 14.5 psf |          | 2.4 psf           |                   |                   |                  |          |         |
| 15 ft     | 0.85           | 13.3 psf       | 8.9 psf | 14.5 psf | 2.4 psf  |          |                   |                   |                   |                  |          |         |

## 2.5 Steel Roof Joist System

### 2.5.1 Member Specifications

Steel will be purchased from Nucor-Yamato Steel co. the members consists of 800S250-68 cold-formed steel C-channel Joist. The joist will be used in both single and built-up sections; the built up section would consist of two joists back-to-

back. Supporting members of the joist consists of built up cold-formed steel header beams, 1200S250-118 on the north side and 800S250-68 on the south side.

## 2.5.2 Load Summary

See Load Summary in Section 1.2.1, loads were assumed to be the same at competition to allow for storage in sections during shipment. These loads were also used for competition checks.

## 2.5.3 Deflection

The deflection was designed to stay under  $L/360$  safety factor. This was to reduce the probability of the roof sagging causing cracking in its frame. During competition, channel sections have a smaller unbraced length then during craning. See Section 2. for deflection checks.

## 2.5.4 Strength

Strength was checked with a phi factor of 0.9 based on AISI code standards. The members were designed to a competition loading to ensure that failure would not occur. During competition, channel sections have a smaller unbraced length than during craning. See Section 2.5.7 for strength checks.

## 2.5.5 Design

The design shown in Figure 2.5.5 consists of four main sections of steel roof joists, split by a dotted line. Each member consists of a single C-channel joist. Built up sections (with two C-channels) are where the sections meet each other.

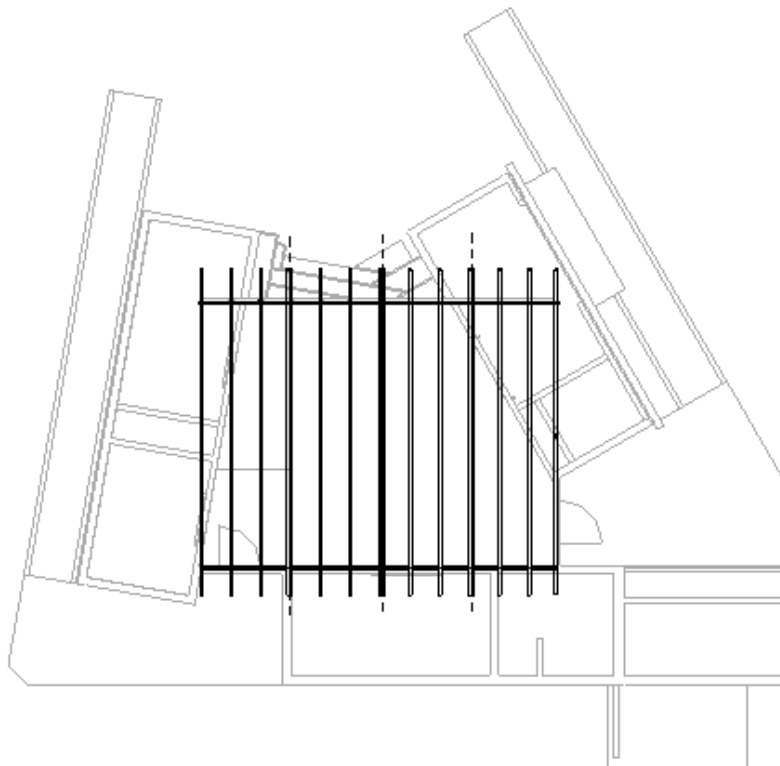


Figure 2.5.5

## 2.5.6 Connection Detail

Figure 2.5.6 A illustrates the connection of two joists to create a built up section. Figure 2.5.6 B illustrates the bolting of the channel members when bringing the sections together. Figure 2.5.6 C illustrates the connection between the joists on top of the built up headers using the built-up joists that are held together by two 12x 1 ¼ self-tapping screws spaced at 1' o.c., and 6" from the end. Where the joists 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 connections between channels are spaced at the upper limit for built-up sections, 1/6.

The steel joists will be connected to the top of the built-up joist header section with MGI-CM5 fastening.

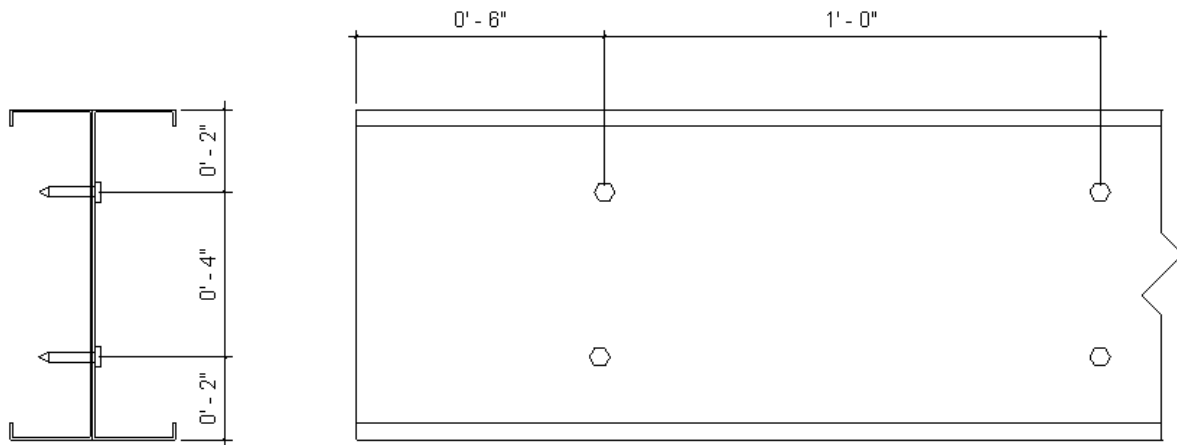


Figure 2.5.6 A

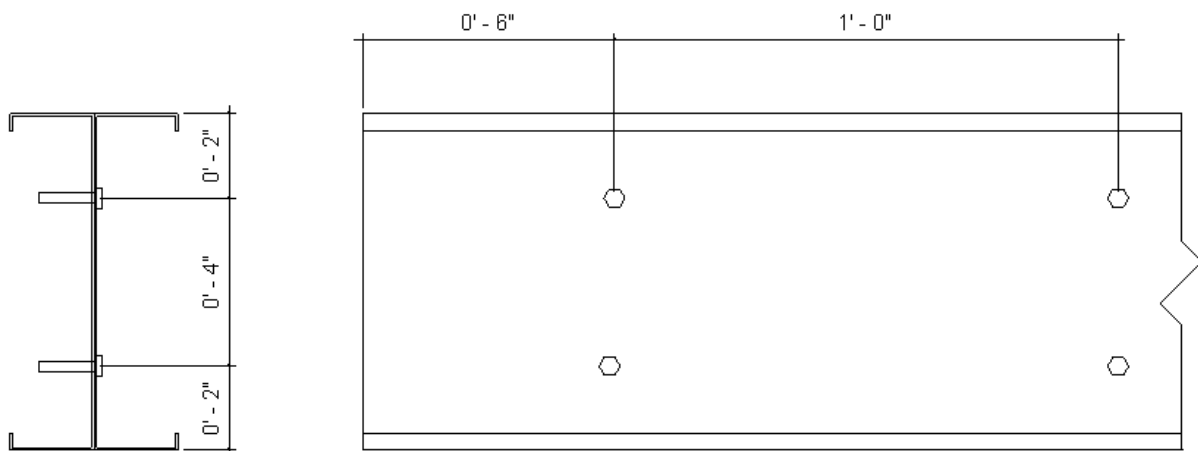


Figure 2.5.6 B

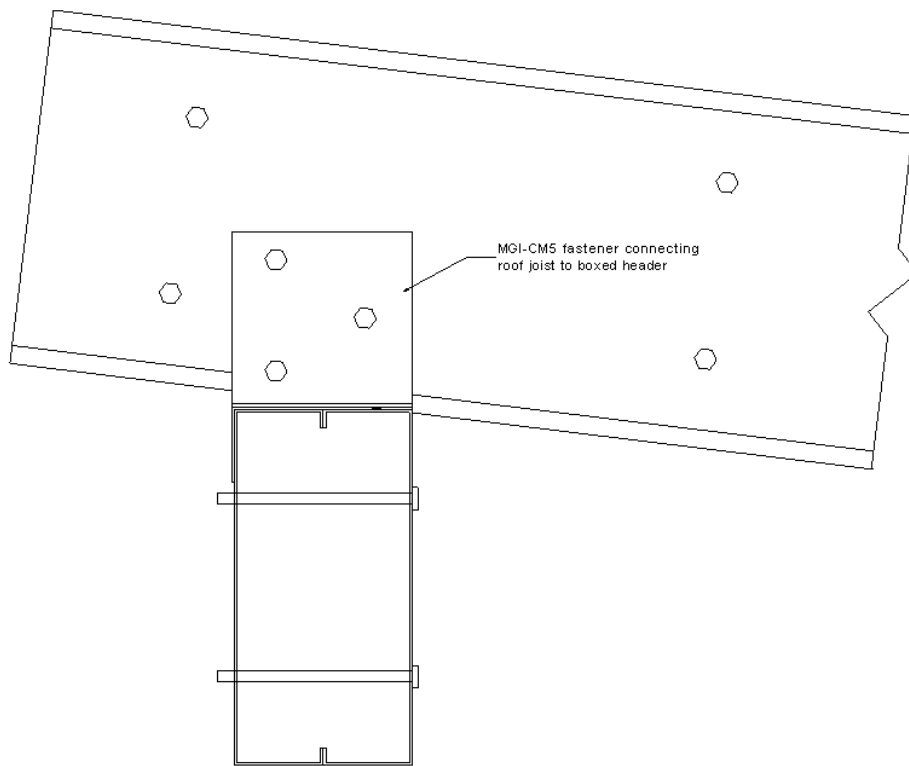


Figure 2.5.6 C

## 2.5.7 Joist Calculations

### Single Joist

f800S250-68 Cold-formed steel joist spaced 2' o.c.

Loads:

DL = 8psf

LL = 20psf

Load Combination:

$$1.2DL + 1.6LL = 1.2(8\text{psf}) + 1.6(20\text{psf}) = 41.6\text{psf}$$

An 800S250-68 ( $F_y = 50\text{ksi}$ ) cold-formed steel joist spaced at 24" o.c.; with a 10psf DL and 20psf LL; and deflection of  $L/360$ ; has a max single span of 21' 7".

Our design span is 19' which is under the max required single span.

## Built-Up Joist Beam

Built up joist beams will increase in load capacity which will continue to meet the design span of 19'.

## **2.6 Steel Floor Joist System**

### 2.6.1 Member Specifications

Steel will be purchased from Nucor-Yamato Steel co. the members consists of 1000S250-118 cold-formed steel C-channel Joist. The joist will be used in both single and built-up sections; the built up section would consist of two joists back-to-back. Joists connecting the floor sections consist of built up 1000S250-118 cold-formed steel header beams.

### 2.6.2 Load Summary

See Load summary in Section 2.6.7, Loads were assumed to be the same 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  $L/360$  safety factor. This was to reduce the probability of the roof sagging and causing cracking in the frame. During competition, channel sections have a smaller unbraced length than during craning. See Section 2. for deflection checks.

### 2.6.4 Strength

Strength was checked with a phi factor of 0.9 based on AISI code standards. The members were design to a competition loading to ensure that failure would not occur. During competition, channel sections have a smaller unbraced length then during craning and. See section 2.5.7 for strength checks.

### 2.6.5 Design

The design shown in figure 2.6.5 consists of three main sections of steel floor joists, spit by a dashed line. Each member consists of either single or built-up C-channel joists, built up sections are where the sections meet each other.



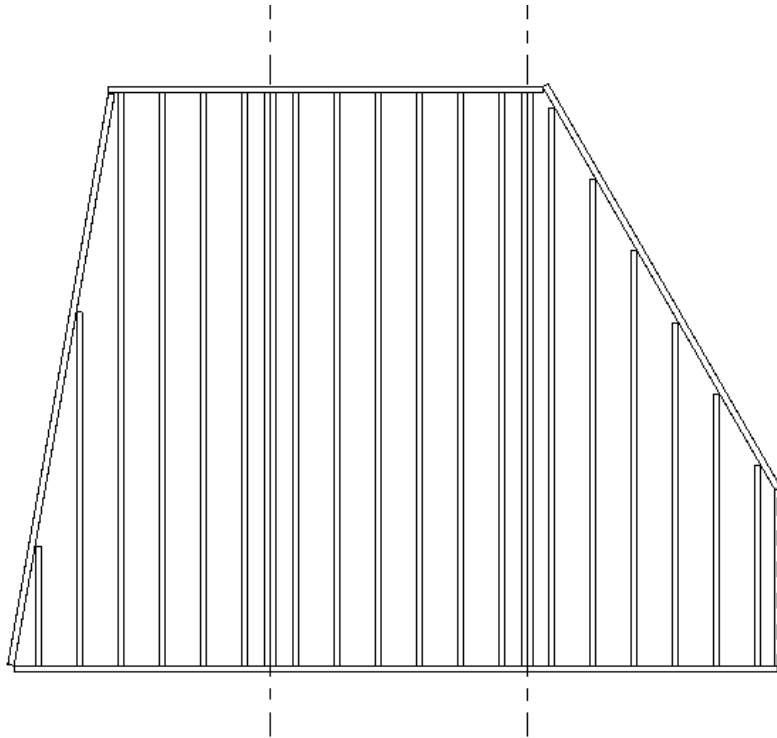


Figure 2.6.5

## 2.6.6 Connection Details

Figure 2.1.6 A illustrates the connection of two joists to create a built up section; Figure 2.1.6 B illustrates the bolting of the channel members when bringing the sections together; this is done by using two 12"x1 1/4" self-tapping screws spaced at 1' O.C. and 6" from the end. Where the joists come together, 3/4" 12-gage bolts are used to help line up the sections as well as hold the pieces together. Out of safety, the connections between channels are spaced at the upper limit for built-up sections, 1/6. Figure 2.2.6 A illustrates the connection of the joists into the trim frame of the floor section

## 2.6.7 Joist Calculations

### Interior Single Joist

1000S250-68 Cold-formed steel joist spaced 16" O.C.

Loads:

DL = 38psf

LL = 100psf

Load Combination:

$$1.2DL + 1.6LL = 1.2(38\text{psf}) + 1.6(100\text{psf}) = 205.6\text{psf}$$

Originally an 1000S250-68 ( $F_y = 50\text{ksi}$ ) cold-formed steel joist spaced at 16" o.c.; with a 40psf DL, 100psf LL, and a deflection of  $L/360$ ; has a max single span of 19'. The joist we will be using from Nucor-Yamato steel co. are 10" deep, 2.855" flange, 0.105". These joists are thicker than the originally planned joist to make sure they will span the same distance.

Our design span is 19' which is under the max required single span. Built up joist beams will increase in load capacity which will continue to meet the design span of 19'.

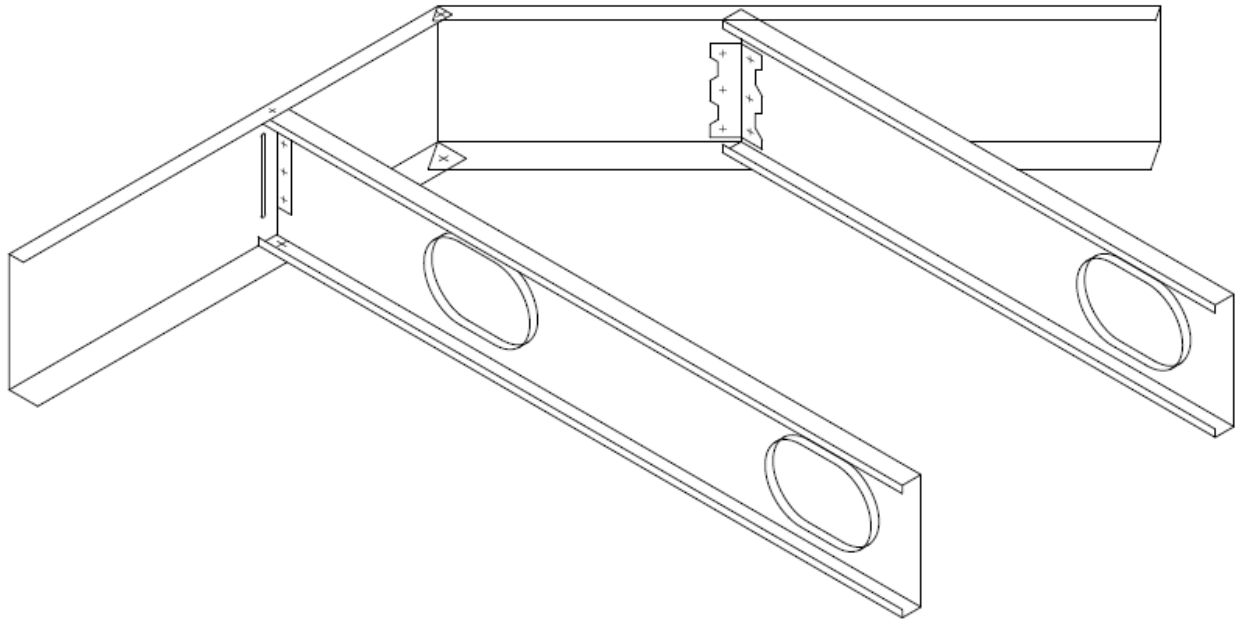


Figure 2.6.7

## 2.7 Container Reinforcement

### 2.7.1 Member Specifications

Steel will be purchased from Nucor-Yamato steel co. See structural drawings S-502, S-503, and S-504 for cut-out reinforcement locations. Three different member profiles will be used steel  $L3 \times 4 \times 3/8$  ( $F_y = 50\text{ksi}$ , tube steel) and steel  $HSS 3 \times 3 \times 3/8$  ( $F_y = 50\text{ksi}$ , tube steel). Welding shall be performed by certified welders licensed by the governing locality. Welding electrodes shall be ASTM a233, class e70xx (use low hydrogen electrodes for a572, grade 50 steel).

### 2.7.2 Load Summary

See Load summary in section 2.7.7. Loads were assumed to be the same at competition to allow for storage in sections during shipment. These loads were also used for competition checks. Loads were assumed to be the max the corrugated container walls are originally designed to withstand according with ISO Shipping Containers and Building Code Requirements.

### 2.7.3 Strength

Strength was checked with a phi factor of 0.9 based on AISI code standards. The members were design to a competition loading to ensure that failure would not occur. During competition, channel sections have a smaller unbraced length then during craning and. See Section 2. for strength checks.

### 2.7.4 Design

The design shown in the structural drawings S-502, S-503, and S-504 show the layout and design of all the container reinforcement.

### 2.7.5 Calculations

#### Steel L3x4x3/8 in compression

Max vertical span of 7' 10".

The compression max load caused by the max horizontal span is less than 40lbs, or .04 kips. The compression design strength of an L3x4x3/8, of a vertical span of 8', is 10.6 kips. The design strength is far greater than the design load, meaning the component will be sufficient.

#### Steel L3x3x3/8 deflection

Max horizontal span of  $L = 8' = 96\text{in.}$

$E = 29,000,000\text{psi}$

$I = 1.75\text{ in.}^4$

$W_u = 8.17\text{ lb/ft} = .681\text{ lb/in.}$

A uniformly distributed load was assumed for on top of the horizontal beam to give a max deflection of

$$\Delta_{\text{MAX}} = \frac{5 \cdot W_u \cdot L^4}{384 \cdot E \cdot I} = 0.0003\text{ in.} \quad \frac{L}{360} = 0.27\text{ in.}$$

$\Delta_{\text{MAX}}$  is less than  $\frac{L}{360}$ , so L3x4x3/8 is sufficient for the horizontal reinforcement spans.

#### Steel HSS6x3x3/8 in compression

Will not be used vertically.

#### Steel HSS 6X3X3/8 deflection

Max horizontal span of  $L = 14' = 168''$

$E = 29,000,000\text{ksi}$

$I = 3.78\text{ in.}^4$

$W_u = 8.17\text{ lb/ft} = .681\text{ lb/in.}$

A uniformly distributed load was assumed for on top of the horizontal beam to give a max deflection of

$$\Delta_{\text{MAX}} = \frac{5 \cdot W_u \cdot L^4}{384 \cdot E \cdot I} = 0.064\text{ in.} \quad \frac{L}{360} = 0.47\text{ in.}$$

$\Delta_{\text{MAX}}$  is less than  $\frac{L}{360}$ , so HSS6x3x3/8 is sufficient for the horizontal reinforcement spans.

### Steel HSS3x3x3/8 in compression

Max vertical span of 9' 6" = 114 in.

The compression max load caused by the max horizontal span is less than 60lbs, or .06 kips. The compression design strength of an HSS3x3x3/8, of a vertical span of 10', is 59.3 kips. The design strength is far greater than the design load, meaning the component will be sufficient.

### Steel HSS 3X3X3/8 deflection

Max horizontal span of  $L = 14' = 168''$

$E = 29,000,000\text{ksi}$

$I = 3.78\text{ in.}^4$

$W_u = 8.17\text{ lb/ft} = .681\text{ lb/in.}$

A uniformly distributed load was assumed for on top of the horizontal beam to give a max deflection of

$$\Delta_{\text{MAX}} = \frac{5 \cdot W_u \cdot L^4}{384 \cdot E \cdot I} = 0.064\text{ in.} \quad \frac{L}{360} = 0.47\text{ in.}$$

$\Delta_{\text{MAX}}$  is less than  $\frac{L}{360}$ , so HSS3x3x3/8 is sufficient for the horizontal reinforcement spans.

## **2.8 Footing Construction**

### 2.8.1 Material Specification

Each footing will be constructed out of Ellis Mini Screw Jack weld underneath the W6x12 steel I beams. The Screw Jacks will then be welded on the bottom plate on 1/8" steel plate.

### 2.8.2 Design

Figure 2.7.2 illustrates a cross-section view of the foundation footings. The footings are made of 2x16 wood board with a 1/8" steel plate on top attached to a 7.5 ton max load capacity adjustable post.

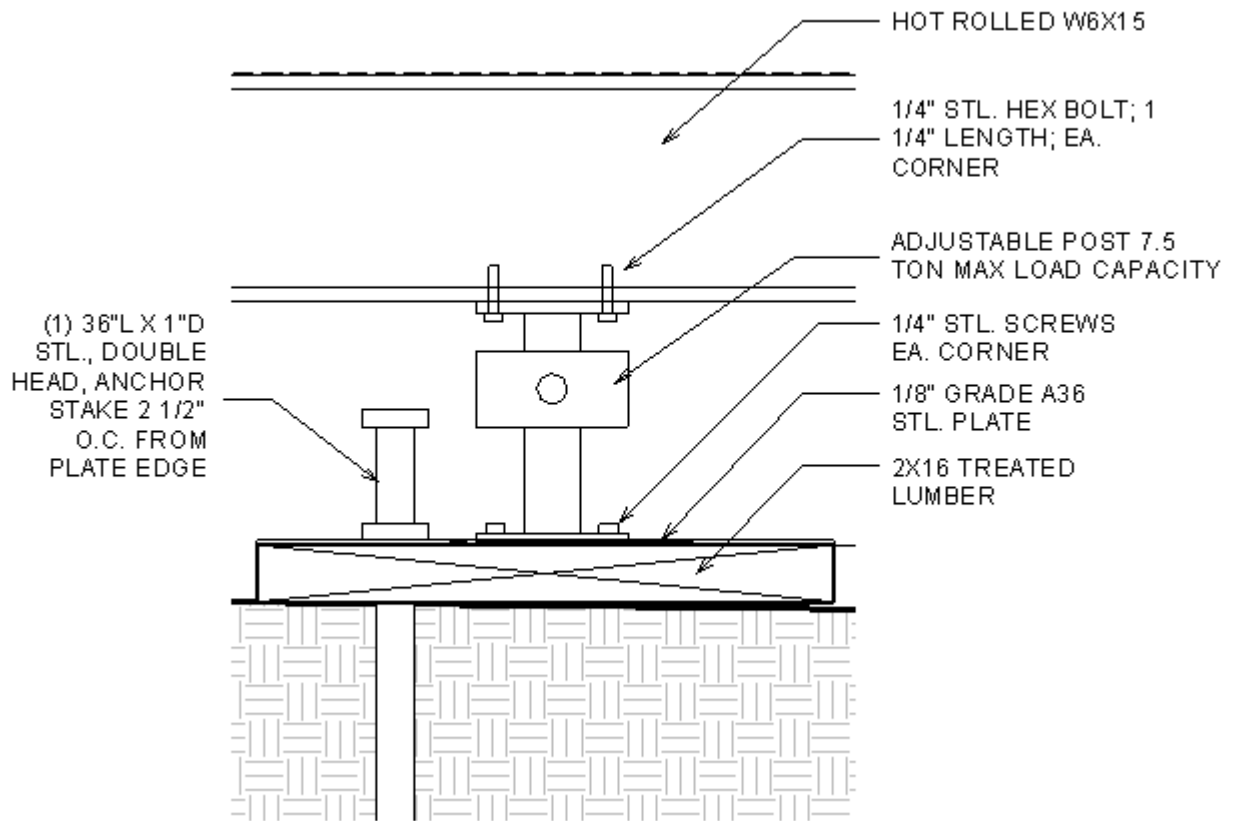


Figure 2.8.2 A

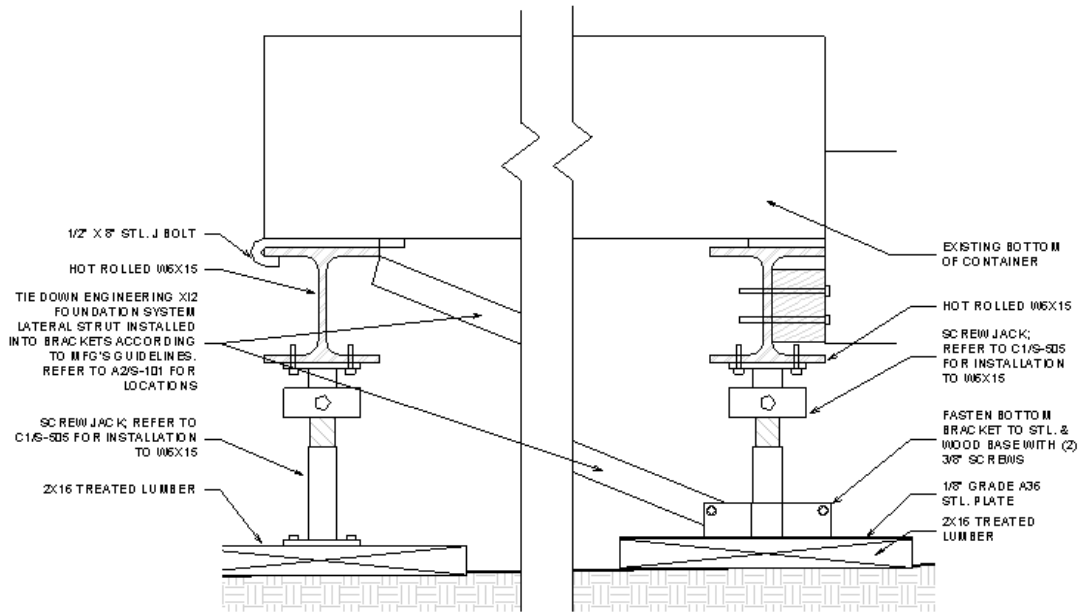


Figure 2.8.2 B

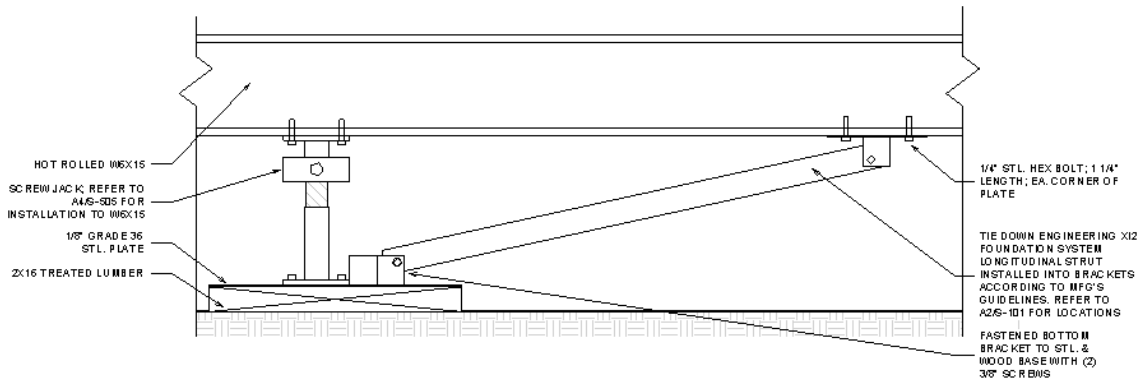


Figure 2.8.2 C

### 2.8.3 Materials and Specifications

A 36", 1" diameter, double head, steel, 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 vertical withdrawal design capacity, 1,500 lb horizontal 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 2.8.3 calls out these locations for tie downs tagged as “A”.

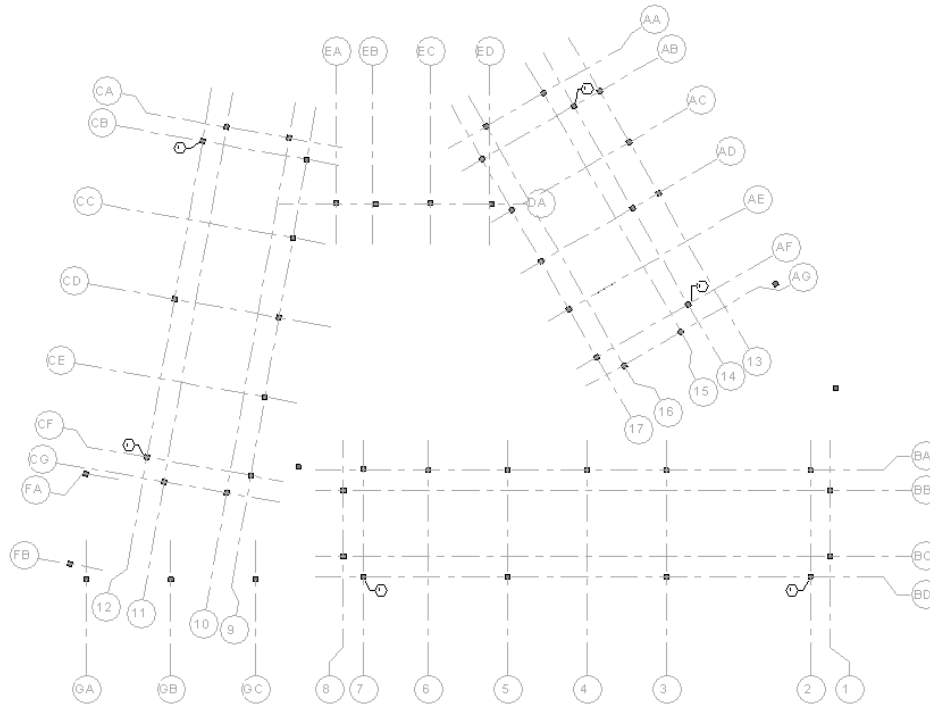


Figure 2.8.3

### 2.8.4 Calculations

Figure 2.8.4 is an example calculation for the seismic load on a seismic footing. Table 2.8.4 summarizes the loads each seismic footing.

Table 2.8.4

| Shear Footings | Force on Footing | Shear (lbs) | Seismic Load Effect (lbs) | Shear Footing Area (in <sup>2</sup> ) |
|----------------|------------------|-------------|---------------------------|---------------------------------------|
| AB14           | 11293            | 1054        | 912                       | 256                                   |
| AF14           | 11837            | 1104.8      | 362.8                     | 256                                   |
| BD2            | 14873            | 1388.1      | 831.8                     | 256                                   |
| BD7            | 12938            | 1207.5      | 861                       | 256                                   |
| CF12           | 12265            | 1144.7      | 577.5                     | 256                                   |
| CB12           | 15297            | 1427.7      | 1003.8                    | 256                                   |

Seismic calculations were done to ASCE 7-10 standards.

AB14 Shear Footing Seismic Calculations

$$E = E_h - E_v$$

Section 12.14.3.1.1

$$E_h = Q_e$$

$Q_e$  = effects from V or  $F_p$  from 12.14.7.5, 12.14.8.1, 13.3.1

Section 12.14.7.5

$$F_p = .4K_a S_{DS} W_p$$

$$K_a = 1 + L_f/100 = 1.36$$

$$S_{DS} = 2/3 * F_{DS} S_s = .467$$

$$W_p = 6105.6 \text{ lbs}$$

$$F_p = 1139.7$$

Section 12.14.8.1

$$V = F * W * S_{DS} / R$$

$$F = 1$$

$$W = 11293 \text{ lbs}$$

$$S_{DS} = 2/3 * F_{DS} S_s = .467$$

$$R = 7$$

$$V = 752.9 \text{ lbs}$$

Section 13.3.1

$$F_p = .4 * a_p * S_{DS} * W_p * (1 + 2(z/h)) / (R_p / I_p)$$

$$a_p = 1$$

$$S_{DS} = 2/3 * F_{DS} S_s = .467$$

$$W_p = 6105.6 \text{ lbs}$$

$$Z = 9 \text{ FT}$$

$$h = 9.5 \text{ FT}$$

$$R_p = 2.5$$

$$I_p = 1.5$$

$$F_p = 1966 \text{ lbs}$$

$$Q_e = 1966 \text{ lbs from } F_p$$

$$E_h = Q_e = 1966 \text{ lbs}$$

Section 12.14.3.1.2

$$E_v = .2 * S_{DS} * D$$

$$S_{DS} = 2/3 * F_{DS} S_s = .467$$

$$D = 11293 \text{ lbs}$$

$$E_v = 1054 \text{ lbs}$$

Seismic Load Calculation

$$E = E_h - E_v$$

$$E = 1966 \text{ lbs} - 1054 \text{ lbs} = 912 \text{ lbs}$$

Figure 2.8.4



## 2.8.5 Sizing Calculations

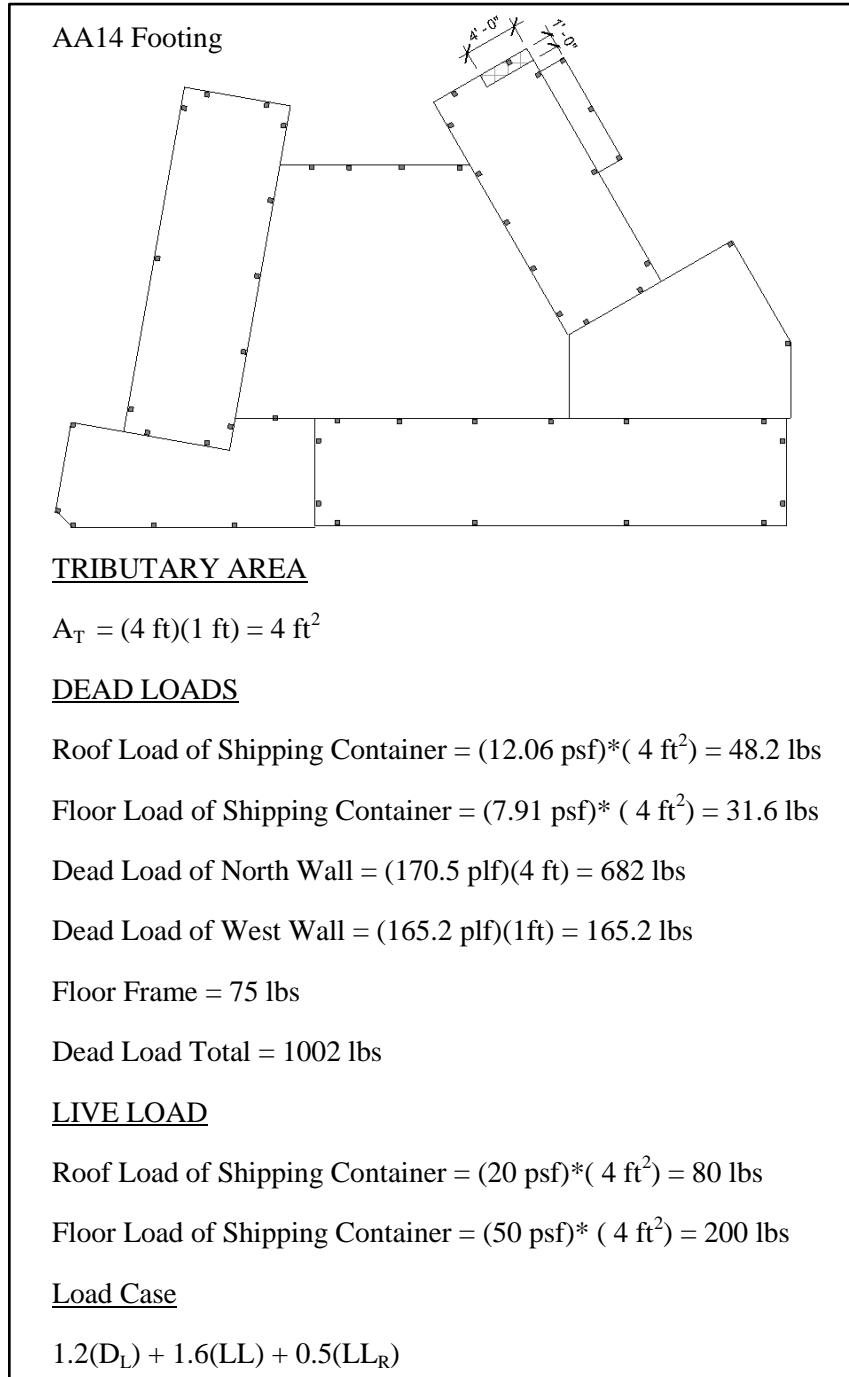


Figure 2.8.5

Figure 2.7.5 shows a sample calculation of how the footings were sized. This method was used for all footings. The locations of each footing were determined by the limitation of a 6000psf bearing capacity as well with the limitations for supports for floor framing sections. Table 2.8.5 summarizes the sample calculations for each footing.

Table 2.8.5

|  |          | Dead Loads (lbs)                  |       |       |        |                 | Live Load (lbs) |      |       | Bearing Capacity (6000 psf) |           |                                    |                    |
|--|----------|-----------------------------------|-------|-------|--------|-----------------|-----------------|------|-------|-----------------------------|-----------|------------------------------------|--------------------|
|  | Footings | Tributary Area (ft <sup>2</sup> ) | Roof  | Floor | Wall   | Sub Floor Frame | Total DL        | Roof | Floor | Total LL                    | Case Load | Area of Footing (ft <sup>2</sup> ) | Bearing Load (psf) |
| Master Bedroom Section                       | AA14     | 4                                 | 48.2  | 31.6  | 847.2  | 75.0            | 1202.5          | 80   | 200   | 360                         | 1562.5    | 1.778                              | 878.8              |
|  | AA16     | 4                                 | 48.2  | 31.6  | 847.2  | 75.0            | 1202.5          | 80   | 200   | 360                         | 1562.5    | 1.778                              | 878.8              |
|  | AB13     | 2                                 | 24.1  | 15.8  | 533.5  | 8.8             | 698.6           | 40   | 100   | 180                         | 878.6     | 1.778                              | 494.2              |
|  | AB14     | 23                                | 277.4 | 181.9 | 332.4  | 86.9            | 1054.3          | 460  | 1150  | 2070                        | 3124.3    | 1.778                              | 1757.2             |
|  | AB17     | 13                                | 156.8 | 102.8 | 500.7  | 47.1            | 968.9           | 260  | 650   | 1170                        | 2138.9    | 1.778                              | 1203.0             |
|  | AC13     | 9                                 | 108.5 | 71.2  | 696.8  | 39.6            | 1099.4          | 180  | 450   | 810                         | 1909.4    | 1.778                              | 1073.9             |
|  | AC17     | 32                                | 394.5 | 175.7 | 658.8  | 128.5           | 1629.0          | 640  | 2350  | 4080                        | 5709.0    | 1.778                              | 3210.9             |
|  | AD13     | 2                                 | 24.1  | 15.8  | 529.6  | 8.8             | 694.0           | 40   | 100   | 180                         | 874.0     | 1.778                              | 491.6              |
|  | AD14     | 34                                | 410.0 | 268.9 | 786.7  | 130.7           | 1915.7          | 680  | 1700  | 3060                        | 4975.7    | 1.778                              | 2798.5             |
|  | AD17     | 36                                | 445.6 | 181.6 | 527.0  | 148.6           | 1563.3          | 720  | 2600  | 4520                        | 6083.3    | 1.778                              | 3421.4             |
|  | AE17     | 36                                | 394.5 | 175.7 | 685.1  | 147.4           | 1683.2          | 720  | 2600  | 4520                        | 6203.2    | 1.778                              | 3488.9             |
|  | AF14     | 19                                | 229.1 | 150.3 | 454.2  | 72.5            | 1087.4          | 380  | 950   | 1710                        | 2797.4    | 1.778                              | 1573.3             |
|  | AF17     | 45                                | 562.1 | 180.5 | 441.4  | 191.5           | 1650.6          | 900  | 3950  | 6770                        | 8420.6    | 1.778                              | 4736.0             |
|  | AG15     | 19                                | 48.2  | 31.6  | 687.3  | 268.6           | 1242.9          | 380  | 1700  | 2910                        | 4152.9    | 1.778                              | 2335.7             |
| AG16   | 46       | 668.3                             | 272.3 | 975.9 | 149.8  | 2479.7          | 920             | 4400 | 7500  | 9979.7                      | 1.778     | 5612.9                             |                    |
| Kitchen / Bathroom / Mechanical Room Section | BA2      | 53                                | 668.3 | 272.3 | 717.9  | 221.4           | 2256.0          | 1060 | 4200  | 7250                        | 9506.0    | 1.778                              | 5346.4             |
|  | BA3      | 52                                | 651.2 | 310.9 | 957.2  | 211.2           | 2556.5          | 1040 | 3700  | 6440                        | 8996.5    | 1.778                              | 5059.9             |
|  | BA4      | 44                                | 619.0 | 251.0 | 959.6  | 256.0           | 2502.7          | 880  | 3900  | 6680                        | 9182.7    | 1.778                              | 5164.6             |
|  | BA5      | 62                                | 694.7 | 267.5 | 673.0  | 186.2           | 2185.8          | 1240 | 4500  | 7820                        | 10005.8   | 1.778                              | 5627.5             |
|  | BA6      | 41                                | 506.4 | 216.0 | 613.2  | 168.7           | 1805.1          | 820  | 3100  | 5370                        | 7175.1    | 1.778                              | 4035.5             |
|  | BA7      | 29                                | 358.9 | 146.8 | 373.9  | 117.3           | 1196.3          | 580  | 2250  | 3890                        | 5086.3    | 1.778                              | 2860.7             |
|  | BB1      | 3                                 | 36.2  | 23.7  | 734.7  | 72.5            | 1040.5          | 60   | 150   | 270                         | 1310.5    | 1.778                              | 737.1              |
|  | BB8      | 20                                | 36.2  | 23.7  | 734.7  | 147.3           | 1130.3          | 400  | 1850  | 3160                        | 4290.3    | 1.778                              | 2413.0             |
|  | BC1      | 3                                 | 36.2  | 23.7  | 734.7  | 72.5            | 1040.5          | 60   | 150   | 270                         | 1310.5    | 1.778                              | 737.1              |
|  | BC8      | 27                                | 36.2  | 23.7  | 734.7  | 173.7           | 1162.0          | 540  | 2450  | 4190                        | 5352.0    | 1.778                              | 3010.1             |
|  | BD2      | 24                                | 289.4 | 189.8 | 1000.7 | 89.4            | 1883.3          | 480  | 1200  | 2160                        | 4043.3    | 1.778                              | 2274.0             |
|  | BD3      | 43                                | 518.6 | 340.1 | 1789.4 | 160.6           | 3370.5          | 860  | 2150  | 3870                        | 7240.5    | 1.778                              | 4072.2             |
|  | BD5      | 43                                | 518.6 | 340.1 | 1789.4 | 160.6           | 3370.5          | 860  | 2150  | 3870                        | 7240.5    | 1.778                              | 4072.2             |

|                                |      |    |       |       |        |       |        |      |      |      |        |       |        |
|--------------------------------|------|----|-------|-------|--------|-------|--------|------|------|------|--------|-------|--------|
|                                | BD7  | 24 | 289.4 | 189.8 | 1000.7 | 89.1  | 1882.9 | 480  | 1200 | 2160 | 4042.9 | 1.778 | 2273.8 |
| Bedroom /<br>Office<br>Section | CA10 | 3  | 36.2  | 23.7  | 746.0  | 71.3  | 1052.7 | 60   | 150  | 270  | 1322.7 | 1.778 | 743.9  |
|                                | CA11 | 3  | 36.2  | 23.7  | 746.0  | 71.3  | 1052.7 | 60   | 150  | 270  | 1322.7 | 1.778 | 743.9  |
|                                | CB9  | 15 | 180.9 | 118.7 | 634.8  | 55.4  | 1187.7 | 300  | 750  | 1350 | 2537.7 | 1.778 | 1427.3 |
|                                | CB12 | 26 | 313.6 | 205.7 | 1131.5 | 96.6  | 2096.8 | 520  | 1300 | 2340 | 4436.8 | 1.778 | 2495.4 |
|                                | CC9  | 52 | 631.6 | 253.8 | 966.6  | 194.6 | 2455.9 | 1040 | 4000 | 6920 | 9375.9 | 1.778 | 5273.3 |
|                                | CD9  | 53 | 656.3 | 264.4 | 1000.1 | 217.6 | 2566.1 | 1060 | 4150 | 7170 | 9736.1 | 1.778 | 5475.9 |
|                                | CD12 | 45 | 542.7 | 356.0 | 1992.9 | 170.6 | 3674.6 | 900  | 2250 | 4050 | 7724.6 | 1.778 | 4344.5 |
|                                | CE9  | 49 | 606.9 | 243.1 | 923.4  | 203.5 | 2372.3 | 980  | 3850 | 6650 | 9022.3 | 1.778 | 5074.4 |
|                                | CF9  | 19 | 358.9 | 146.8 | 862.2  | 77.6  | 1734.6 | 380  | 1000 | 1790 | 3524.6 | 1.778 | 1982.3 |
|                                | CF12 | 26 | 313.6 | 205.7 | 1146.1 | 98.1  | 2116.1 | 520  | 1300 | 2340 | 4456.1 | 1.778 | 2506.2 |
|                                | CG10 | 8  | 36.2  | 23.7  | 746.0  | 71.3  | 1052.7 | 160  | 600  | 1040 | 2092.7 | 1.778 | 1177.0 |
|                                | CG11 | 9  | 36.2  | 23.7  | 746.0  | 71.3  | 1052.7 | 180  | 650  | 1130 | 2182.7 | 1.778 | 1227.6 |
| Living<br>Room<br>Section      | DA1  | 16 | 202.1 | 202.1 | 477.6  | 70.4  | 1142.6 | 320  | 1600 | 2720 | 3862.6 | 1.778 | 2172.4 |
|                                | DA2  | 22 | 277.9 | 277.9 | 681.8  | 96.8  | 1601.2 | 440  | 2200 | 3740 | 5341.2 | 1.778 | 3004.0 |
|                                | DA3  | 18 | 227.3 | 227.3 | 557.2  | 79.2  | 1309.3 | 360  | 1800 | 3060 | 4369.3 | 1.778 | 2457.4 |
|                                | DA4  | 20 | 252.6 | 252.6 | 623.0  | 88.0  | 1459.4 | 400  | 2000 | 3400 | 4859.4 | 1.778 | 2733.1 |
| Decking<br>Section             | EA1  | 25 | 0.0   | 68.8  | 0.0    | 110.0 | 214.5  | 500  | 2500 | 4250 | 4464.5 | 1.778 | 2511.0 |
|                                | EA2  | 26 | 0.0   | 71.5  | 0.0    | 114.4 | 223.1  | 520  | 2600 | 4420 | 4643.1 | 1.778 | 2611.4 |
|                                | EA3  | 45 | 442.1 | 442.1 | 504.5  | 228.8 | 1940.9 | 900  | 4400 | 7490 | 9430.9 | 1.778 | 5304.2 |
|                                | FA1  | 20 | 0.0   | 55.0  | 0.0    | 88.0  | 171.6  | 400  | 2000 | 3400 | 3571.6 | 1.778 | 2008.8 |
|                                | FB1  | 21 | 0.0   | 57.8  | 0.0    | 92.4  | 180.2  | 420  | 2100 | 3570 | 3750.2 | 1.778 | 2109.2 |
|                                | GA1  | 10 | 0.0   | 27.5  | 0.0    | 44.0  | 85.8   | 200  | 1000 | 1700 | 1785.8 | 1.778 | 1004.4 |
|                                | GB1  | 12 | 0.0   | 33.0  | 0.0    | 52.8  | 103.0  | 240  | 1200 | 2040 | 2143.0 | 1.778 | 1205.3 |
|                                | GC1  | 12 | 0.0   | 33.0  | 0.0    | 52.8  | 103.0  | 240  | 1200 | 2040 | 2143.0 | 1.778 | 1205.3 |

## 2.9 Container Roof Loads

### 2.9.1 Calculations

Calculated by using the largest roof load, which will be on the 20ft shipping container due to the load added from the center roof overhang.

Dead Load (D) = 1100lbs

Live Load (L) = 7200lbs

Seismic Load (E) = 216.2lbs

Wind Load (W) = -4500lbs

$$\text{Snow (S)} = 7200\text{lbs}$$

### LRFD Load Combinations

1.  $1.4D = 1540 \text{ lbs}$
2.  $1.2D + 1.6L + .5S = 16440 \text{ lbs}$
3.  $1.2D + 1.6S + .5L = 16440 \text{ lbs}$
4.  $1.2D + 1.6W + .5L + .5S = 1320 \text{ lbs}$
5.  $1.2D + 1.0E + .5L + .2S = 6230 \text{ lbs}$
6.  $.9D + 1.6W + 1.6H = -6210 \text{ lbs}$
7.  $.9D + 1.0E + 1.6H = 860 \text{ lbs}$

Greatest load from combination 2 and 3 of 16440 lbs

Container Roof Load (pst) = Load Combination / Container Roof Area

$$16440\text{lbs}/360\text{ft}^2 = 45.7 \text{ psf}$$

Additional Load from support

= Roof Load + added load from center roof hanging over

$$45.7\text{psf} + 15.2\text{psf} = 60.9\text{psf}$$

61psf is the max load on top of shipping containers

Container Roof Design Strength is equal to 330psf per ISO standards

$$61\text{psf} < 330\text{psf}$$

Container Strength is acceptable for the design load

## **2.10 Deck**

The deck design will consist of a joist system. They will be made by 10" C-channels along with blocking to keep the joist from rotating. This is over engineered, but is done so to provide a quick assembly with a modular deck system. The 10" steel joist will be spaced at 16" off center. The span and spacing calculation can be seen in Figure 2.10 B.

Figure 2.9 A illustrates the joist system all together.

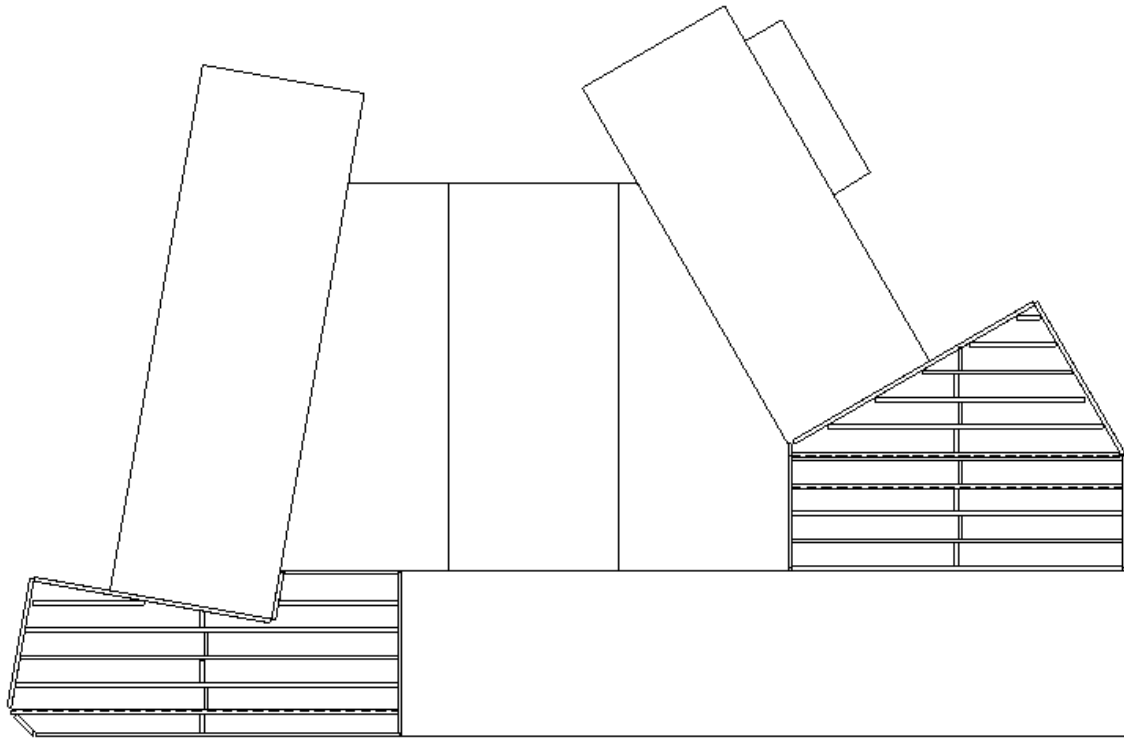


Figure 2.10 A

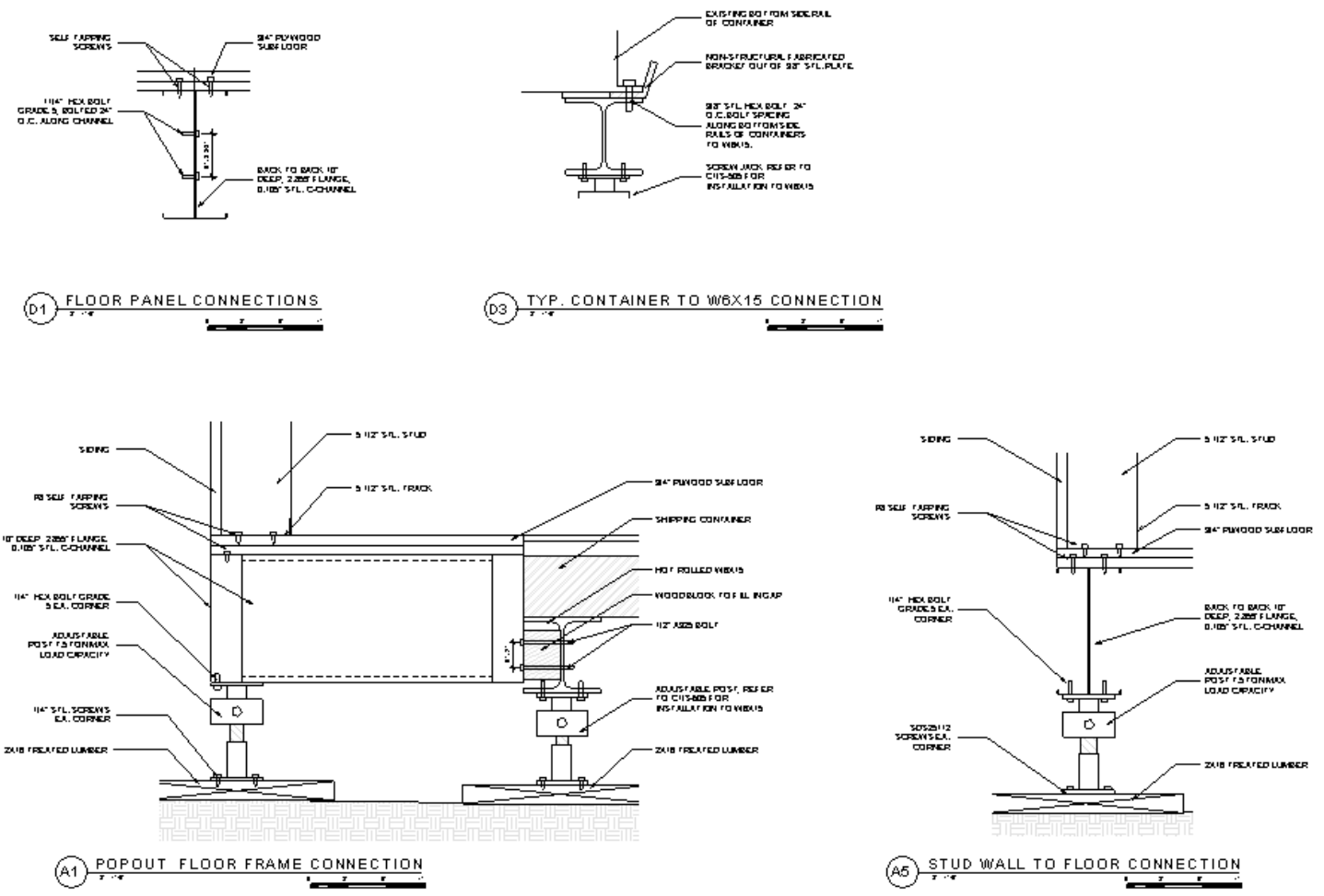


Figure 2.10 B

### 3. Craning

#### 3.1 Weight Calculations

Table 3.1 A 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 3.1 A

| CRANE LOAD SUMMARY                                 |                 |               |
|--|-----------------|---------------|
| Section  | Weight (lbs)    | Weight (tons) |
| <b>Master Bedroom (Total)</b>                      | <b>9516.01</b>  | <b>4.76</b>   |
| Roof   | 1308.24         | 0.65          |
| Container  | 6302.17         | 3.15          |
| Pop-Out  | 1905.6          | 0.95          |
| <b>Bedroom / Office (Total)</b>                    | <b>13105.3</b>  | <b>6.55</b>   |
| Roof   | 1681.67         | 0.84          |
| Container  | 11423.63        | 5.71          |
| <b>Kitchen / Mechanical Room / Bathroom(Total)</b> | <b>15120.76</b> | <b>7.56</b>   |
| Roof   | 3970.51         | 1.99          |
| Container  | 11150.25        | 5.58          |
| <b>Living Room (Total)</b>                         | <b>13554.17</b> | <b>6.78</b>   |
| Roof   | 5101.05         | 2.55          |
| Upper North Wall                                   | 1216.09         | 0.61          |
| Lower North Wall                                   | 1714.74         | 0.86          |
| South Wall   | 766.77          | 0.38          |
| Upper East Wall                                    | 403.94          | 0.20          |
| Lower East Wall                                    | 766.77          | 0.38          |
| West Wall  | 403.94          | 0.20          |
| Floor Section 1                                    | 1467.27         | 0.73          |
| Floor Section 2                                    | 985.32          | 0.49          |
| Floor Section 3                                    | 728.28          | 0.36          |
| <b>Decking (Total)</b>                             | <b>2836.08</b>  | <b>1.42</b>   |
| East Deck  | 1478.88         | 0.74          |
| West Deck  | 1357.2          | 0.68          |
| <b>TOTAL</b>                                       | <b>54132.32</b> | <b>27.07</b>  |

Table 3.1 B

| MASTER BEDROOM CRANE WEIGHT CALCULATIONS |          |             |                 |        |       |                          |
|--|----------|-------------|-----------------|--------|-------|--------------------------|
| Item                                     | Quantity | Measurement | Units           | Total  | Units | Grand Total (lbs)        |
| <b>Master Bedroom Roof</b>               |          |             |                 |        |       |                          |
| Area with Overhang                       |          | 189.6       | ft <sup>2</sup> |        |       |                          |
| Area without Overhang                    |          | 160         | ft <sup>2</sup> |        |       |                          |
| Roofing Material                         |          | 3           | psf             | 568.8  | lbs   |                          |
| Plywood (1")                             |          | 2.25        | psf             | 426.6  | lbs   | <b>Roof Total:</b>       |
| 2x4 stud frame (24" O.C.)                |          | 1.65        | psf             | 312.84 | lbs   | 1308.24                  |
| <b>Master Bedroom Container</b>          |          |             |                 |        |       |                          |
| <b>North Wall</b>                        |          |             |                 |        |       |                          |
| Area                                     |          | 79          | ft <sup>2</sup> |        |       |                          |
| Length                                   |          | 8.17        | ft              |        |       |                          |
| Height                                   |          | 9.67        | ft              |        |       |                          |
| Plywood (1")                             |          | 2.25        | psf             | 177.75 | lbs   |                          |
| Exterior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 39.5   | lbs   |                          |
| Interior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 39.5   | lbs   |                          |
| Casement Window (24" x 48")              | 1        | 136         | lbs             | 136    | lbs   |                          |
| (2"x4") Wood Siding                      |          | 3.5         | psf             | 276.5  | lbs   |                          |
| 1/2" gypsum board                        |          | 4           | psf             | 316    | lbs   | <b>North Wall Total:</b> |
| Shipping Container                       |          | 5.16        | psf             | 407.64 | lbs   | 1392.89                  |
| <b>South Wall</b>                        |          |             |                 |        |       |                          |
| Area                                     |          | 79          | ft <sup>2</sup> |        |       |                          |
| Length                                   |          | 8.17        | ft              |        |       |                          |
| Height                                   |          | 9.67        | ft              |        |       |                          |
| Plywood (1")                             |          | 2.25        | psf             | 177.75 | lbs   |                          |
| 1/2" gypsum board                        |          | 4           | psf             | 316    | lbs   |                          |
| Interior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 39.5   | lbs   | <b>South Wall Total:</b> |
| Shipping Container                       |          | 5.16        | psf             | 407.64 | lbs   | 940.89                   |
| <b>East Wall</b>                         |          |             |                 |        |       |                          |
| Area                                     |          | 116.04      | ft <sup>2</sup> |        |       |                          |
| Length                                   |          | 12          | ft              |        |       |                          |
| Height                                   |          | 9.67        | ft              |        |       |                          |
| Plywood (1")                             |          | 2.25        | psf             | 261.09 | lbs   |                          |



|  |   |        |                 |          |                                       |                  |                |
|--|---|--------|-----------------|----------|---------------------------------------|------------------|----------------|
| Exterior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 58.02    | lbs                                   |                  |                |
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 58.02    | lbs                                   |                  |                |
| Casement Window (24" x 48")            | 1 | 136    | lbs             | 136      | lbs                                   |                  |                |
| (2"x4") Wood Siding                    |   | 3.5    | psf             | 406.14   | lbs                                   |                  |                |
| 1/2" gypsum board                      |   | 4      | psf             | 464.16   | lbs                                   | East Wall Total: |                |
| Shipping Container                     |   | 5.16   | psf             | 598.7664 | lbs                                   | 1982.20          |                |
| <b>West Wall</b>                       |   |        |                 |          |                                       |                  |                |
| Area                                   |   | 116.04 | ft <sup>2</sup> |          |                                       |                  |                |
| Length                                 |   | 12     | ft              |          |                                       |                  |                |
| Height                                 |   | 9.67   | ft              |          |                                       |                  |                |
| Plywood (1")                           |   | 2.25   | psf             | 261.09   | lbs                                   |                  |                |
| Exterior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 58.02    | lbs                                   |                  |                |
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 58.02    | lbs                                   |                  |                |
| Door (60" x 84")                       | 1 | 140    | lbs             | 140      | lbs                                   |                  |                |
| (2"x4") Wood Siding                    |   | 3.5    | psf             | 406.14   | lbs                                   |                  |                |
| 1/2" gypsum board                      |   | 4      | psf             | 464.16   | lbs                                   | West Wall Total: |                |
| Shipping Container                     |   | 5.16   | psf             | 598.7664 | lbs                                   | 1986.20          |                |
| <b>Master Bedroom Floor</b>            |   |        |                 |          |                                       |                  |                |
| Area                                   |   | 160    | ft <sup>2</sup> |          |                                       |                  |                |
| Length                                 |   | 20     | ft              |          |                                       |                  |                |
| Width                                  |   | 8      | ft              |          |                                       |                  |                |
| Container Floor                        |   | 5.16   | psf             | 63.6228  | lbs                                   |                  |                |
| Insulation                             |   | 0.5    | psf             | 6.165    | lbs                                   | Floor Total:     |                |
| 1" Plywood Floor                       |   | 2.25   | psf             | 27.7425  | lbs                                   | 97.53            |                |
|  |   |        |                 |          | <b>Master Bedroom Container Total</b> |                  | <b>6302.17</b> |
| <b>Pop-out Walls</b>                   |   |        |                 |          |                                       |                  |                |
| Area                                   |   | 119.26 | ft <sup>2</sup> |          |                                       |                  |                |
| Length                                 |   | 12.33  | ft              |          |                                       |                  |                |
| Height                                 |   | 9.67   | ft              |          |                                       |                  |                |
| Plywood (1")                           |   | 2.25   | psf             | 360      | lbs                                   |                  |                |
| 1/2" gypsum board                      |   | 4      | psf             | 640      | lbs                                   |                  |                |
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 80       | lbs                                   | Pop-out Walls    |                |
| Shipping Container                     |   | 5.16   | psf             | 825.6    | lbs                                   | 1905.6           |                |

Table 3.1 C

| BEDROOM/OFFICE CRANE WEIGHT CALCULATIONS |          |             |                 |         |       |                            |
|--|----------|-------------|-----------------|---------|-------|----------------------------|
| Item                                     | Quantity | Measurement | Units           | Total   | Units | Grand Total (lbs)          |
| <b>Bedroom/Office Roof</b>               |          |             |                 |         |       |                            |
| Area with Overhang                       |          | 243.72      | ft <sup>2</sup> |         |       |                            |
| Area without Overhang                    |          | 208         | ft <sup>2</sup> |         |       |                            |
| Roofing Material                         |          | 3           | psf             | 731.16  | lbs   |                            |
| Plywood (1")                             |          | 2.25        | psf             | 548.37  | lbs   | <b>Bedroom Roof Total:</b> |
| 2x4 stud frame (24" O.C.)                |          | 1.65        | psf             | 402.138 | lbs   | 1681.668                   |
| <b>Bedroom/Office Container</b>          |          |             |                 |         |       |                            |
| <b>North Wall</b>                        |          |             |                 |         |       |                            |
| Area                                     |          | 79          | ft <sup>2</sup> |         |       |                            |
| Length                                   |          | 8.17        | ft              |         |       |                            |
| Height                                   |          | 9.67        | ft              |         |       |                            |
| Plywood (1")                             |          | 2.25        | psf             | 177.75  | lbs   |                            |
| Exterior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 39.5    | lbs   |                            |
| Interior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 39.5    | lbs   |                            |
| (2"x4") Wood Siding                      |          | 3.5         | psf             | 276.5   | lbs   |                            |
| 1/2" gypsum board                        |          | 4           | psf             | 316     | lbs   | <b>North Wall Total:</b>   |
| Shipping Container                       |          | 5.16        | psf             | 407.64  | lbs   | 1256.89                    |
| <b>South Wall</b>                        |          |             |                 |         |       |                            |
| Area                                     |          | 79          | ft <sup>2</sup> |         |       |                            |
| Length                                   |          | 8.17        | ft              |         |       |                            |
| Height                                   |          | 9.67        | ft              |         |       |                            |
| Plywood (1")                             |          | 2.25        | psf             | 177.75  | lbs   |                            |
| 1/2" gypsum board                        |          | 4           | psf             | 316     | lbs   |                            |
| Interior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 39.5    | lbs   |                            |
| Shipping Container                       |          | 5.16        | psf             | 407.64  | lbs   | <b>South Wall Total:</b>   |
| Curtain wall (72"x72")                   |          | 375.93      | lbs             | 375.93  | lbs   | 1316.82                    |
| <b>East Wall</b>                         |          |             |                 |         |       |                            |
| Area                                     |          | 261.28      | ft <sup>2</sup> |         |       |                            |
| Length                                   |          | 27.02       | ft              |         |       |                            |
| Height                                   |          | 9.67        | ft              |         |       |                            |
| Plywood (1")                             |          | 2.25        | psf             | 587.88  | lbs   |                            |
| Exterior 2x2 Furring strips (12" O.C.)   |          | 0.5         | psf             | 130.64  | lbs   |                            |

|  |   |        |                 |           |                                 |                  |                 |
|--|---|--------|-----------------|-----------|---------------------------------|------------------|-----------------|
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 130.64    | lbs                             |                  |                 |
| Awning Window (48"x14")                | 3 | 102    | lbs             | 306       | lbs                             |                  |                 |
| Casement Round Window (48" D)          | 1 | 215    | lbs             | 215       | lbs                             |                  |                 |
| (2"x4") Wood Siding                    |   | 3.5    | psf             | 914.48    | lbs                             |                  |                 |
| 1/2" gypsum board                      |   | 4      | psf             | 1045.12   | lbs                             | East Wall Total: |                 |
| Shipping Container                     |   | 5.16   | psf             | 1348.2048 | lbs                             | 4677.96          |                 |
| <b>West Wall</b>                       |   |        |                 |           |                                 |                  |                 |
| Area                                   |   | 195.04 | ft <sup>2</sup> |           |                                 |                  |                 |
| Length                                 |   | 27.02  | ft              |           |                                 |                  |                 |
| Height                                 |   | 9.67   | ft              |           |                                 |                  |                 |
| Plywood (1")                           |   | 2.25   | psf             | 438.84    | lbs                             |                  |                 |
| Exterior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 97.52     | lbs                             |                  |                 |
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5    | psf             | 97.52     | lbs                             |                  |                 |
| Casement Window (24"x48")              | 1 | 136    | lbs             | 136       | lbs                             |                  |                 |
| Sliding Barn Door (36"x84")            | 2 | 147    | lbs             | 294       | lbs                             |                  |                 |
| (2"x4") Wood Siding                    |   | 3.5    | psf             | 682.64    | lbs                             | West Wall Total: |                 |
| 1/2" gypsum board                      |   | 4      | psf             | 780.16    | lbs                             | 2526.68          |                 |
| <b>Bedroom/Office Floor</b>            |   |        |                 |           |                                 |                  |                 |
| Area                                   |   | 208    | ft <sup>2</sup> |           |                                 |                  |                 |
| Length                                 |   | 26     | ft              |           |                                 |                  |                 |
| Width                                  |   | 8      | ft              |           |                                 |                  |                 |
| Container Floor                        |   | 5.16   | psf             | 1073.28   | lbs                             |                  |                 |
| Insulation                             |   | 0.5    | psf             | 104       | lbs                             | Floor Total:     |                 |
| 1" Plywood Floor                       |   | 2.25   | psf             | 468       | lbs                             | 1645.28          |                 |
|  |   |        |                 |           | <b>Bedroom/Office Container</b> |                  | <b>11423.63</b> |

Table 3.1 D

| LIVING ROOM CRANE WEIGHT CALCULATIONS |          |             |                 |         |       |                                |
|---------------------------------------|----------|-------------|-----------------|---------|-------|--------------------------------|
| Item                                  | Quantity | Measurement | Units           | Total   | Units | Grand Total (lbs)              |
| <b>Living Room Roof</b>               |          |             |                 |         |       |                                |
| Area with Overhang                    |          | 676.2       | ft <sup>2</sup> |         |       |                                |
| Area without Overhang                 |          | 475         | ft <sup>2</sup> |         |       |                                |
| Roofing Material                      |          | 2           | psf             | 1352.4  | lbs   |                                |
| Solar Panels                          | 24       | 39.68       | lbs             | 952.32  | lbs   |                                |
| Plywood (1")                          |          | 2.25        | psf             | 1521.45 | lbs   | <b>Living Room Roof Total:</b> |
| 8" C-Channel                          | 16       | 79.68       | lbs             | 1274.88 | lbs   | 5101.05                        |
| <b>Living Room</b>                    |          |             |                 |         |       |                                |
| <b>Upper North Wall</b>               |          |             |                 |         |       |                                |
| Area                                  |          | 73.96       | ft <sup>2</sup> |         |       |                                |
| Length                                |          | 25.33       | ft              |         |       |                                |
| Height                                |          | 2.92        | ft              |         |       |                                |
| 12" Steel Boxed Header Beam           | 1        | 217.87      | lbs             | 217.87  | lbs   |                                |
| 5 1/2" Steel Studs                    | 1        | 111.19      | lbs             | 111.19  | lbs   |                                |
| 1/2" Gypsum Board                     |          | 4           | psf             | 295.85  | lbs   |                                |
| Curtain Wall                          | 1        | 554.19      | lbs             | 554.19  | lbs   | <b>Upper North Wall Total:</b> |
| Insulation Closed Cell (4")           |          | 0.5         | psf             | 36.9818 | lbs   | 1216.09                        |
| <b>Lower North Wall</b>               |          |             |                 |         |       |                                |
| Area                                  |          | 130.67      | ft <sup>2</sup> |         |       |                                |
| Length                                |          | 14.25       | ft              |         |       |                                |
| Height                                |          | 9.17        | ft              |         |       |                                |
| Insulation Closed Cell (4")           |          | 0.5         | psf             | 65.34   | lbs   |                                |
| 1/2" gypsum board                     |          | 4           | psf             | 522.69  | lbs   |                                |
| 5 1/2" Steel Studs                    | 1        | 83.25       | lbs             | 83.25   | lbs   | <b>Lower North Wall Total:</b> |
| Shipping Container                    | 1        | 1043.46     | lbs             | 1043.46 | lbs   | 1714.74                        |
| <b>South Wall</b>                     |          |             |                 |         |       |                                |
| Area                                  |          | 55.02       | ft <sup>2</sup> |         |       |                                |
| Length                                |          | 6           | ft              |         |       |                                |
| Height                                |          | 9.17        | ft              |         |       |                                |
| 1/2" Gypsum Board                     |          | 4           | psf             | 220.08  | lbs   |                                |
| 10" Steel Boxed Header Beam           | 1        | 190.5       | lbs             | 190.5   | lbs   |                                |
| 5 1/2" Steel Studs                    | 1        | 111.19      | lbs             | 111.19  | lbs   |                                |

|                             |   |        |                 |        |     |                             |
|-----------------------------|---|--------|-----------------|--------|-----|-----------------------------|
| Casement Window (24" x 48") | 1 | 136    | lbs             | 136    | lbs | South Wall Total:<br>766.77 |
| Single Flush Door           | 1 | 109    | lbs             | 109    | lbs |                             |
| <b>East Wall</b>            |   |        |                 |        |     |                             |
| Area                        |   | 99.56  | ft <sup>2</sup> |        |     |                             |
| 1/2" Gypsum Board           |   | 4      | psf             | 398.24 | lbs |                             |
| 5 1/2" Steel Studs          | 1 | 116.82 | lbs             | 116.82 | lbs |                             |
| Insulation Closed Cell (4") |   | 0.5    | psf             | 49.78  | lbs |                             |
| Single Flush Door           | 1 | 105    | lbs             | 105    | lbs | East Wall Total:            |
| Curtain Wall                | 1 | 136.35 | psf             | 136.35 | lbs | 806.19                      |
| <b>West Wall</b>            |   |        |                 |        |     |                             |
| Area                        |   | 43.41  | ft <sup>2</sup> |        |     |                             |
| 5 1/2" Steel Studs          | 1 | 72.24  | lbs             | 72.24  | lbs |                             |
| 1/2" Gypsum Board           |   | 4      | psf             | 173.64 | lbs |                             |
| Insulation Closed Cell (4") |   | 0.5    | psf             | 21.705 | lbs | West Wall Total:            |
| Curtain Wall                | 1 | 136.35 | lbs             | 136.35 | lbs | 403.94                      |
| <b>Floor</b>                |   |        |                 |        |     |                             |
| Area                        |   | 387    | ft <sup>2</sup> |        |     |                             |
| 10" Steel C-Channel         |   | 5.86   | plf             | 0      | lbs |                             |
| Plywood (1")                |   | 2.25   | psf             | 870.75 | lbs |                             |
| Finished Floor              |   |        | psf             | 0      | lbs | Floor Total:                |
| Insulation Closed Cell (4") |   | 0.5    | psf             | 193.5  | lbs | 1064.25                     |
| <b>Living Room Total:</b>   |   |        |                 |        |     | <b>10008.77</b>             |

Table 3.1 E

| KITCHEN / BATHROOM / MECHANICAL ROOM CRANE WEIGHT CALCULATIONS |          |              |                 |           |       |                            |
|--|----------|--------------|-----------------|-----------|-------|----------------------------|
| Item   | Quantity | Measurements | Units           | Total     | Units | Grand Total (lbs)          |
| <b>Kitchen/Bathroom/Mechanical Roof</b>                        |          |              |                 |           |       |                            |
| Area with Overhang   |          | 329.23       | ft <sup>2</sup> |           |       |                            |
| Area without Overhang  |          | 280          | ft <sup>2</sup> |           |       |                            |
| Roofing Material   |          | 3            | psf             | 987.69    | lbs   |                            |
| Plywood (1")   |          | 2.25         | psf             | 740.7675  | lbs   |                            |
| 2x4 stud frame (24" O.C.)                                      |          | 1.65         | psf             | 543.2295  | lbs   | <b>Bedroom Roof Total:</b> |
| Shipping Container   |          | 5.16         | psf             | 1698.8268 | lbs   | 3970.5138                  |
| <b>Bedroom/Office Container</b>                                |          |              |                 |           |       |                            |
| <b>North Wall</b>  |          |              |                 |           |       |                            |
| Area   |          | 101.54       | ft <sup>2</sup> |           |       |                            |
| Length   |          | 10.5         | ft              |           |       |                            |
| Height   |          | 9.67         | ft              |           |       |                            |
| Plywood (1")   |          | 2.25         | psf             | 228.465   | lbs   |                            |
| Interior 2x2 Furring strips (12" O.C.)                         |          | 0.5          | psf             | 50.77     | lbs   |                            |
| 1/2" gypsum board  |          | 4            | psf             | 406.16    | lbs   |                            |
| Single-flush Door (36"x84")                                    | 1        | 105          | lbs             | 105       | lbs   | <b>North Wall Total:</b>   |
| Shipping Container   |          | 5.16         | psf             | 523.9464  | lbs   | 1314.3414                  |
| <b>South Wall</b>  |          |              |                 |           |       |                            |
| Area   |          | 343.29       | ft <sup>2</sup> |           |       |                            |
| Length   |          | 35.5         | ft              |           |       |                            |
| Height   |          | 9.67         | ft              |           |       |                            |
| Plywood (1")   |          | 2.25         | psf             | 772.4025  | lbs   |                            |
| 1/2" gypsum board  |          | 4            | psf             | 1373.16   | lbs   |                            |
| Interior 2x2 Furring strips (12" O.C.)                         |          | 0.5          | psf             | 171.645   | lbs   |                            |
| Shipping Container   |          | 5.16         | psf             | 1771.3764 | lbs   |                            |
| Exterior 2x2 Furring strips (12" O.C.)                         |          | 0.5          | psf             | 171.645   | lbs   |                            |
| Casement Window (24"x42")                                      | 3        | 119          | lbs             | 357       | lbs   |                            |
| Awning Window (48"x18")  | 1        | 102          | lbs             | 102       | lbs   | <b>South Wall Total:</b>   |
| (2"x4") Wood Siding  |          | 3.5          | psf             | 1201.515  | lbs   | 5920.7439                  |
| <b>East Wall</b>   |          |              |                 |           |       |                            |
| Area   |          | 79           | ft <sup>2</sup> |           |       |                            |

|  |   |      |                 |         |                                 |                  |
|--|---|------|-----------------|---------|---------------------------------|------------------|
| Length                                 |   | 8.17 | ft              |         |                                 |                  |
| Height                                 |   | 9.67 | ft              |         |                                 |                  |
| Plywood (1")                           |   | 2.25 | psf             | 177.75  | lbs                             |                  |
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5  | psf             | 39.5    | lbs                             |                  |
| 1/2" gypsum board                      |   | 4    | psf             | 316     | lbs                             |                  |
| Shipping Container                     |   | 5.16 | psf             | 407.64  | lbs                             |                  |
| (2"x4") Wood Siding                    |   | 3.5  | psf             | 276.5   | lbs                             | East Wall Total: |
| Exterior 2x2 Furring strips (12" O.C.) |   | 0.5  | psf             | 39.5    | lbs                             | 1256.89          |
| <b>West Wall</b>                       |   |      |                 |         |                                 |                  |
| Area                                   |   | 79   | ft <sup>2</sup> |         |                                 |                  |
| Length                                 |   | 8.17 | ft              |         |                                 |                  |
| Height                                 |   | 9.67 | ft              |         |                                 |                  |
| Plywood (1")                           |   | 2.25 | psf             | 177.75  | lbs                             |                  |
| Exterior 2x2 Furring strips (12" O.C.) |   | 0.5  | psf             | 39.5    | lbs                             |                  |
| Interior 2x2 Furring strips (12" O.C.) |   | 0.5  | psf             | 39.5    | lbs                             |                  |
| Casement Window (24"x42")              | 2 | 119  | lbs             | 238     | lbs                             |                  |
| (2"x4") Wood Siding                    |   | 3.5  | psf             | 276.5   | lbs                             |                  |
| 1/2" gypsum board                      |   | 4    | psf             | 316     | lbs                             | West Wall Total: |
| 3 1/2" Steel stud                      |   | 1.31 | psf             | 103.49  | lbs                             | 1012.99          |
| <b>Bedroom/Office Floor</b>            |   |      |                 |         |                                 |                  |
| Area                                   |   | 208  | ft <sup>2</sup> |         |                                 |                  |
| Length                                 |   | 26   | ft              |         |                                 |                  |
| Width                                  |   | 8    | ft              |         |                                 |                  |
| Container Floor                        |   | 5.16 | psf             | 1073.28 | lbs                             |                  |
| Insulation                             |   | 0.5  | psf             | 104     | lbs                             | Floor Total:     |
| 1" Plywood Floor                       |   | 2.25 | psf             | 468     | lbs                             | 1645.28          |
|  |   |      |                 |         | <b>Bedroom/Office Container</b> |                  |
|  |   |      |                 |         | 11150.25                        |                  |

Table 3.1 F

| C-CHANNEL FRAME CRANE WEIGHT CALCULATIONS |          |             |                 |        |       |                   |
|---|----------|-------------|-----------------|--------|-------|-------------------|
| Item                                      | Quantity | Measurement | Units           | Total  | Units | Grand Total (lbs) |
| <b>Decks</b>                              |          |             |                 |        |       |                   |
| West Deck                                 | 145      |             | ft <sup>2</sup> |        |       |                   |
| 10" Steel C-Channel                       | 5.86     |             | plf             | 849.7  | lbs   | Floor Total:      |
| Finished Decking                          | 3.5      |             | psf             | 507.5  | lbs   | 1357.2            |
| East Deck                                 | 158      |             | ft <sup>2</sup> |        |       |                   |
| 10" Steel C-Channel                       | 5.86     |             | plf             | 925.88 | lbs   | Floor Total:      |
| Finished Decking                          | 3.5      |             | psf             | 553    | lbs   | 1478.88           |
| <b>Living Room Floor</b>                  |          |             |                 |        |       |                   |
| Area 1                                    | 137      |             | ft <sup>2</sup> |        |       |                   |
| 10" Steel C-Channel                       | 5.86     |             | plf             | 802.82 | lbs   |                   |
| Plywood (1")                              | 2.25     |             | psf             | 308.25 | lbs   |                   |
| Finished Floor                            | 2.1      |             | psf             | 287.7  | lbs   | Floor Total:      |
| Insulation Closed Cell (4")               | 0.5      |             | psf             | 68.5   | lbs   | 1467.27           |
| Area 2                                    | 92       |             | ft <sup>2</sup> |        |       |                   |
| 10" Steel C-Channel                       | 5.86     |             | plf             | 539.12 | lbs   |                   |
| Plywood (1")                              | 2.25     |             | psf             | 207    | lbs   |                   |
| Finished Floor                            | 2.1      |             | psf             | 193.2  | lbs   | Floor Total:      |
| Insulation Closed Cell (4")               | 0.5      |             | psf             | 46     | lbs   | 985.32            |
| Area 3                                    | 68       |             | ft <sup>2</sup> |        |       |                   |
| 10" Steel C-Channel                       | 5.86     |             | plf             | 398.48 | lbs   |                   |
| Plywood (1")                              | 2.25     |             | psf             | 153    | lbs   |                   |
| Finished Floor                            | 2.1      |             | psf             | 142.8  | lbs   | Floor Total:      |
| Insulation Closed Cell (4")               | 0.5      |             | psf             | 34     | lbs   | 728.28            |

### 3.1.2 Lift Points

#### 3.1.2.1 Specifications

The house will be lifted up with straps that are specified by the craning company. To lift the different sections of the house, the straps will be attached to the corners. In addition to corners, straps will also be placed along sides to prevent buckling.



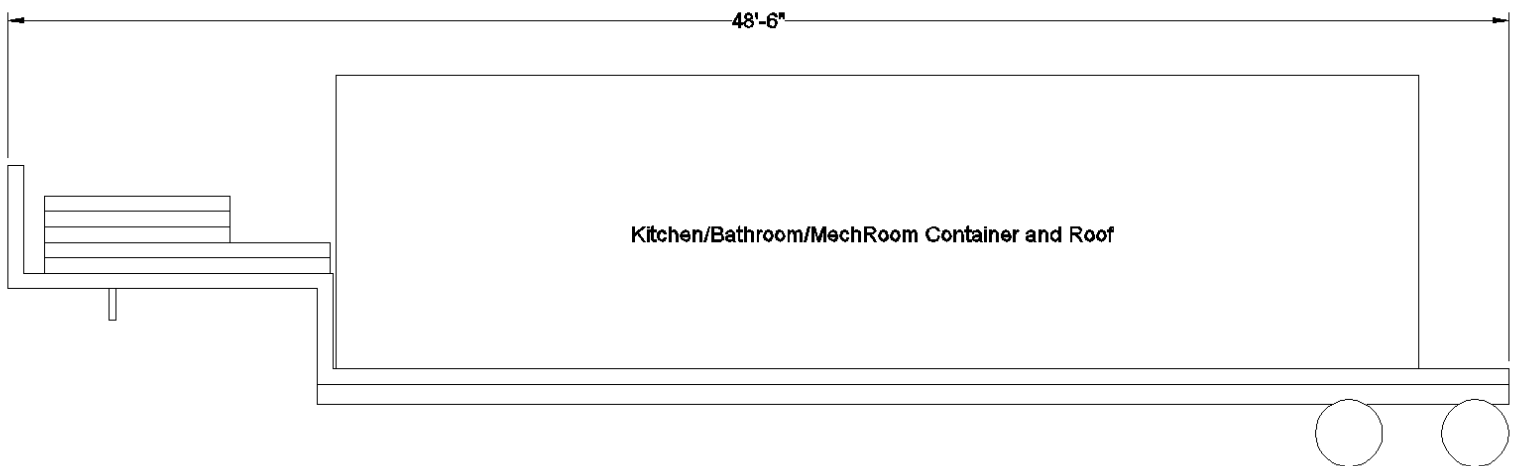
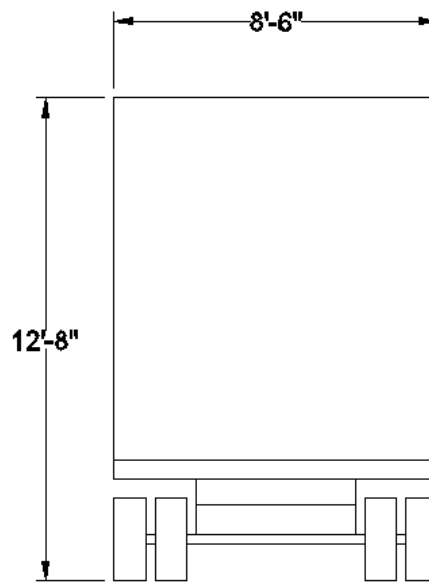
### 3.1.2.2 Loads

Refer to Table 3.1 A.

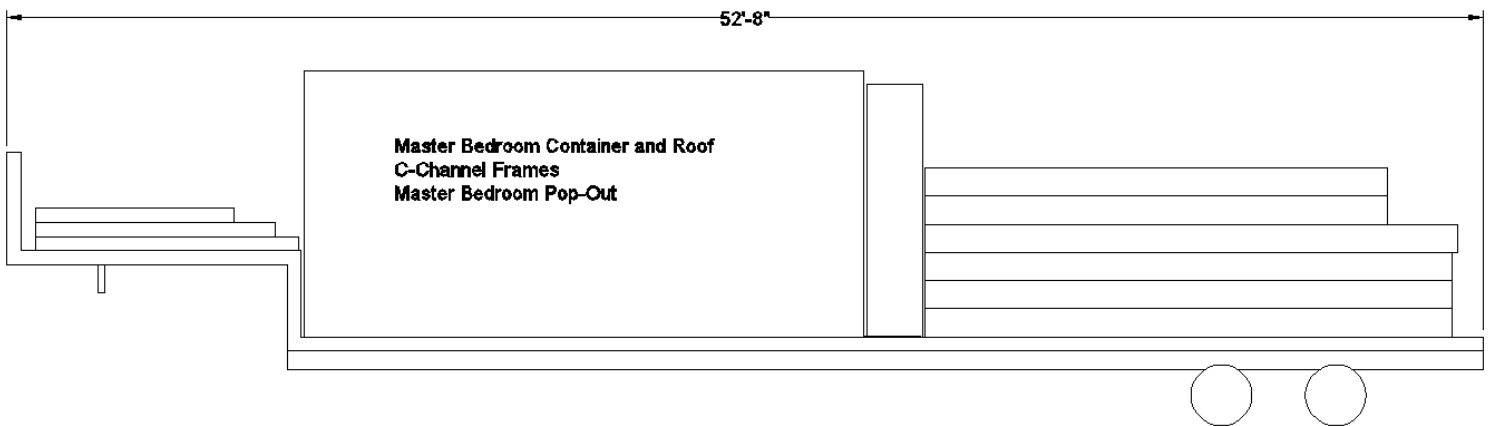
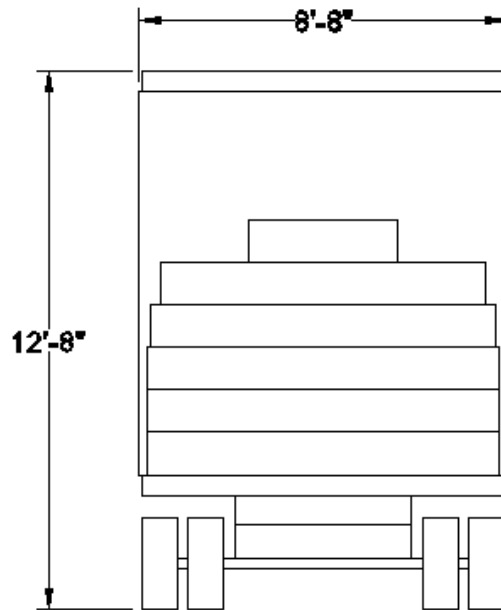
## 4. Trucking

### 4.1 Section Diagram

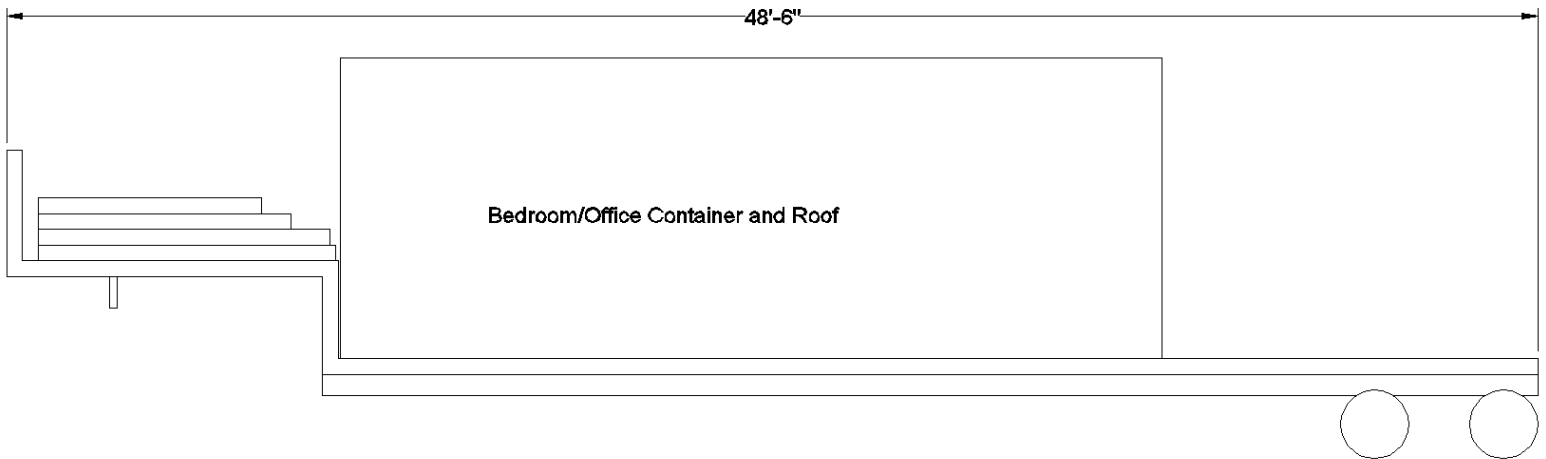
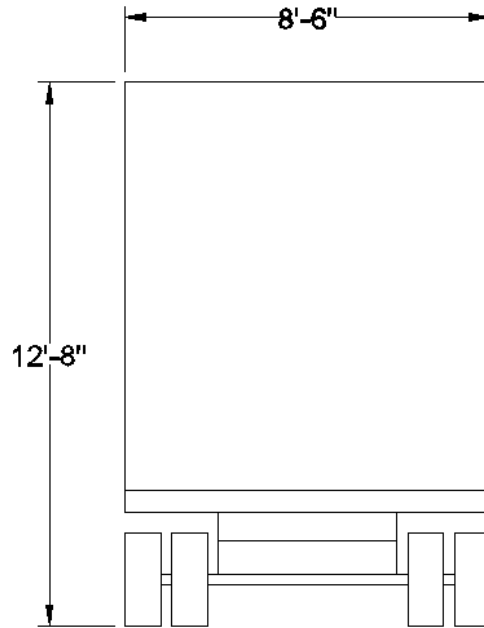
#### 4.1.1 Kitchen/Bathroom/Mechanical Trailer



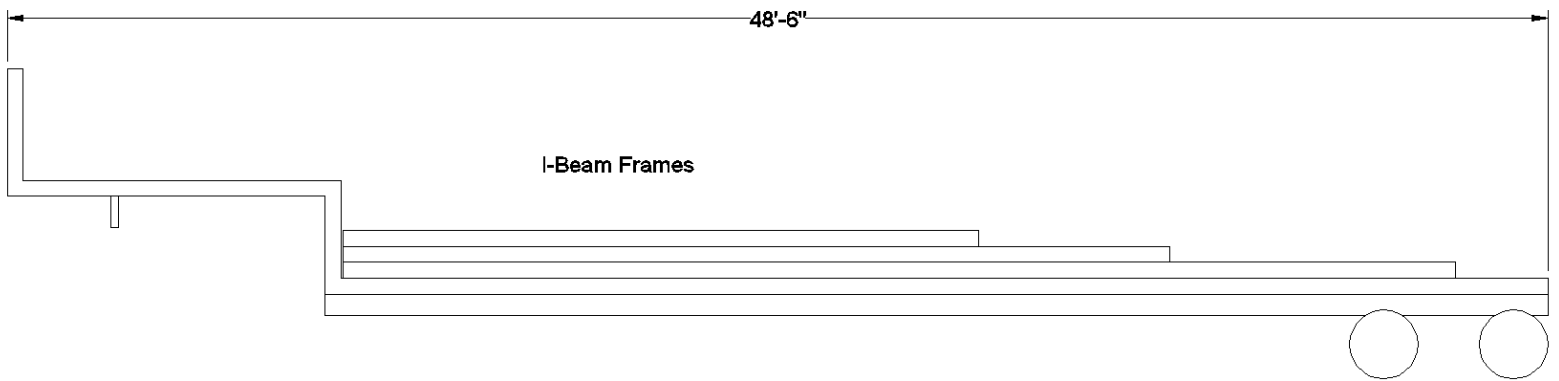
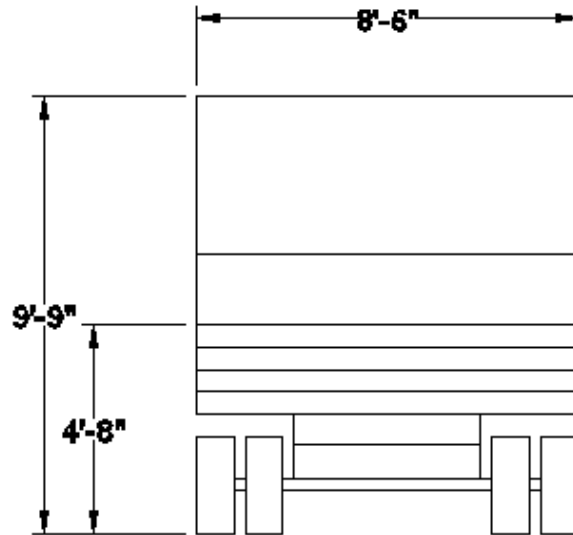
### 4.1.2 Master Bedroom Trailer



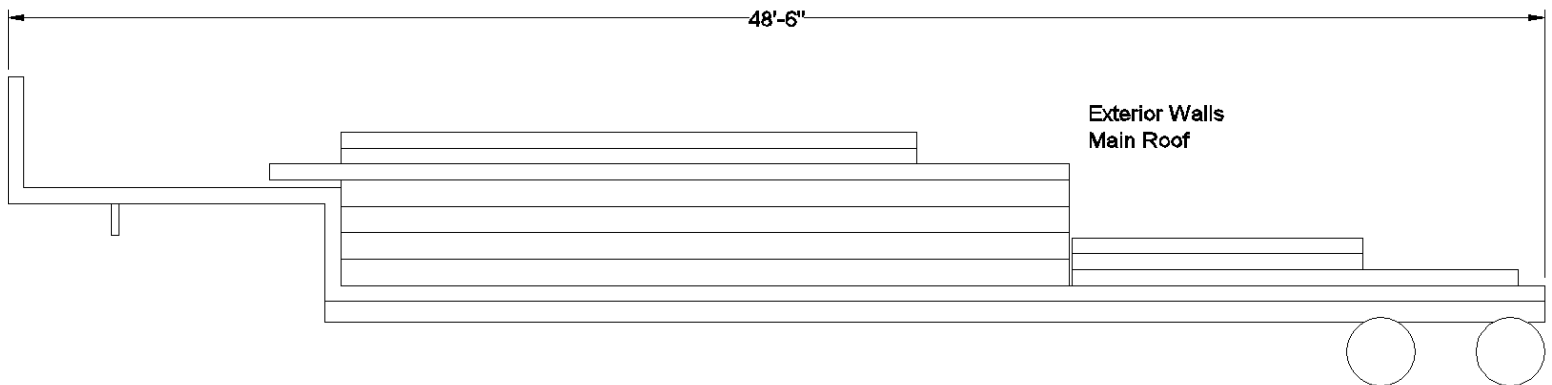
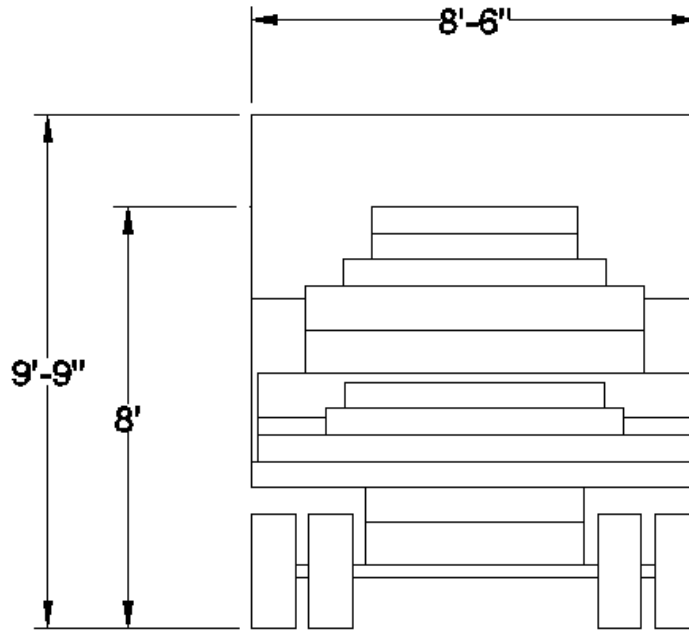
### 4.1.3 Office/Bedroom Trailer



#### 4.1.4 I-Beam Trailer



#### 4.1.5 C-Channel/Exterior Wall Trailer



# **APPENDIX C**

## **U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2015 RULES**



U.S. DEPARTMENT OF ENERGY  
**SOLAR DECATHLON**

# **RULES**

Last Updated: September 23, 2014

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## SECTION I: DEFINITIONS

### **Assembly**

The period of time between the allowed arrival of trucks on site 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

### **Contest official**

An [organizer](#) 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 who has 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 who is also considered a [rules official](#)

## **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 contest**

A [contest](#) based on a [jury](#) evaluation

## **Juror**

An [organizer](#) selected by the [director](#) to make subjective evaluations of specific aspects of each [team's](#) [competition prototype](#)

## **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**

An [organizer](#), assigned by the [competition manager](#) to observe team activities during [contest week](#), who reports observed [rules](#) infractions to the [rules officials](#) and records the results of specific [contest](#) tasks, but does not provide interpretations of the rules

## **Organizer**

A DOE or NREL employee, subcontractor, [juror](#) or [observer](#) working on the [project](#)

## **Project**

All activities related to the U.S. Department of Energy Solar Decathlon 2015—from the issuance of the request for proposals through the closing of subcontracts

## **Protest resolution committee**

A group of three [organizers](#) selected by the [director](#) to resolve team protests during the [competition](#)

## **Public exhibit**

Areas of the competition site open to the public during designated hours

## **Qualified Electrical Worker**

A [team member](#) who has met OSHA 29 CFR Part 1910, Subpart S Electrical 1910.399 requirements for qualified electrical work on the [competition site](#); only qualified electrical workers will be permitted to work on teams' electrical systems on the [competition site](#)

## **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**

An organizer selected by the [competition manager](#) to operate the [scoring server](#) during the [competition](#)

## **Scoring server**

A server that collects data from the central datalogger server and calculates composite scores; includes forms for manually entering juried and task-based measured [contest](#) results

## **Site operations manager**

The [organizer](#) responsible for all [event](#) site operations, such as implementation and management of the [village grid](#) and movement of construction vehicles, 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**

An individual working for the [organizers](#) on the [project](#) whose role is not described elsewhere in these definitions.

## **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 [team member](#) who is involved with a team's [project](#) who may be unaffiliated with a participating school; school staff, 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 [team crew](#) are all considered team members

**Village grid**

The bi-directional, 60-hz AC electrical network on the [competition](#) site to which each house has an individually metered connection

**Volunteer**

An individual selected by the [volunteer coordinator](#) to support activities on the [competition site](#) but who is not affiliated with a [team](#) and whose role is not described elsewhere in these definitions

**Volunteer coordinator**

An [organizer](#) selected by the [event production manager](#) to manage [volunteer](#) activities on the [competition site](#)

**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. Each rules official is authorized to revise the project schedule, change a team's score, and enforce the rules in any manner that is, in his or her sole judgment, required for the fair and efficient operation or safety of the competition.

- 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. 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/SD2015>): Official communications suitable for viewing by all teams and organizers are posted on the Yahoo Group message board. The Yahoo Group includes a section for posting files. If files are too large for the Yahoo Group, they are posted on the FTP site or in the uplink, 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.

<sup>1</sup> Members of the public without access to the Yahoo Group who are interested in receiving the rules and any documents referenced by the rules may email a request to the competition manager at [sdrules@nrel.gov](mailto:sdrules@nrel.gov).

- 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. **Uplink** (<http://hightail.com/u/solardecathlon>): The uplink 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 expected 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 database on the Yahoo Group 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 that are 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 Yahoo Group and update the scoring server when a penalty has been assessed against any team. The notification shall include the identity of the team receiving the penalty; an indication of the specific rule violation; a brief description of the infraction, including its severity; and the penalty to be applied.

## 2-8. Protests

- a. 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.
- b. 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.
- c. 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 p.m. Pacific Time on the final day of contest week.
- d. **Exception:** The results of one or more contests or 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.
- e. The protest shall be submitted to a rules official in a sealed envelope or emailed to the competition manager at [sdrules@nrel.gov](mailto:sdrules@nrel.gov). If submitted electronically, the protest shall be attached as a PDF to the email and the email subject should include “Solar Decathlon 2015 Protest” and the name of the team submitting the protest. The protest 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.
- f. 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 team’s 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 reads the protest in private. No appearance by the competition manager, rules officials, 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 shall call the decathlete who submitted the protest for testimony to fully understand the protest. The committee may choose to call additional individuals for testimony, including the competition manager, after speaking with the decathlete who filed the protest.
  - 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, if any. The decision of the committee is final and no further appeals are allowed. The director may not modify the decision of the committee.
  - 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 via the Yahoo Group 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 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. Decathletes must fill all other team officer positions.

**Table 1: Team officers**

| Title                        | Responsibilities  |
|------------------------------|---|
| 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; 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 organizers’ equipment   |
| Electrical engineer          | Completes the Interconnection Application and works in conjunction with the site operations manager to interconnect the house to the village 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. Individuals 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, and violations are subject to penalty points. 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, the use of alcohol, and the use of illegal substances will not be tolerated and will be considered a rules violation subject to Rule 2-7. Improper conduct may include, but is not limited to, improper language, unsportsmanlike conduct, unsafe behavior, distribution of inappropriate media, and cheating.

### 3-5. Use of Likeness, Content, and Images

Team members 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 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 deliverables may be made publicly available any time after their receipt by the organizers.

### 3-6. Withdrawals

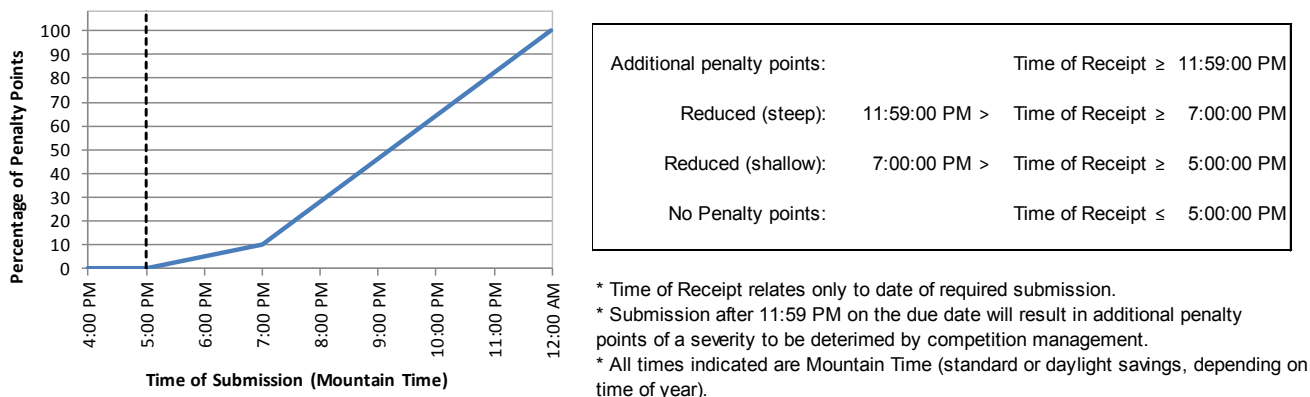
Any team wishing to withdraw from the project must notify the competition manager in writing. Teams considering withdrawal are encouraged to communicate early and frequently with the competition manager. All written withdrawals signed by a faculty advisor are final.

### 3-7. Deliverables

Teams are required to submit all deliverables associated with the project as described in Appendix D and summarized in the “Deliverable Status Sheet”<sup>2</sup> available on the Yahoo Group. All deliverables shall be submitted on time and complete. All deliverables are due by 5 p.m. Mountain Time on the dates indicated within the “Deliverable Status Sheet.” Following initial submission, organizers will review the deliverables and provide comments to teams approximately 3 weeks after submission. For deliverables that allow resubmission, revised deliverables that correct all issues will be due at 5 p.m. Mountain Time 14 days after receipt of comments. Eventual approval of all deliverables is required for competition participation.

<sup>2</sup> The Deliverable Status Sheet is available on the Yahoo Group and is updated throughout the project to indicate receipt and approval status

Penalty points for late submissions still received on the due date are scaled linearly, as shown in Figure 1. The penalty associated with same-day late submission of each deliverable is indicated on the “Deliverable Status Sheet”; however, additional penalty points may be assigned for failure to meet submission requirements beyond the scenarios indicated in Figure 1, including incomplete but on-time deliverables and deliverables received after the due date.



**Figure 1: Scoring function for deliverables**

## *Rule 4. Site Operations*

### **4-1. Damage Liability**

Each team is financially responsible for any damage it causes to the competition site, except as allowed under Rule 4-3.

### **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 approved method for tie-downs needed to meet wind loading and seismic requirements. Ground penetrations should be minimized and must be approved by the organizers prior to arrival at the competition site. All other ground penetrations shall not be permitted.

- a. 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 shall 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

A vertical elevation change of up to 22 in. (55.88 cm) may exist across a lot. Organizers will provide topographical maps of the site and indication of team lot location. Exact placement of team lots may vary by up to 5 ft. (1.524 m) and lots may vary within the tolerances of a 6 in. (15.24 cm) topographical survey. Teams must design adjustable foundations and plan accordingly to meet the specific conditions of the site.

#### 4-8. Electric Vehicles

Teams are expected to provide an electric vehicle within their solar envelopes 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 half hour prior to, one half hour after, and throughout all public exhibit periods.
- c. The competition prototype house must include the infrastructure required to charge the vehicle.
- d. Any vehicle used must be commercially available to all teams at the beginning of contest week.
- e. The vehicle must be listed on the DOE Energy Efficiency & Renewable Energy [all-electric vehicles website](#).
- f. The vehicle must have four wheels and, at a minimum, seat two individuals side by side.
- g. The vehicle must be licensed, registered, and insured as required for operation on Orange County, CA, roadways.

### *Rule 5. The Solar Envelope*

#### 5-1. Lot Size

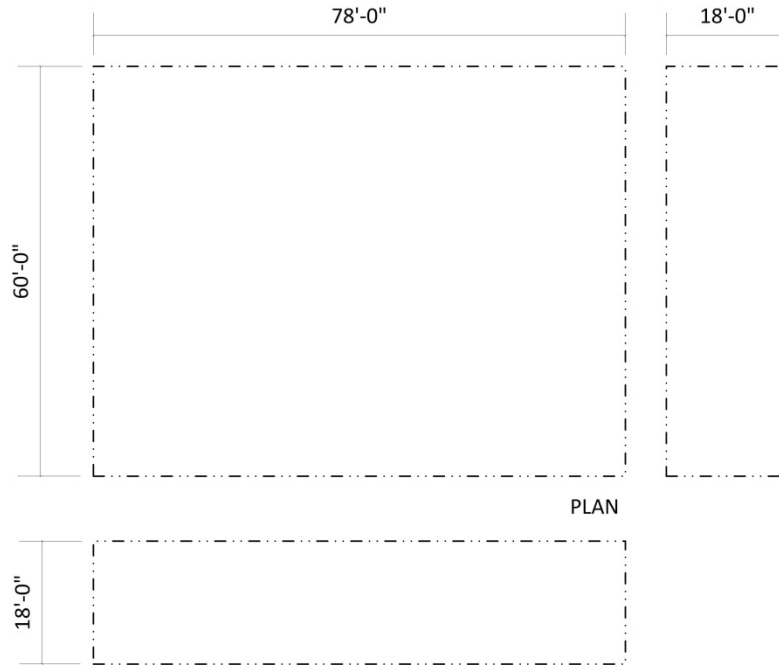
Lots are 78 ft. (23.8 m) east to west by 60 ft. (18.3 m) north to south.

#### 5-2. Solar Envelope Dimensions

The house and all site components on a team's lot must stay within the 18 ft. (5.486 m) height of the solar envelope shown in Figure 2. The north, south, east, and west planes of the solar envelope are vertical, i.e., slope of 90 degrees from horizontal.

- a. 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).
- b. 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:
  - i. The team makes a request to the competition manager for an exemption prior to the start of assembly.
  - ii. The team can prove to the competition manager's satisfaction that the component is not significantly restricting a neighbor's right to the sun.
  - iii. The competition manager determines that the component is sufficiently unique in function and small in size to warrant an exemption.
- c. 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.

- d. Any vehicle 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 2: 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 eligible for California registration reciprocity.

- 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.
- 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>).

- 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.
- For the purposes of the Solar Decathlon, all finished square footage built is included in the finished square footage calculation, regardless of whether or not the finished square footage is contiguous (i.e. attached to the main dwelling unit).

### **6-3. Entrance and Exit Routes**

- 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 as part of the competition prototype.



- b. The house exit route shall be accessible to the public and lead from the main house exit to one of the publically accessible streets of the solar village adjacent to the solar envelope.
- 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 lot equal in size and orientation to the solar envelope. 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, providing 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 element included in a competition prototype house that is not used during the competition, does not impact the performance of the house, and is not presented or visible to the juries in any way.

The cost estimator and juries will disregard the electric vehicle used as part of Contest 9. All required charging equipment and vehicle-associated structures, however, shall be included in their evaluations.

### ***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 the 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 village grid 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

Hardwired battery banks and large plug-in uninterruptible power supplies (UPS) are not permitted. Batteries include most commercially available energy storage devices, such as electrochemical batteries and capacitors.

- 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. The use of the factory-installed battery within the team’s electric vehicle is permitted for the operation of the electric vehicle only. Vehicle-to-grid power flow is not permitted.
- c. “Plug-in” (non-hardwired) 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 tablets, are permitted within the solar envelope without having to be plugged into the house’s electrical system.

- d. Stand-alone, PV-powered devices with small secondary batteries are permitted, but the aggregate battery capacity of these devices may not exceed 100 Wh.

## 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. All houses shall operate with an AC service of 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. Failure to have switched by this time will be considered a rule violation subject to Rule 2-7.

## 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.
- c. The team's electric vehicle shall begin and end the contest week with a fully charged battery. Failure to do so will be considered a rules violation and any difference measured will be considered as energy consumption within Contest 10.

# 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 beneath the finished square footage.  
**Exception:** Teams may utilize one or more small tanks up to a maximum aggregate volume of 20 gal (75.7 L) to accept wastewater discharge in preparation for delivery to the main wastewater tank(s).
- 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) 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 gal (189.2 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>3</sup>
- f. Assembly (e.g., hydraulic fluid), finishing (e.g., paint), and cleaning (e.g., mineral spirits).
- g. Teams may provide glycol, deionized water, or other working fluids for thermodynamic systems using working fluids other than non-potable water if approved by the organizers prior to arrival at the competition site.

## 9-3. Greywater Reuse

A team may reuse greywater for irrigation only.

<sup>3</sup> The water may only fill isolated loops; it shall not enter tanks.

**Exception:** Greywater reuse for other purposes may be approved by the Solar Decathlon Building Official on a case-by-case basis. Alternative purposes must be approved by the Solar Decathlon Building Official before the start of assembly on the competition site to be permitted.

- 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.

**Exception:** Rainwater reuse for other purposes may be approved by the Solar Decathlon Building Official on a case-by-case basis. Alternative uses must be approved by the Solar Decathlon Building Official before the start of assembly on the competition site.

#### **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 gal (5678.1 L) of water from the organizers in its detailed water budget.<sup>4</sup>

The procedure and associated requirements for water delivery follow.

- a. On water delivery day, two water trucks begin at the north ends of Decathlete Way in the morning and proceed to service each house. Each truck will be equipped with a pump to aid in water delivery.
- 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 visit 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.
- e. Team 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.

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<sup>4</sup> The detailed water budget shall be included in the Project Manual (see *Content Requirements* in Appendix D-5).

## 9-9. Water Removal

The procedure and associated requirements for water removal follow.

- a. On water removal day, two water trucks begin at the north Ends of Decathlete Way 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 visit 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. Team 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 participants**:
  - 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 access to the competition site.
  - iii. When registering, event participants must complete all required information and forms before access to the competition site is allowed.
- b. **Organizers, team members, 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.  
**Exception:** team crew are not required to provide a photo.
- c. **Visiting media** are not considered participants and will not be required to register, but must check in at registration 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>5</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.

<sup>5</sup> Solar Decathlon identity guidelines are available at: <http://www.solardecathlon.gov/commstandards>.

- 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. Inspections will occur only between the hours of 7 a.m. and 7 p.m. during the assembly period, but may be restricted further due to environmental constraints.
- b. 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.
- c. Additional random inspections for compliance shall take place throughout contest week.
- d. 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 may disqualify a team for participation in the event and will be considered a rules violation subject to Rule 2-7. 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.

**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.

- e. 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. Rule 11-1 is automatically suspended whenever the Comfort Zone Contest measurements are suspended. See Appendix A-3 for the Comfort Zone Contest schedule.
- b. 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.
- c. 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.
- b. Non-decathlete team members are permitted to give tours to the public and be present on the competition site.

## **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.
- 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.

## **11-4. Public Exhibit**

- a. Teams are required to provide an accessible route to all areas of the house and site that is 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 are encouraged to provide visitors a means to return the handout at the end of the tour for reuse.
- d. Teams shall develop signage that complements public exhibit tours by informing visitors about the team project and engaging visitors waiting in line.
- e. Teams are prohibited from selling items to the general public on the competition site.
- f. 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 shall not occupy the competition site during impound hours. There is a 10-minute impound grace period for teams to leave the competition site.

## SECTION III: CONTEST CRITERIA

The Solar Decathlon competition consists of 10 separately scored contests, and some contests contain one or more subcontests. For example, Contest 7: Appliances consists of six 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 | Contest or Subcontest Type | Brief Description  |
|----------------|-------------------|---------------------------|------------------|---|------------------|----------------------------|--|
| 1              | n/a               | Architecture <sup>6</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              | 7-1               | Appliances                | 100              | Refrigerator  | 10               | Measured   Monitored       | Keep refrigerator temperature in 34°F – 40°F (1°C – 4°C) range   |
|                | 7-2               |                           |                  | Freezer   | 10               | Measured   Monitored       | Keep freezer temperature in -20°F – 5°F (-29°C to -15°C) range   |
|                | 7-3               |                           |                  | Clothes Washer  | 16               | Measured   Task            | Successfully wash eight loads of laundry (one load = six bath towels) during contest week  |
|                | 7-4               |                           |                  | Clothes Drying  | 32               | Measured   Task            | Return eight loads of laundry to their original weight (one load = six bath towels) during contest week  |
|                | 7-5               |                           |                  | Dishwasher  | 17               | Measured   Task            | Successfully wash five loads of dishes (one load = eight place settings) during contest week   |
|                | 7-6               |                           |                  | Cooking   | 15               | Measured   Task            | Successfully perform five cooking tasks (one task = vaporize 5 lb or 2 kg of water in less than 2 hours) during contest week   |
| 8              | 8-1               | Home Life                 | 100              | Lighting  | 25               | Measured   Task            | All interior and exterior lights on at full levels at night  |
|                | 8-2               |                           |                  | Hot Water   | 50               | Measured   Task            | Successfully conduct 16 water draws during contest week [one water draw = deliver 15 gal (56.8 L) of water at average 110°F (43°C) temperature within 10 minutes]                              |
|                | 8-3               |                           |                  | Home Electronics  | 10               | Measured   Task            | Operate a TV and computer during specified hours   |
|                | 8-4               |                           |                  | Dinner Party  | 10               | Measured   Task            | Host two dinner parties for up to eight guests   |
|                | 8-5               |                           |                  | Movie Night   | 5                | Measured   Task            | Host neighbors to watch a movie on the home theater system   |
| 9              | n/a               | Commuting                 | 100              | n/a   | n/a              | Measured   Task            | Drive an electric vehicle at least 25 miles, eight times during contest week   |
| 10             | 10-1              | Energy Balance            | 100              | Energy Production   | 50               | Measured   Monitored       | Produce at least as much electrical energy (kWh) as is consumed during contest week  |
|                | 10-2              |                           |                  | Energy Consumption  | 50               | Measured   Monitored       | Consume less than 175 kWh of electrical energy during contest week   |
| <b>TOTALS</b>  |                   |                           | <b>1,000</b>     | <b>500 total juried points and 500 total measured points from 21 individually scored contest elements</b> |                  |                            |  |

<sup>6</sup> Lighting quality and lighting control evaluations are conducted by the Architecture, Market Appeal, and Engineering juries.

There are three ways to earn points:

- Jury evaluation
- Task completion
- Monitored performance.

Subcontests based on task completion or monitored performance are called measured subcontests.

Points for task completion, or measured performance, 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 contests 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 contests, 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 conceptual coherence, merit, integration 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:

### ***Architectural Concept and Design Approach***

- How well did the team utilize an overall clear concept, idea or ideas to guide the development of the whole design process?
- How well does the competition prototype house demonstrate overall coherence among architectural, structural, mechanical, electrical, plumbing, landscaping, and other related disciplines?
- How effectively will the overall architectural design offer a sense of inspiration and delight to Solar Decathlon visitors?

### ***Architectural Implementation and Innovation***

- To what degree was the team effective in its use of architectural elements including, but not limited to: scale and proportion, indoor/outdoor connections, composition, and linking of various house elements?
- How effectively did the team create a holistic and integrated design, inclusive of space, structure and building envelope; that will be comfortable for occupants and compatible with the surrounding environment in the target market climate?
- How well does the team integrate both natural and electric lighting into the competition prototype? For instance, 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?
- How well does the competition prototype demonstrate quality design through material selection, well-conceived details, and architectural implementation?<sup>7</sup>
- To what extent does the competition prototype take an innovative approach to addressing residential architecture?

### ***Documentation***

- How effectively 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?

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<sup>7</sup> The jury should consider the design, detailing and implementation from the perspective of a professionally constructed house. Student-built or installed elements should be evaluated as if they were professionally built and installed.



- How well do 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 Market Appeal jury narrative and project summary).

Teams shall define their target client with a minimum level of specificity as indicated in Table 3. The target market defined for the competition prototype house must be a primary residence intended for year-round occupancy.

### **Livability**

- How well does the design offer the intended occupant(s) a safe, functional, convenient, comfortable, and enjoyable place to live?
- How appropriate is the operation of the house’s lighting, entertainment, and other controls for the target client?
- How successfully does the design meet the unique needs and desires of the target client?

### **Marketability**

- How successfully does the house demonstrate exterior and interior appeal for the target client?
- How appropriate are the material, equipment, and detailing choices to the desires of the target client?
- How effectively does the team use sustainability features and strategies to make a positive contribution to the house’s marketability to the target client?
- To what extent does the house offer a good value to the target client?

### **Buildability**

- How effectively do the drawings and construction specifications enable, through sufficient quality and detail, a contractor to generate an accurate, detailed construction cost estimate?
- How effectively do the drawings and construction specifications enable, through sufficient quality and detail, a contractor to construct the building as the design team intended it to be built?

**Table 3: Examples of target client characteristics and requirements**

| Characteristic or Requirement | Example #1            | Example #2                         | Example #3         |
|-------------------------------|-----------------------|------------------------------------|--------------------|
| Location of permanent site    | Minot, ND             | Folsom, CA                         | Boston, MA         |
| Housing type                  | Remote worker housing | Single family                      | Single family      |
| # of occupants                | 2                     | 3                                  | 1                  |
| Client demographic            | Working professionals | Mid-30s married couple with infant | Retired individual |
| Client annual income          | \$85,000              | \$100,000                          | \$65,000           |
| # of bedrooms                 | 2                     | 3                                  | 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 project summary (see Appendix D).

### **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, 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:

#### ***Innovation***

- To what extent were unique approaches used to solve engineering design challenges?
- To what extent do the proposed innovations have true market potential?
- How well does the design demonstrate market-leading technologies and engineering integration?

#### ***Functionality***

- How well do the house systems function to enhance occupant comfort and house performance?
- How well will the HVAC system as designed maintain uniform thermal comfort conditions via temperature control, humidity control, air movement, and a successful distribution system design?
- How effective is the design of the HVAC system and thermal envelope in minimizing energy use while ensuring occupant comfort, including indoor air quality?

#### ***Efficiency***

- To what extent does the team consider energy efficiency and overall system performance as part of the competition prototype design? Relative to conventional systems, how much energy is the design expected to save over the course of an entire year?
- How effectively will house controls facilitate a reduction in energy consumption during an entire year of operation?
- How effective, efficient and practical is the design in its engineering approach?

#### ***Reliability***

- How well does the design address maintenance and owner operation of house systems?
- How long are the systems expected to operate at a high level of performance?

#### ***Documentation***

- How effectively did the drawings, construction specifications, energy analysis results and discussion, and audiovisual presentation enable the jury to conduct a preliminary evaluation of the design prior to its arrival at the competition site?
- How well do the drawings, construction specifications, energy analysis results and discussion, and audiovisual 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 efforts by reviewing the quality, delivery, and innovation of each team's final electronic communications, communications narrative, and audiovisual presentation (see Appendix D), and by evaluating the public exhibit materials, public exhibit, and communications summary presentation onsite (see Appendix B). The Communications Contest is designed to ensure that each team's communications materials educate the public about its project.

The jury will consider the following specific criteria:

### ***Communications Strategy***

- How well did the team's communications deliverables work together to convey a comprehensive, consistent, and integrated communications strategy?
- How effective are the team's educational and outreach messages about the Solar Decathlon, the team, and the competition prototype house?

### ***Electronic Communications (team website and social media)***

- How well does the team communicate its messages to online audiences?
- How well do the website's graphical elements and information architecture support a logical, consistent, enjoyable and successful user experience?
- How well does the team employ social media to achieve comprehensive and successful communications outreach?

### ***Public Exhibit Materials (on-site signage and handout)***

- How well do the signage and handout communicate the team's messages to visitors?
- How creative, original and informative are the team's public exhibit materials?
- How well does the team's handout align with its communications objectives as stated in the narrative?

### ***Public Exhibit Presentation***

- How informative, interesting, engaging, and audience-appropriate was the team's comprehensive tour?
- How effective was the team at describing their approach for an informative, interesting, engaging and audience-appropriate fast tour designed to accommodate large crowds and long lines?

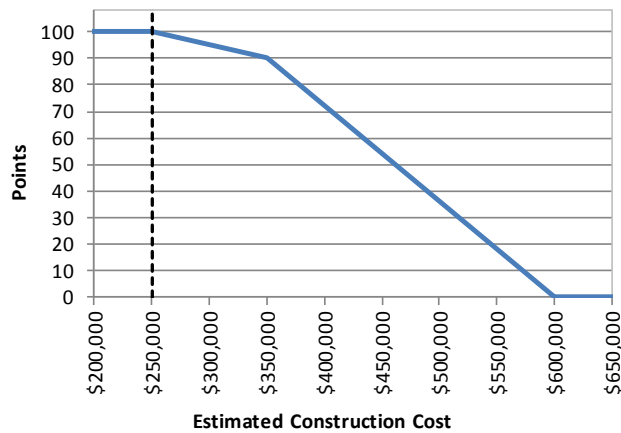
### ***Audiovisual Presentation***

- How interesting and informative was the audiovisual presentation of the team's house?
- How well does the audiovisual presentation explain to viewers what they're seeing and the philosophy behind the house design?
- How effectively does the audiovisual presentation showcase the completed, constructed as-built house as presented on the competition site?

## ***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.

- a. 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 3.
- b. When information necessary for completing a thorough, accurate estimate is missing, the estimators will err on the high side to accommodate for uncertainty.
- c. 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.
- d. Teams may submit a request to competition management to have the cost of a particular innovative technology included in their competition prototype considered equal to a market-ready equivalent. The procedures for submission of this request and approval are described in the Affordability Contest methodology document (see item "e" below).
- e. A file describing the estimating methodology is posted in the "/Files/Rules/Rules Reference Documents/" folder on the Yahoo Group.



|                           |                              |
|---------------------------|------------------------------|
| Full points:              | Cost ≤ \$250,000             |
| Reduced points (shallow): | \$250,000 < Cost ≤ \$350,000 |
| Reduced points (steep):   | \$350,000 < Cost < \$600,000 |
| No points:                | Cost ≥ \$600,000             |

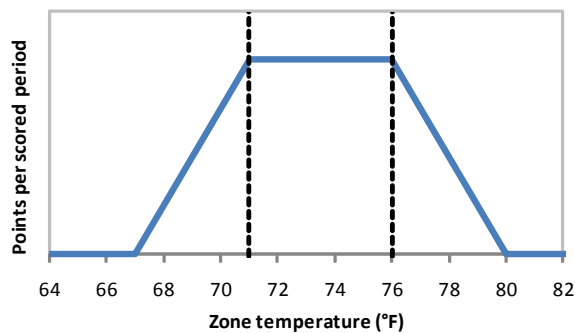
**Figure 3: Scoring function for the Affordability Contest**

## 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 4.
- 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.



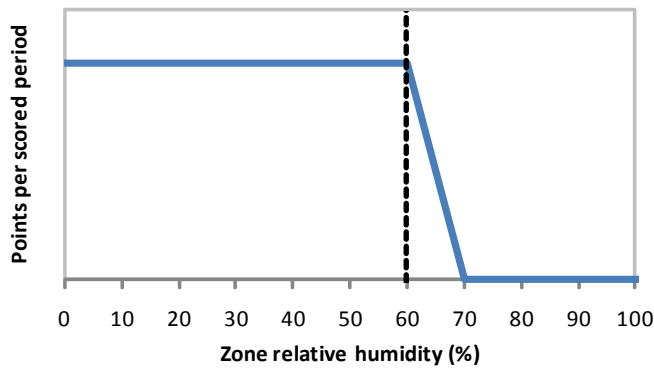
|                 |  |
|-----------------|--|
| Full points:    | 71 °F (22 °C) ≤ Temperature ≤ 76 °F (24 °C)    |
| Reduced points: | 67 °F (19 °C) < Temperature < 71 °F (22 °C)    |
|                 | or 76 °F (24 °C) < Temperature < 80 °F (27 °C) |
| No points:      | Temperature ≤ 67 °F (19 °C)                    |
|                 | or Temperature ≥ 80 °F (27 °C)                 |

**Figure 4: 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 5.
- b. In multi-zone houses, the zone humidity deviating farthest from the target humidity range is the zone humidity of record.



|                 |                                 |
|-----------------|---------------------------------|
| Full points:    | Relative humidity $\leq$ 60 %   |
| Reduced points: | 60 % < Relative humidity < 70 % |
| No points:      | Relative humidity $\geq$ 70 %   |

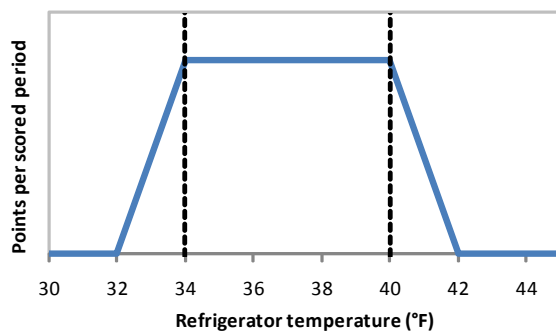
Figure 5: Scoring function for the Temperature Subcontest

## Contest 7. Appliances

### 7-1. 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.



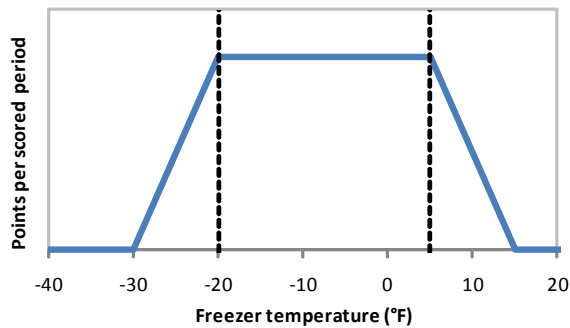
|                 |  |
|-----------------|--|
| Full points:    | 34 °F (1.1 °C) $\leq$ Temperature $\leq$ 40 °F (4.4 °C)  |
| Reduced points: | 32 °F (0 °C) < Temperature < 34 °F (1.1 °C)<br>or<br>40 °F (4.4 °C) < Temperature < 42 °F (5.6 °C) |
| No points:      | Temperature $\leq$ 32 °F (0 °C)<br>or<br>Temperature $\geq$ 42 °F (5.6 °C)                         |

Figure 5: Scoring function for the Refrigerator Subcontest

### 7-2. 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°F (-28.9°C) and 5.0°F (-15.0°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°F (-34.4°C) and -20.0°F (-28.9°C) or between 5.0°F (-15.0°C) and 15.0°F (-9.44°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 ft<sup>3</sup> (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).



|                 |  |
|-----------------|--|
| Full points:    | $-20\text{ }^{\circ}\text{F}\text{ }(-29\text{ }^{\circ}\text{C}) \leq \text{Temperature} \leq 5\text{ }^{\circ}\text{F}\text{ }(-15\text{ }^{\circ}\text{C})$   |
| Reduced points: | $-30\text{ }^{\circ}\text{F}\text{ }(-34\text{ }^{\circ}\text{C}) < \text{Temperature} < -20\text{ }^{\circ}\text{F}\text{ }(-29\text{ }^{\circ}\text{C})$<br>or<br>$5\text{ }^{\circ}\text{F}\text{ }(-15\text{ }^{\circ}\text{C}) < \text{Temperature} < 15\text{ }^{\circ}\text{F}\text{ }(-9.4\text{ }^{\circ}\text{C})$ |
| No points:      | $\text{Temperature} \leq -30\text{ }^{\circ}\text{F}\text{ }(-34\text{ }^{\circ}\text{C})$<br>or<br>$\text{Temperature} \geq 15\text{ }^{\circ}\text{F}\text{ }(-9.4\text{ }^{\circ}\text{C})$   |

**Figure 6: Scoring function for the Freezer Subcontest**

### 7-3. Clothes Washer

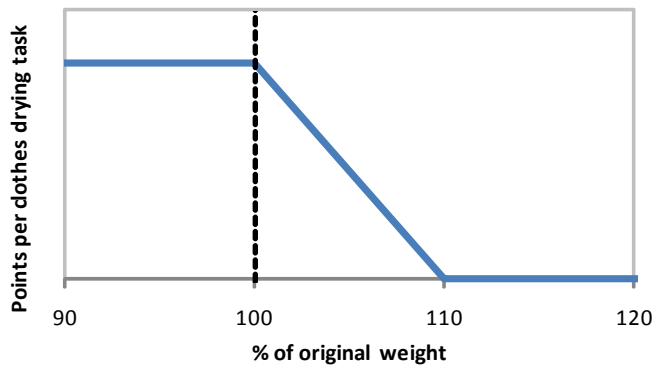
All available points are earned for washing laundry by running a clothes washer through one or more complete, uninterrupted, “normal” (or equivalent) cycles within a specified period of time. See Appendix A-3 for specific details regarding the number of points per clothes-washing task and the time periods 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) cycles 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.

### 7-4. Clothes Drying

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.
- A load of laundry is eligible for clothes-drying points only if the load experienced a complete, uninterrupted cycle (see Contest 7-3h for required cycle settings) in an automatic clothes washer.
- The drying method may include active drying (e.g., machine drying), passive drying, (e.g., on a clothesline), or any combination of active and passive drying. All drying methods that require the towels to be visible (such as on a clothesline) must be demonstrated to the Architecture and Market Appeal juries as they visit the houses.
- 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.



|                 |   |
|-----------------|---|
| Full points:    | % of original weight $\leq 100$           |
| Reduced points: | $100 < \text{% of original weight} < 110$ |
| No points:      | % of original weight $\geq 110$           |

**Figure 7: Scoring function for the Clothes Drying Subcontest**

## 7-5. Dishwasher

All available points are earned by running a dishwasher through a complete, uninterrupted, “normal” (or equivalent) cleaning 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.

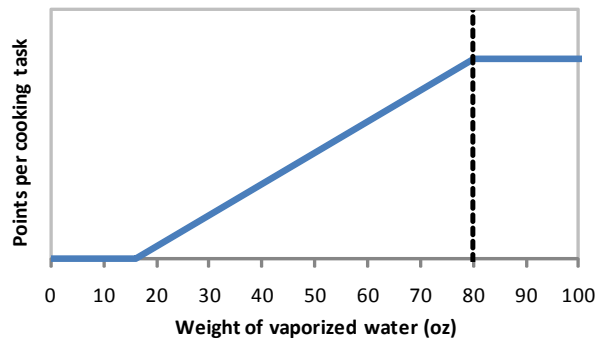
- Half of the available points are earned if the temperature sensor reaches 115°F (46.1°C), but does not reach 120°F (48.9°C).
- For redundancy, two temperature sensors shall be placed in the dishwasher for each test. The higher of the two readings is the temperature of record, unless it is determined that the sensor with the higher reading is defective, in which case the lower of the two readings is the temperature of record.
- 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.
- If the dishwasher has a heated drying option, this option shall be disabled.
- 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.
- Cycle completion shall be confirmed by the observance of an audible or visible signal.
- The teams shall consult the operation manual to identify appropriate cycle settings. The setting chosen shall be a complete wash cycle. “Normal” or “regular” settings shall be selected, if available. Otherwise, settings most closely resembling typical “normal” or “regular” settings shall be selected.
- The dishwasher may be run empty, partially loaded, or fully loaded; the load may be soiled or clean.

## 7-6. 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.

- 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.
- Any kitchen appliance may be used, but it must operate in its normal configuration as it is vaporizing the water.
- The water shall be vaporized in a single container and the starting water weight shall be at least 96.00 oz (2.721 kg).





|                 |   |
|-----------------|---|
| Full points:    | Weight $\geq$ 80 oz (2300 g)            |
| Reduced points: | 16 oz (450 g) < Weight < 80 oz (2300 g) |
| No points:      | Weight $\leq$ 16 oz (450 g)             |

Figure 8: Scoring function for the Cooking Subcontest

## Contest 8. Home Life

### 8-1. 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.

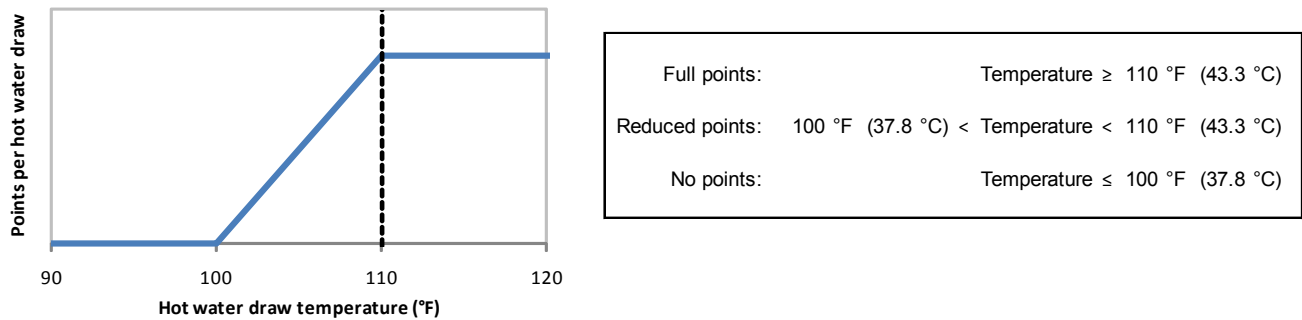
- All dimmers shall be adjusted to their highest positions and all other lighting control equipment shall be disabled or overridden so that the controlled lamps are fully and continuously on during the specified periods.
- Partial credit will be awarded for partial compliance.

### 8-2. 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 10.

- 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 occurs in a different contest.*
- The schedule for hot water draws will 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, 0.5 in. (1.27 cm) National Pipe Thread Tapered Thread (NPT) to accept the organizer equipment.





**Figure 9: Scoring function for the Hot Water Contest**

### 8-3. 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.

- 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.
- 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.
- 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.

### 8-4. 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. To earn full points for the dinner party, teams shall:

- Host at least eight individuals for the dinner party—two decathletes from each of three other teams 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. If VIP guests do not participate, at least two host team decathletes shall participate in the dinner party.
- Meet all house occupancy rules described in Rule 11-1c for the dinner party.
- Have two decathletes attend each of the assigned houses for the duration of the dinner party period as indicated in Appendix A-3. While in attendance, decathletes shall participate in the meal and act respectfully.
- Serve a complete meal with an adequate amount of food for all guests, at appropriate serving temperatures, and in a timely manner within the dinner party period as indicated in Appendix A-3.
- Serve a unique meal at each dinner party.
- Ensure that team decathletes in the house during the dinner party are performing one or more of the following three functions: 1) eating the meal; 2) cooking/preparing the food; or 3) operating the house during scheduled Contest 6, 7, or 8 activities.
- 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/Rules Reference Documents" folder on the Yahoo Group.

- h. Serve and have guests eat the meal in the finished square footage at the eating area designated in the drawings.
- i. Submit to the organizers detailed dinner party menus, recipes, and ingredient lists that accurately reflect the meal served for each dinner party.
- j. 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. Prior to use for the Dinner Party, 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, wheat, and gluten.
  - 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.

## 8-5. 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. To earn full points for the movie night, teams shall:

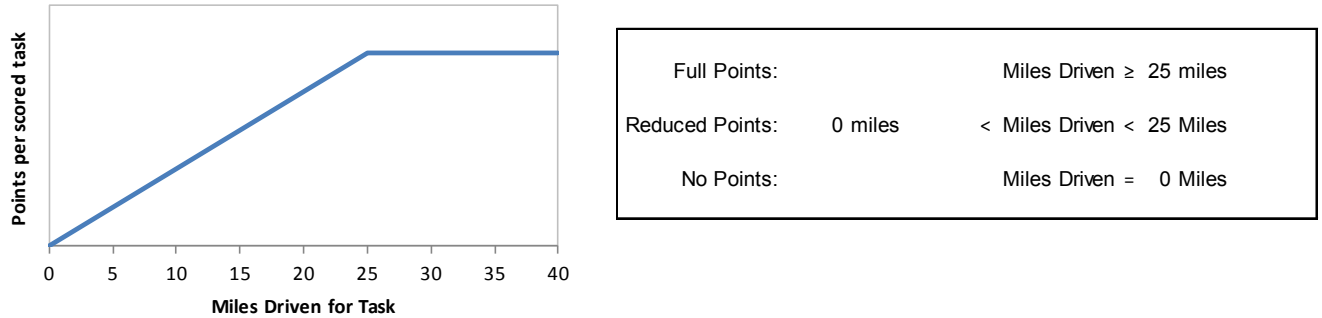
- a. Host at least eight individuals for the movie night—two decathletes from each of three other teams and up to two VIP guests. VIP guests may include organizers, media, government employees, family members, or other individuals approved by the organizers to attend the dinner parties.
- b. Have two decathletes attend each assigned house for the duration of the movie night period as indicated in Appendix A-3. While in attendance, decathletes shall participate and act respectfully.
- c. Vote for one of three movies selected by the organizers via the poll posted to the Yahoo Group prior to the event. 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.
- d. Maintain normal audiovisual equipment settings throughout the duration of the subcontest. Observers or a small team of organizers, or both, will verify that these settings are maintained on movie night.

## *Contest 9. Commuting*

Electric vehicle driving tasks will occur at the approximate times specified in Appendix A-3. Teams shall complete each task in no more than 120 minutes to qualify for points. All available points are earned by driving at least 25 miles (40.23 kilometers). For driving between 0 miles and 25 miles (40.23 kilometers), points for each task are scaled linearly, as shown in Figure 11.

- a. These driving tasks are designed to simulate most of the transportation requirements that would take place for a household.
- b. The schedule for the commuting tasks varies from one day to the next.

- c. The vehicle must meet the requirements of Rule 4-8.
- d. The vehicle must be driven by a decathlete who is licensed to operate a motor vehicle and accompanied by at least one passenger, who shall also be a decathlete.
- e. Both the driver and the passenger must wear a seat belt and follow all applicable driving laws.
- f. The electric vehicle may only be charged from the house electrical system. Any charging from alternate locations is considered a rules violation.



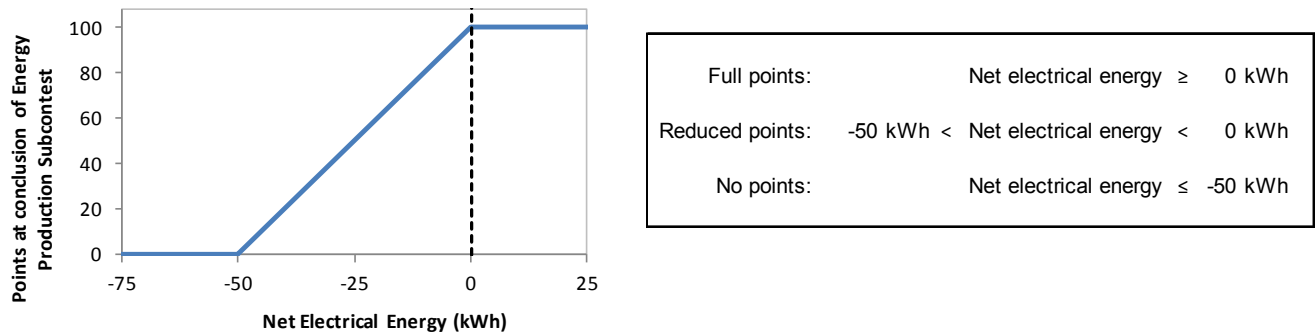
**Figure 10: Scoring function for the Commuting Contest**

## Contest 10. Energy Balance

### 10-1. Energy Production

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.

- a. 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 12.

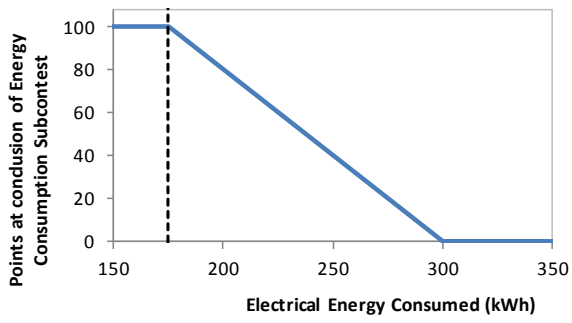


**Figure 11: Scoring function for the Energy Production Subcontest**

### 10-2. Energy Consumption

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 measured consumption of 175 kWh or less.

- a. Reduced points are earned for measured electrical energy consumption between 175 kWh and 300 kWh. Reduced points are scaled linearly, as shown in Figure 13.



|                 |  |
|-----------------|--|
| Full points:    | Electrical Energy Consumed $\leq$ 175 kWh      |
| Reduced points: | 175 kWh < Electrical Energy Consumed < 300 kWh |
| No points:      | Electrical Energy Consumed $\geq$ 300 kWh      |

**Figure 12: Scoring function for the Energy Consumption Subcontest**

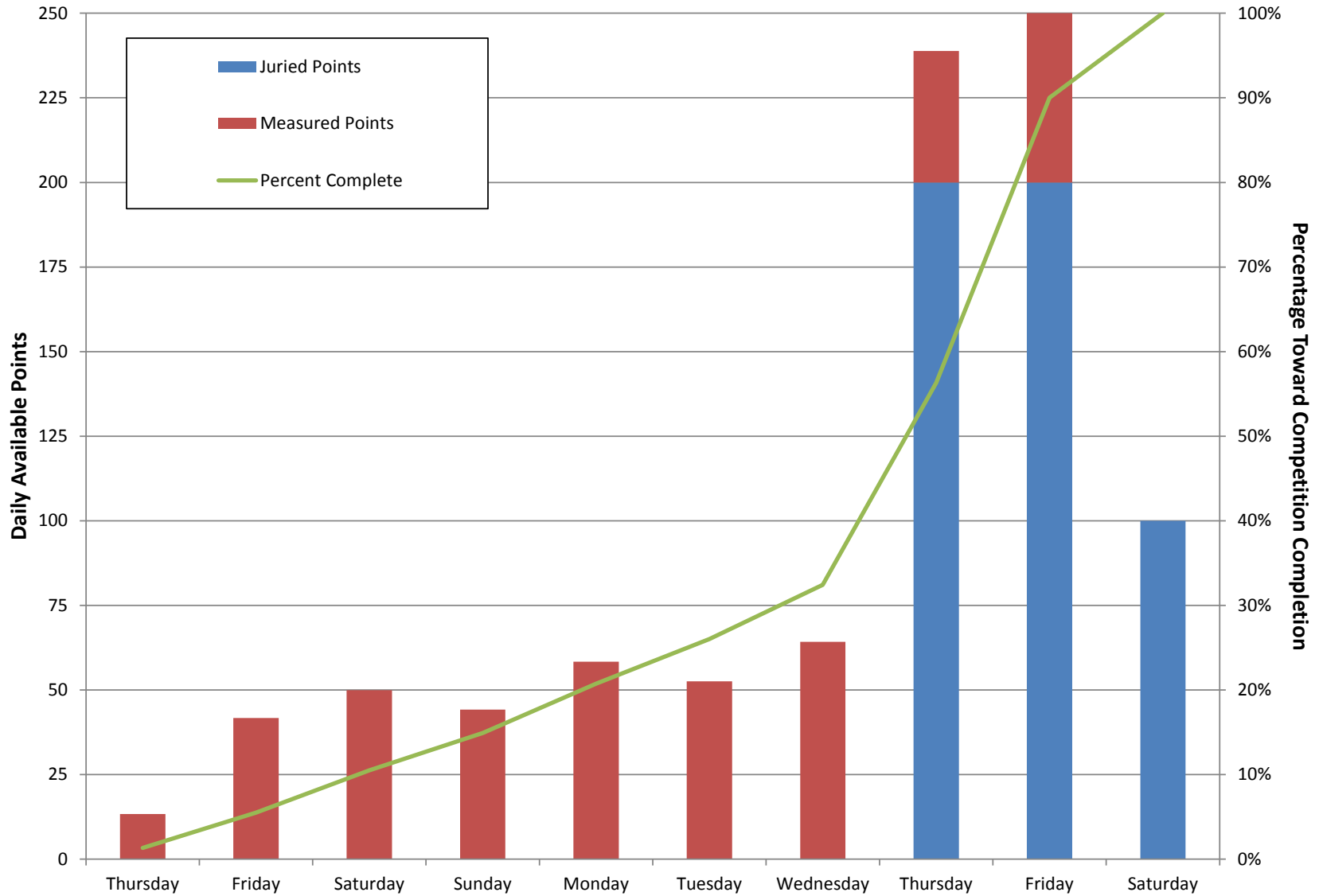
# Appendix A Event Schedules

## 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<br>DAY 0 - SEPT 27   | MONDAY<br>DAY 1 - SEPT 28   | TUESDAY<br>DAY 2 - SEPT 29  | WEDNESDAY<br>DAY 3 - SEPT 30   | THURSDAY<br>DAY 4 - OCT 1  | FRIDAY<br>DAY 5 - OCT 2   | SATURDAY<br>DAY 6 - OCT 3   |
|---|---|---|--|--|---|---|
| REGISTRATION<br>(12 p.m. - 2 p.m.; 4 p.m.-7 pm)                       | REGISTRATION<br>(6:30 a.m. - 6:30 p.m. Daily)                                 | IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(2 a.m. - 7 a.m.)   | IMPOUND<br>(2 a.m. - 7 a.m.)                                       | IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(2 a.m. - 7 a.m.)  |
| ALL-TEAM MEETING<br>(2 p.m. - 4 p.m.)                                 | STAND-ALONE ASSEMBLY<br>(Begins at 7 a.m.)                                    | STAND-ALONE ASSEMBLY  | STAND-ALONE ASSEMBLY   | STAND-ALONE ASSEMBLY   | STAND-ALONE or<br>GRID-TIE ASSEMBLY<br>(Grid available at 12:00 pm) | STAND-ALONE or<br>GRID-TIE ASSEMBLY   |
| VEHICLE STAGING<br>(Permitted Sat. and<br>Sun. from 8 a.m. to 6 p.m.) |   |   |  |  | GRID-TIE ASSEMBLY<br>AVAILABLE<br><br>(Grid available at 12:00 pm)  |   |
| DAY 7 - OCT 4   | DAY 8 - OCT 5   | DAY 9 - OCT 6   | DAY 10 - OCT 7   | DAY 11 - OCT 8   | DAY 12 - OCT 9  | DAY 13 - OCT 10   |
| IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                            | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                  | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                   | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)   |
| STAND-ALONE or<br>GRID-TIE ASSEMBLY                                   | STAND-ALONE or<br>GRID-TIE ASSEMBLY<br>(Until 12 p.m.)                        | GRID-TIE ASSEMBLY<br>(Until 8 a.m.)   | <b>REST DAY</b>  | CONTESTS<br>(11:00 a.m. - Midnight)                                | CONTESTS<br>(24 hours)  | CONTESTS<br>(24 hours)  |
|   |   | FINAL SITE CLEANUP, STAGING<br>AND SIGNAGE<br>(8 a.m. - 12 p.m.)  |  | ALL TEAM PHOTO<br>(8:30 a.m. - 9 a.m.)                             |   |   |
| WATER DELIVERY<br>(8 a.m. - 5 p.m.)                                   | GRID-TIE ASSEMBLY<br>(After 12 p.m.)  | STOP WORK FOR LAST-CHANCE<br>FINAL INSPECTIONS*<br>(No work to take place while<br>teams wait for final inspections)<br><br>(12 p.m.) | MEDIA PREVIEW<br>(10:30 a.m. - 2 p.m.)                                       | OPENING CEREMONY<br>(9:30 a.m. - 11 a.m.)                          | PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)                                | PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)  |
|   |   |   | OPENING REHEARSAL<br>(3 p.m. - 3:30 p.m.)                                    | PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)                               |   |   |
|   |   |   | OPENING RECEPTION<br>(6 p.m. - 8:30 p.m.)                                    |  |   |   |
|   |   |   | TEAM OPEN HOUSE<br>(8:30 p.m. - 11 p.m.)                                     |  |   |   |
| DAY 14 - OCT 11   | DAY 15 - OCT 12   | DAY 16 - OCT 13   | DAY 17 - OCT 14  | DAY 18 - OCT 15  | DAY 19 - OCT 16   | DAY 20 - OCT 17   |
| IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                     | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                             | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)   | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                            | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                  | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)                   | IMPOUND<br>(12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)   |
| CONTESTS<br>(24 hours)  | CONTESTS<br>(24 hours)  | CONTESTS<br>(24 hours)  | CONTESTS<br>(24 hours)   | CONTESTS<br>(24 hours)   | CONTESTS<br>(Midnight - 11a.m.)                                     | ENGINEERING RESULTS &<br>AWARDS CEREMONY<br><br>(10:00 a.m. - 10:45 a.m.)   |
|   | JURY WALKTHROUGHS<br>(7:30 a.m. - 12:30 p.m.)<br>and (7:30 p.m. to 9:30 p.m.) | JURY WALKTHROUGHS<br>(7:30 a.m. - 12:30 p.m.)<br>and (7:30 p.m. to 9:30 p.m.)   | JURY WALKTHROUGHS<br>(7:30 a.m. - 10:00 a.m.)<br>and (7:30 p.m. - 8:30 p.m.) | AFFORDABILITY &<br>MARKET APPEAL RESULTS<br>(10:00 a.m. - 11 a.m.) | COMMUNICATIONS &<br>ARCHITECTURE RESULTS<br>(10:00 a.m. - 11 a.m.)  |   |
| PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)                                  |   |   |  | PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)                               | PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)                                | TEAM OPEN HOUSE<br><br>(7:30 p.m. - 11 p.m.)  |
|   |   |   |  |  |   | VICTORY CELEBRATION<br><br>(7:30 p.m. - 10:30 p.m.)   |
| DAY 21 - OCT 18   | DAY 22 - OCT 19   | DAY 23 - OCT 20   | DAY 24 - OCT 21  | DAY 25 - OCT 22  | DAY 26 - OCT 23   | <b>Last Updated On:<br/>2014-06-09</b><br><br>* Significant precipitation or the<br>occurrence of an unforeseen<br>circumstance that equally affects all<br>teams' progress during the assembly<br>phase may result in a postponement of<br>the last-chance final inspections. The<br>remainder of the schedule will remain<br>unchanged. |
| IMPOUND<br>(12 a.m. - 7 a.m.)   | IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(2 a.m. - 7 a.m.)  | IMPOUND<br>(2 a.m. - 7 a.m.)   | IMPOUND<br>(2 a.m. - 7 a.m.)                                       | IMPOUND<br>(2 a.m. - 7 a.m.)  |   |
| PUBLIC EXHIBIT<br>(11 a.m. - 7 p.m.)                                  | DISASSEMBLY   | DISASSEMBLY   | DISASSEMBLY  | DISASSEMBLY  | DISASSEMBLY   |   |
| DISASSEMBLY<br>(Begins at 7 p.m.)                                     |   |   |  |  | FINAL DISASSEMBLY<br>INSPECTIONS<br>(7 p.m.)                        |   |
|   |   |   |  |  | ALL TEAMS OFF SITE<br>(9 p.m.)                                      |   |

## A-2. Scoring Chronology



### A-3. Detailed Event Schedule

#### Sunday (Day 0)

|  | 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 |  |
|--|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| On-site registration   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Kickoff team/organizer meeting                                   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Teams provide competition management with house keys             |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Vehicle staging - Permitted Sat and Sunday from 8 a.m. to 6 p.m. |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

\*Time shown is associated with the vertical line to the left of the time

#### Monday (Day 1)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| On-site registration  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Stand-alone house assembly                                  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting                                      |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

#### Tuesday (Day 2) - Thursday (Day 4)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| On-site registration (Continues 6:30am-6:30pm during all days the competition site is open) |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Stand-alone house assembly  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| [Sub]contest 6-1, 6-2, 8-1, 8-2, and 10 sensors and datalogger installation                 |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation                                 |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

#### Friday (Day 5)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| Stand-alone house assembly  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Stand-alone or grid-tie house assembly                                      |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| [Sub]contest 6-1, 6-2, 7-1, 7-2, and 10 sensors and datalogger installation |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation                 |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

#### Saturday (Day 6)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| Stand-alone or grid-tie house assembly                                      |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| [Sub]contest 6-1, 6-2, 7-1, 7-2, and 10 sensors and datalogger installation |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation                 |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

Impound period
  Task Period
  Event/Activity
  Public exhibit hours
  Juried contest results
  Tasks requiring observer
  Food preparation and cooking
  Jury walkthroughs

## Sunday (Day 7)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| Stand-alone or grid-tie house assembly                                      |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| [Sub]contest 6-1, 6-2, 7-1, 7-2, and 10 sensors and datalogger installation |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation                 |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Water delivery  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

## Monday (Day 8)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| Stand-alone or grid-tie house assembly  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Final opportunity to request grid-tie to organizer utility services without penalty |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Grid-tie house assembly and cleanup (all significant construction complete)         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| [Sub]contest 6-1, 6-2, 7-1, 7-2, and 10 sensors and datalogger installation         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation                         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

## Tuesday (Day 9)

|  | 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 |  |
|--|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| Final grid-tie house assembly and cleanup (all significant construction complete)                    |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Completion of all construction activities. Clean-up, staging and signage work only after this point. |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Site clean-up, staging, and signage work only  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Stop work for last-chance final inspections  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Last-chance final inspections (teams must stop all work and wait for inspectors to arrive)           |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Minor house cleanup and competition preparation  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| [Sub]contest 6-1, 6-2, 7-1, 7-2, and 10 sensors and datalogger installation                          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Inspections  |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Measured Contest Overview and Training   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

## Wednesday: Rest Day (Day 10)

|   | 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 |  |
|---|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|
| [Sub]contest 6-1, 6-2, 7-1, 7-2, and 10 sensors and datalogger installation |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Microgrid, network, and village infrastructure installation                 |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Media Preview   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Opening Rehearsal   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Opening reception   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team Open House   |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

Impound period
  Task Period
  Event/Activity
  Public exhibit hours
  Juried contest results
  Tasks requiring observer
  Food preparation and cooking
  Jury walkthroughs



## Thurs (Day 11)

| 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 |  |  |  |  |
|------------------------------------|--------------|---------------------|-----------------------------|-----------------------------|------------------------|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|--|--|--|
| Energy Balance Contest begins      |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 52                     | 0.679    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 52                     | 0.679    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Temperature                        | C6-1         | MEAS                | 75,000                      | 574                         | 18                     | 2.352    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 18                     | 0.784    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 8                      | 3.846    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Dinner Parties                     | C8-4         | SUBJ                | 10,000                      | 2                           | 1                      | 5,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>13.340</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>13.340</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| House Photography                  |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| All Team Photo                     |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Opening Ceremony Dress Rehearsal   |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Opening ceremony line-up           |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |
| Opening ceremony                   |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |

## Fri (Day 12)

| 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                      | 574                         | 46                     | 6.010    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 46                     | 2.003    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1.253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1.253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Clothes Washer                     | C7-3         | TASK                | 16,000                      | 8                           | 1                      | 2,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Clothes Dryer                      | C7-4         | TASK                | 32,000                      | 8                           | 1                      | 4,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 3                      | 0.882    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Dishwasher                         | C7-5         | TASK                | 17,000                      | 5                           | 1                      | 3,400    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 1                      | 12,500   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 1                      | 3,125    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Movie Night                        | C8-5         | SUBJ                | 5,000                       | 1                           | 1                      | 5,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>41.428</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>54.768</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Team/organizer meeting             |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |

## Sat (Day 13)

| 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                      | 574                         | 60                     | 7.840    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 60                     | 2.613    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1.253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1.253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Clothes Washer                     | C7-3         | TASK                | 16,000                      | 8                           | 1                      | 2,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Clothes Dryer                      | C7-4         | TASK                | 32,000                      | 8                           | 1                      | 4,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 3                      | 0.882    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Cooking                            | C7-6         | TASK                | 15,000                      | 6                           | 1                      | 2,500    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 1                      | 12,500   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 2                      | 6,250    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 8                      | 3.846    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Dinner Parties                     | C8-4         | SUBJ                | 10,000                      | 2                           | 1                      | 5,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>49.938</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>104.706</b>         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |
| Team/organizer meeting             |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |

Impound period
  Task Period
  Event/Activity
  Public exhibit hours
  Juried contest results
  Tasks requiring observer
  Food preparation and cooking
  Jury w walkthroughs

## 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                      | 574                         | 60                     | 7,840    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 60                     | 2,613    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Clothes Washer                     | C7-3         | TASK                | 16,000                      | 8                           | 1                      | 2,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Clothes Dryer                      | C7-4         | TASK                | 32,000                      | 8                           | 1                      | 4,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 3                      | 0,882    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Dishwasher                         | C7-5         | TASK                | 17,000                      | 5                           | 1                      | 3,400    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Cooking                            | C7-6         | TASK                | 15,000                      | 6                           | 1                      | 2,500    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 1                      | 12,500   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 1                      | 3,125    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 6                      | 2,885    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>44,251</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>148,957</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                      | 574                         | 96                     | 12,544   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 96                     | 4,181    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Jury Walkthroughs                  | C1,2,3,4     | JURIED              | -                           | -                           | -                      | -        |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Clothes Washer                     | C7-3         | TASK                | 16,000                      | 8                           | 2                      | 4,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Clothes Dryer                      | C7-4         | TASK                | 32,000                      | 8                           | 2                      | 8,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 5                      | 1,471    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 3                      | 9,375    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 1                      | 12,500   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 8                      | 3,846    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>58,423</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>207,380</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                      | 574                         | 96                     | 12,544   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 96                     | 4,181    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Jury Walkthroughs                  | C1,2,3,4     | JURIED              | -                           | -                           | -                      | -        |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 6                      | 1,765    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 1                      | 12,500   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Dishwasher                         | C7-5         | TASK                | 17,000                      | 5                           | 1                      | 3,400    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 3                      | 9,375    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Cooking                            | C7-6         | TASK                | 15,000                      | 6                           | 1                      | 2,500    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 8                      | 3,846    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>52,617</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>259,997</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

### Weds (Day 17)

| 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                      | 574                         | 96                     | 12,544   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 96                     | 4,181    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Jury Walkthroughs                  | C1,2,3,4     | JURIED              | -                           | -                           | -                      | -        |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Clothes Washer                     | C7-3         | TASK                | 16,000                      | 8                           | 2                      | 4,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Clothes Dryer                      | C7-4         | TASK                | 32,000                      | 8                           | 2                      | 8,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 8                      | 2,353    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Cooking                            | C7-6         | TASK                | 15,000                      | 6                           | 2                      | 5,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 3                      | 9,375    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 2                      | 25,000   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 8                      | 3,846    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>76,805</b>          |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>336,803</b>         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |
| Team/organizer meeting             |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |

### Thurs (Day 18)

| 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                      | 574                         | 60                     | 7,840    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 60                     | 2,613    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 96                     | 1,253    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 3                      | 0,882    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Dishwasher                         | C7-5         | TASK                | 17,000                      | 5                           | 1                      | 3,400    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Commuting                          | C9           | TASK                | 100,000                     | 8                           | 1                      | 12,500   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 2                      | 6,250    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Lighting                           | C8-1         | TASK                | 25,000                      | 52                          | 6                      | 2,885    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Market Appeal                      | C2           | SUBJ                | 100,000                     | n/a                         | n/a                    | 100,000  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Affordability                      | C5           | SUBJ                | 100,000                     | n/a                         | n/a                    | 100,000  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>238,876</b>         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>575,679</b>         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Team/organizer meeting             |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Market Appeal contest awards       |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Affordability contest awards       |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |

### Fri (Day 19)

| 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                      | 574                         | 42                     | 5,488    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Humidity                           | C6-2         | MEAS                | 25,000                      | 574                         | 42                     | 1,829    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Refrigerator                       | C7-1         | MEAS                | 10,000                      | 766                         | 42                     | 0,548    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Freezer                            | C7-2         | MEAS                | 10,000                      | 766                         | 42                     | 0,548    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Clothes Washer                     | C7-3         | TASK                | 16,000                      | 8                           | 1                      | 2,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Clothes Dryer                      | C7-4         | TASK                | 32,000                      | 8                           | 1                      | 4,000    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Home Electronics                   | C8-3         | TASK                | 10,000                      | 34                          | 3                      | 0,882    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Dishwasher                         | C7-5         | TASK                | 17,000                      | 5                           | 1                      | 3,400    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Cooking                            | C7-6         | TASK                | 15,000                      | 6                           | 1                      | 2,500    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Hot Water                          | C8-2         | TASK                | 50,000                      | 16                          | 1                      | 3,125    |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Architecture                       | C1           | SUBJ                | 100,000                     | n/a                         | n/a                    | 100,000  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Communications                     | C4           | SUBJ                | 100,000                     | n/a                         | n/a                    | 100,000  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Energy Balance                     | C10          | MEAS                | 100,000                     | n/a                         | n/a                    | 100,000  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| <b>DAILY AVAILABLE POINTS</b>      |              |                     |                             |                             | <b>324,321</b>         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b> |              |                     |                             |                             | <b>900,000</b>         |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Team/organizer meeting             |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Architecture contest awards        |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Communications contest awards      |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Final Protest Submission Deadline  |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Team Open House                    |              |                     |                             |                             |                        |          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |

Impound period
  Task Period
  Event/Activity
  Public exhibit hours
  Juried contest results
  Tasks requiring observer
  Food preparation and cooking
  Jury w walkthroughs

## Sat (Day 20)

| 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 |  |  |
|---|--------------|---------------------|-----------------------------|-----------------------------|------------------------|-----------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|--|
| Engineering Contest Awards                                  | C3           | SUBJ                | 100.000                     | n/a                         | n/a                    | 100.000         |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| <b>DAILY AVAILABLE POINTS</b>                               |              |                     |                             |                             |                        | <b>100.000</b>  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| <b>CUMULATIVE AVAILABLE POINTS</b>                          |              |                     |                             |                             |                        | <b>1000.000</b> |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Contest instrumentation removal                             |              |                     |                             |                             |                        |                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Engineering contest and overall competition awards ceremony |              |                     |                             |                             |                        |                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Team/organizer meeting                                      |              |                     |                             |                             |                        |                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |
| Victory Celebration   |              |                     |                             |                             |                        |                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |

## Sunday (Day 21)

| 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 |  |  |  |  |  |  |
|--|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|--|--|--|--|--|
|  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| [Sub]contest 6-1, 6-2, 8-1, 8-2, and 10 sensors and datalogger removal |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Team/organizer meeting   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Stand-alone house disassembly  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |

## Monday (Day 22)

| 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 |  |  |  |  |  |  |
|--|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|--|--|--|--|--|
|  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Stand-alone house disassembly  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| [Sub]contest 6-1, 6-2, 8-1, 8-2, and 10 sensors and datalogger removal |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Microgrid, network, and village infrastructure removal                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Water removal  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Team/organizer meeting   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |

## Tuesday (Day 23) - Thursday (Day 25)

| 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 |  |  |  |  |  |  |
|--|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|--|--|--|--|--|
|  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Stand-alone house disassembly  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| [Sub]contest 6-1, 6-2, 8-1, 8-2, and 10 sensors and datalogger removal |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Microgrid, network, and village infrastructure removal                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Team/organizer meeting   |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |

## Friday (Day 26)

| 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 |  |  |  |  |  |  |
|--|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|--|--|--|--|--|--|
|  |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Stand-alone house disassembly                          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Microgrid, network, and village infrastructure removal |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Team/organizer meeting                                 |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |
| Final disassembly inspections                          |          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |          |          |          |          |  |  |  |  |  |  |

Impound period
  Task Period
  Event/Activity
  Public exhibit hours
  Juried contest results
  Tasks requiring observer
  Food preparation and cooking
  Jury walkthroughs

## Appendix B Juried Contest 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   | 1-2 hours  | <ol style="list-style-type: none"> <li>1. Drawings<sup>8</sup></li> <li>2. Construction specifications<sup>9</sup></li> <li>3. Audiovisual presentation<sup>10</sup></li> <li>4. Architecture narrative<sup>11</sup></li> </ol>  | 30 minutes (daytime)<br>10 minutes (nighttime)     |
| Market Appeal  | 1 to 2 hours                                       | <ol style="list-style-type: none"> <li>1. Drawings<sup>8</sup></li> <li>2. Construction specifications<sup>9</sup></li> <li>3. Audiovisual presentation<sup>10</sup></li> <li>4. Market appeal narrative<sup>11</sup></li> </ol>   | 30 minutes   |
| Engineering    | 1 to 2 hours                                       | <ol style="list-style-type: none"> <li>1. Drawings<sup>8</sup></li> <li>2. Construction specifications<sup>9</sup></li> <li>3. Energy analysis results and discussion<sup>12</sup></li> <li>4. Audiovisual presentation<sup>10</sup></li> <li>5. Engineering narrative<sup>11</sup></li> </ol> | 30 minutes   |
| Communications | 1 to 2 hours                                       | <ol style="list-style-type: none"> <li>1. Website<sup>13</sup></li> <li>2. Audiovisual presentation<sup>10</sup></li> <li>3. Public exhibit presentation and materials<sup>14</sup></li> <li>4. Communications narrative<sup>11</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>8</sup> See Appendix D-4 for drawings requirements.

<sup>9</sup> The construction specifications are located in the project manual. See Appendix D-5 for project manual requirements.

<sup>10</sup> See Appendix D-7 for audiovisual presentation requirements.

<sup>11</sup> See Appendix D-6 for jury narrative requirements.

<sup>12</sup> The energy analysis results and discussion is located in the engineering jury narrative.

<sup>13</sup> See Appendix D-8 for website requirements.

<sup>14</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%.

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 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 the jury's evaluation. 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.
- 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, and Market Appeal jury walkthroughs. Also be aware that the Architecture, Engineering and Market Appeal juries may request plug-in, portable, or hardwired 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 prepare 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 given 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 up to 5 minutes to describe the fast-yet-informative tour to the Communications Jury.
- The version of the fast tour described 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 expected to present the team communications strategy, including brand management and outreach off the competition site 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.
- The use of power-consuming devices, such as LCD displays, house lighting, mobile electronics, etc., shall not be included as part of the fast tour described 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>15</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 “monitored performance” subcontests**

| Subcontest(s)                     | Sensor Type                         | Vendor               | Model Number                           | Approx. Price |
|-----------------------------------|-------------------------------------|----------------------|--|---------------|
| 6-1. Temperature<br>6-2. Humidity | Wireless temperature/humidity probe | Point Six            | 3009-02-V5                             | \$327         |
| 7-1. Refrigerator                 | Wireless RTD sensor                 | Point Six            | <a href="#">3009-20-V4 and 1000-21</a> | \$408         |
| 7-2. Freezer                      | Wireless RTD sensor                 | Point Six            | <a href="#">3009-20-V4 and 1000-21</a> | \$408         |
| 10-1. Energy Balance              | Revenue wattnode                    | Continental Controls | TBD                                    | \$250         |
| 10-2. Energy Consumption          | Revenue wattnode                    | Continental Controls | TBD                                    | \$250         |
| 10-1. Energy Production           | Current transformers                | TBD                  | TBD                                    | \$50          |
| 10-2. Energy Consumption          | Current transformers                | TBD                  | TBD                                    | \$50          |

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>16</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         |
| Transceiver for wireless sensors    | Point Six           | 4010-01                        | \$636         |
| Sensor wire and miscellaneous parts | Various             | Various                        | \$125         |

<sup>15</sup> The sensors and equipment listed here represent the expected solution, but may change as procedures are further developed. All sensors listed as TBD are expected to be determined by spring 2015.

<sup>16</sup> These documents are expected to be posted to the Yahoo Group in spring 2015.

## 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    |
|-----------------------|-----------------------------------|-------------|--------------|------------------|
| 7-3. Clothes Washer   | Visual/audible inspection         | n/a         | n/a          | n/a              |
| 7-4. Clothes Drying   | Scale                             | Acculab     | SVI-50C      | \$350            |
| 7-5. Dishwasher       | Nonreversible temperature label   | Omega       | TL-5-105-10  | \$10 (pkg of 10) |
| 7-6. Cooking          | Kitchen scale                     | Salton      | 1008         | \$50             |
| 8-1. Lighting         | Visual inspection                 | n/a         | n/a          | n/a              |
| 8-2. Hot Water        | Multiple Components <sup>17</sup> | Constructed | None         | \$600            |
| 8-3. Home Electronics | Visual inspection                 | n/a         | n/a          | n/a              |
| 8-4. Dinner Party     | Visual inspection                 | n/a         | n/a          | n/a              |
| 8-5. Movie Night      | Visual inspection                 | n/a         | n/a          | n/a              |

Please refer to the “Measured Contest Procedures” slideshow<sup>18</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>17</sup> A detailed component list is expected to be posted to the Yahoo Group in spring 2015.

<sup>18</sup> This slideshow is expected to be posted in spring 2015.

## 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 and white   |
| <input type="checkbox"/> ANSI "A" (8.5 in. X 11 in.) sheet size and/or 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>• Complete floor plans, including interior and exterior accessible tour route</li><li>• Building sections</li><li>• Exterior building structures, such as decks, outbuildings, and overhead structures</li><li>• Ramps, railings, and guards</li><li>• Glazing types and locations</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 public exhibit, communications, and outreach strategy (1 to 2 pages)  |
| <input type="checkbox"/> Computer-generated renderings of competition prototype (5-6 images; 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 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 2015 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 1 and 1.5 minutes  |
| <input type="checkbox"/> Shall be accompanied by a verbatim transcript in a Microsoft Word-compatible format to meet <a href="#">Section 508</a> Accessibility standards. |

#### Content Requirements

|   |
|---|
| <input type="checkbox"/> Comprises 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 view of the competition prototype</li><li>• Two (2) interior views of the competition prototype.</li></ul> |
|--|

## D-3. Building Information Model (BIM)

The BIM is a 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. Each 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 -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 |
|--|

- |  |
|--|
| <input type="checkbox"/> Should feature extensive use of the Revit template (.rvt) file <sup>19</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"/> 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. |

## **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***

- |  |
|--|
| <input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements) using NCSv5-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 expected                   |
| <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>20</sup> generated from the sample BIM.   |

### ***Content Requirements***

- |  |
|--|
| <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>20</sup> for download in the “/Files/Rules/Resources” folder on the Yahoo Group include the minimum required level of detail. |
|--|

## **D-5. Project Manual**

The project manual is a 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.

### ***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 2014 Edition</a> , SectionFormat, and PageFormat standards |
| <input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements)  |

<sup>19</sup> The Revit template was posted in summer 2014

<sup>20</sup> A first version of the sample drawings was posted for download in summer 2014

- Should feature extensive use of the Word template (.dotx) file<sup>21</sup> available for download in the “/Files/Rules/Resources” folder on the Yahoo Group.

### ***Content Requirements***

|   |
|---|
| <input type="checkbox"/> Rules compliance checklist <sup>22</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                                  |
| <input type="checkbox"/> Complete set of construction specifications (including links to manufacturers’ data sheets). |

### ***Content Requirements for Rules Compliance Checklist***

| <b>Rule #</b>                | <b>Rule Description</b>          | <b>Content Requirement(s)</b>  |
|------------------------------|----------------------------------|--|
| <input type="checkbox"/> 4-2 | Construction Equipment           | Drawing(s) showing the assembly and disassembly sequences and the movement of vehicles and equipment on the competition site   |
| <input type="checkbox"/> 4-2 | Construction Equipment           | Specifications for equipment   |
| <input type="checkbox"/> 4-3 | Ground Penetration               | Drawing(s) showing the locations and depths of all ground penetrations on the competition site, if any   |
| <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), if any   |
| <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 given site specific vertical elevation change  |
| <input type="checkbox"/> 4-7 | Lot Conditions                   | Drawing(s) showing shimming methods and materials to be used if vertical elevation change varies   |
| <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"/> 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 |
| <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"/> 6-3 | 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, if any  |
| <input type="checkbox"/> 8-1 | PV Technology Limitations        | Specifications for photovoltaic components   |

<sup>21</sup> A project manual template was posted in summer 2014.

<sup>22</sup> A template version of the rules compliance checklist was included in the project manual template.

| Rule #                   | Rule Description            | Content Requirement(s)  |
|--------------------------|-----------------------------|---|
| <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, if any   |
| <input type="checkbox"/> | 8-4 Desiccant Systems       | Specifications for desiccant system components, if any  |
| <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, if any  |
| <input type="checkbox"/> | 9-4 Rainwater Collection    | Drawing(s) showing the layout and operation of rainwater collection systems, if any   |
| <input type="checkbox"/> | 9-6 Thermal Mass            | Drawing(s) showing the locations of liquid-based thermal mass systems, if any   |
| <input type="checkbox"/> | 9-6 Thermal Mass            | Specifications for components of liquid-based thermal mass systems, if any  |
| <input type="checkbox"/> | 9-7 Greywater Heat Recovery | Drawing(s) showing the layout and operation of greywater heat recovery systems, if any  |
| <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: Juror time commitments for deliverables review and on-site walkthroughs. The narratives may include any combination of text and graphics. 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 (10 pages, maximum + appendices)<br>In addition to the summary of each team’s approach to meeting the contest requirements (5 pages), the engineering jury narrative should include an “energy analysis and discussion” (5 pages + appendices) which clearly outlines team climate analysis, energy balance analysis, system sizing analysis, design and testing of any unique technologies, and expected house performance discussion. |
| <input type="checkbox"/> Communications Narrative (2 pages, maximum)<br>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 the team will 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: Juror time commitments for deliverables review and on-site walkthroughs. 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 \(Text Version\)](#). Closed captioning does not need to be included within the video file.

### **Content Requirements**

|  |
|--|
| <input type="checkbox"/> Must primarily include video footage of the actual constructed house as built prior to the competition  |
| <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"/> Includes an audio narrative that explains to viewers what they’re seeing and describes the underlying philosophy behind the design and team approach to the competition   |
| <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 |
| <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 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: Juror time commitments for deliverables review and on-site walkthroughs.

**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 one courtesy review 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) |
| <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)  |

<sup>23</sup> The Minimum Website Coding Standards document was posted for download in spring 2014

Team organization and contacts. How is your team organized and approximately how many students, faculty, and others (e.g., sponsors, volunteers, family members) are involved in the project? (1 page)

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*

Native format of the camera, such as JPEG or RAW, if available

2048 × 1080 minimum pixel dimensions

RGB, 8-bit color, not black and white.

#### *Content Requirements*

Include all team members (if possible) and strive for creativity; for examples of past team photos, visit the [History section](#) of the Solar Decathlon website

For a photograph to be properly credited, the following information shall be included in a Microsoft Word-compatible text file accompanying the photograph file:

- Name, phone number, and email of person submitting the photograph
- Photograph date and location
- Photographer's name and affiliation.

### **Team Logo**

The team logo is used by organizers in village signage, the event program, media kit, and Solar Decathlon website.

#### *Format Requirements*

Submit two versions of your logo:

- One for Web (GIF or JPG, at least 200 px wide); GIF is preferred for simple flat-color logos and JPG is preferred for complex logos
- One for print (high-resolution or vector format; EPS preferred).

#### *Content Requirements*

Include a text file containing the following additional information:

- Name, phone number, and email of person submitting the logo
- 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).

### **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*

Minimum resolution of each image shall be 3000 px wide by 2400 px

Composed of image files (JPEG, TIFF, etc.) packaged as one Zip (.zip) file.

#### *Content Requirements*

Includes, at a minimum:

- North elevation view of the competition prototype

- South elevation view of the competition prototype
- East elevation view of the competition prototype
- West elevation view of the competition prototype
- Two (2) birds-eye perspective views of the competition prototype
- Four (4) interior views of the competition prototype.

### **Competition Prototype Graphic Floor Plan**

The graphic floor plan will be posted to the Solar Decathlon website and used in various communications materials to introduce the public to each competition prototype. The single plan should be presented in a way to demonstrate the layout of the house, interior furnishings, and all site elements.

#### ***Format Requirements***

- Natively-generated vector PDF file (see Appendix F for PDF formatting and file-naming requirements)
- Scale of drawing: 1/4" = 1'-0".

#### ***Content Requirements***

- Complete plan showing all exterior elements, including landscaping, ramps, decks, and solar envelope
- Complete floor plan showing all interior elements, including furniture and fixtures.

### **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***

- Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements).

#### ***Content Requirements***

- Restaurant-style dinner party menu for each dinner party
- Cookbook-style recipes for all components of dinner party
- 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***

- Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements)
- 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***

- Team handout (shall abide by Rules 10-2, 10-3, and 11-4b)
- Signage (shall abide by Rules 10-2, 10-3, and 11-4d)

|  |
|--|
| <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 and 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"/> Discussion of fundraising activities— final project budget and 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 team 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 are equivalent. Each plan shall be developed in consideration of the unique needs and requirements of each team’s competition prototype alternate and construction methodologies on the competition site.

Teams are expected to work or consult with their 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 (each role must be filled by a different individual) are required to complete the OSHA 30-hour Construction Safety Training course. 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 for updating the Health and Safety Plan, 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 its house when the plan was submitted but later decided that a crane would 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 2014

## 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 300 dpi, 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, 2014, would have the following file name:

WVU\_BIM\_2014-04-05.rvt

**Table 8: Team and deliverable abbreviations**

| <b>Team Name</b>     | <b>TEAM ABBREVIATION</b> | <b>Deliverable Name</b>         | <b>DELIVERABLE ABBREVIATION<sup>25</sup></b> |
|----------------------|--------------------------|---------------------------------|--|
| Team NY Alfred       | ALFRED                   | Schematic Design Summary        | SCHEMATIC                                    |
| Team Orange County   | CAIRV                    | Building Information Model      | BIM  |
| Cal Poly             | CALPOLY                  | Constructions Drawings          | DRAW   |
| Sacramento State     | CASAC                    | Project Manual                  | MANUAL                                       |
| Clemson              | CLEM                     | Health and Safety Plan          | SAFETY                                       |
| Crowder/Drury        | CROWD                    | Computer-Animated Walkthrough   | ANIMATION                                    |
| Florida/Singapore    | FLOR                     | Stamped Structural Drawings     | STRUCT                                       |
| Missouri S&T         | MST                      | Stamped Structural Calculations | CALCS  |
| U at Buffalo         | NYBUFF                   | Project Summary ZIP file        | SUMMARY                                      |
| NY City Tech         | NYCCT                    | Jury Narratives                 | NARRATIVE                                    |
| Stevens              | SIT                      | Audiovisual Presentation        | AV   |
| Stanford             | STAN                     | Overview                        | OVERVIEW                                     |
| Team Tennessee       | TENN                     | Team Photograph                 | PHOTO  |
| Texas/Germany        | TEX                      | Team logo                       | LOGO   |
| UC Davis             | UCDAV                    | Computer-Generated Renderings   | RENDER                                       |
| Mass/Central America | WNE                      | Dinner Party Menus and Recipes  | DINNER                                       |
| West Virginia/Rome   | WVU                      | Public Exhibit Materials        | EXHIBIT                                      |
| Yale                 | YALE                     | Final Report                    | FINALREPORT                                  |
|                      |                          | Construction Drawings           | CD   |
|                      |                          |                                 |  |

#### **F-4. Electronic File Submission Options**

All electronic files shall be uploaded to the Solar Decathlon [uplink](#). Teams wishing to reduce file upload times may submit electronic files as ZIP files.

<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.



# **APPENDIX D**

**U.S. DEPARTMENT OF ENERGY  
SOLAR DECATHLON 2015  
BUILDING CODE**



U.S. DEPARTMENT OF ENERGY  
**SOLAR DECATHLON**

# **BUILDING CODE**

Last Updated: September 24, 2014

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## ***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 2014 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. The following provisions are amended and emphasized as they constitute the highest degree of risk to the building occupants during public exhibition. Compliance with the letter or intent of the referenced codes is mandatory in addition to the items discussed in the paragraphs below.

### **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 (i.e., the team's health and safety officer) for public tour life safety during the event. Include a written operations plan for team-facilitated 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**

**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. Stairs to habitable spaces excluded from use by the public or any other individual during public tours may be provided following specific approval by the Building Official.

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 2010 Standard for Accessible Design Section 505.

### 3-3. Interior Finishes

Interior finishes must comply with IRC Section R302.9. Synthesized building materials, such as those using plastics, must be provided with the manufacturer’s test documentation indicating compliance with ASTM E-84 or UL 723 demonstrating a minimum Class C. Exceptions:

- a. Materials tested to EN 13501 with a minimum Euro-Class C
- b. Materials tested to DIN 4102 with a minimum B1 classification
- c. Other testing methods subject to approval by the Solar Decathlon Building Official

### 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 in. (152 cm) 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**

Drawings submitted for review shall contain 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 in habitable locations and as otherwise specified in 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 sprinkler system 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. A test and valve shall be placed in an accessible location at the most remote point of the sprinkler system. This valve will be used to assist in charging the system with water, and will be operated by the team during the inspection period to demonstrate that the sprinkler system is charged and that the pump used for sprinkler pressurization is operating correctly. Pumps used for fire sprinklers may be dedicated to the fire sprinkler system or be used for both domestic and fire system purposes.

## ***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. Components of the accessible route used by the touring public must comply with 2010 Standard for Accessible Design. 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 available and intended for use by the public, they shall be accessible in accordance with the 2010 Standard for Accessible Design. Voluntary accessibility provided outside of areas accessible to the touring public should comply 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 [2010 Standard for Accessible Design](http://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards_prt.pdf): [http://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards\\_prt.pdf](http://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards_prt.pdf) 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 and specific Solar Decathlon criteria 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 2010 Standard for Accessible Design 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) (2010 Standard for Accessible Design Section 405). Handrails shall be continuous and be provided with 12-in. (305-mm) extensions beyond the top and bottom of the ramp's sloping surface. Handrails with a circular cross section shall have an outside diameter of at least 1.25 in. (32 mm) and not greater than 2 in. (51 mm). If the handrail is not circular, it shall have a perimeter dimension of at least 4 in. (102 mm) and not greater than 6.25 in. (160 mm) with a maximum cross-section dimension of 2.25 in. (57 mm). Handrails shall be uniform in height, not less than 34 in. (864 mm) and not more than 38 in. (965 mm) above the walking surface of the ramp.
- 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 in. (305mm) beyond the termination of the transition plate. The design of the transition plate shall accommodate the lateral loads placed on the handrails and extensions without relying on ground embedment for support.

#### **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 (2010 Standard for Accessible Design Section 405).
- c. Sloped walking surfaces complying with 2010 Standard for Accessible Design Section 403 shall be permitted.

#### **4-5. Doors and Door Approaches**

All doors shall comply with the 2010 Standard for Accessible Design 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 steel stake anchor embedment tie-down because of the lack of a permanent foundation and 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. The design must accommodate all design loads, including gravity and lateral derived from wind and seismic. Plans shall include location and size of all temporary 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.
- b. Uplift design may employ uplift anchorage, dead-load analysis, or a combination of both. Anchorage embedment into the temporary site will be limited to the method and design values indicated in Section 5.5(c). 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 designed 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.
- c. Ground anchorage may be affected by use of minimum 1-inch (25.4-mm) diameter, A36 mild solid steel stakes driven a minimum of 36 in. into the existing pavement surface. Such stakes shall be driven vertically. Design stake capacity shall be assumed as:
  - 1,250 pounds vertical withdrawal (pull out)
  - 1,500 pounds horizontal shear
  - Or as determined by Calculation 5.5c, where both forces are applied.

$$\text{Calculation 5.5c:} \quad \frac{\text{Actual Withdrawal Load (lbs)}}{1,250 \text{ Pounds}} + \frac{\text{Actual Shear Load (lbs)}}{1,500 \text{ Pounds}} \leq 1$$

Teams will be responsible for the design and structural qualification for the load transference mechanism between the stake and the building structure being anchored. Threaded rods may be used. Driven rods used in multiples must be spaced a minimum of 24 in. on center.

Teams are responsible for removal of the stakes at the conclusion of the event. Teams are not permitted to drive the stake below the surface of the existing pavement. All stakes must be removed from the site at the conclusion of the event.

Alternative ground anchorage methods may be permitted upon approval of the Solar Decathlon Building Official and by special permission of the Orange County Great Park.

## **5-6. Alternate Materials**

Alternate materials are permitted as follows:

- a. Engineered lumber (e.g., TJIs, LPs, 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 2014 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.

### 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.

### 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.

- 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 team shall provide a grounding electrode conductor from the dwelling's main service equipment to the organizer utility panel. The grounding electrode conductor shall be a minimum size of 4 AWG copper, either bare or insulated. The organizers will bond the dwelling grounding electrode conductor to the organizer grounding electrode.

Each dwelling shall *not* have or install a grounding electrode (commonly referred to as a ground rod).

## 6-10. Inverter Disconnect

Each team shall provide a disconnecting means located between the inverter and the solar array where panel-integrated microinverters are not employed. The disconnecting means should be capable of ready lockout/tagout to facilitate safe service of the inverter(s).

# *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 may 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 or with the test plug knock-out in place. 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. Bowl openings should be provided with a concealed opaque cover to discourage use of the toilet during the temporary exhibit.

### **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.

## 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.

## 9-10. Rainwater Harvesting

Teams may demonstrate or actively engage in harvesting and utilizing captured rainwater provided that the rainwater harvesting system meets the following minimum criteria:

- a. The act of harvesting rainwater must be permitted within the jurisdiction where the competition is being held.
- b. The act of harvesting rainwater must be permitted within the jurisdiction where the house is intended to be permanently placed. Authorization and approval for rainwater harvesting by Solar Decathlon organizers shall in no way constitute permission to harvest and use rainwater in any other location aside from the competition event location. Permission and regulatory oversight must be obtained from the local authority having jurisdiction to ensure compliance when the house is permanently placed following competition. If a final location for the house is unknown, the team should be prepared to eliminate the entire harvesting system and connected piping.
- c. The rainwater harvesting system must comply with the Solar Decathlon Building Code and its adopted International Residential Code

### **Rainwater Harvesting for Non-Potable Irrigation Use**

Rainwater harvesting systems used exclusively for irrigation or other non-potable purposes shall comply with the gray water recycling provisions contained in International Residential Code Section P3009.

Roof gutters or downspout entrances providing captured rainwater intended to be processed and used shall be provided with an effective means to prevent leaf and other roof debris from entering the collection piping. Screening providing ¼ inch (6mm) maximum openings located immediately upstream of conveyance piping including exterior downspouts shall be deemed compliant.

### **Rainwater Harvesting for Potable Use**

Rainwater harvesting systems used for potable and combination potable and non-potable applications must comply with this section.

- a. Leaf and Debris Screens. Roof gutters or downspout entrances shall be provided with an effective means to prevent leaf and other roof debris from entering the collection piping. Screening providing  $\frac{1}{4}$  inch (6mm) maximum openings located immediately upstream of conveyance piping including exterior downspouts shall be deemed compliant.
- b. Initial Discharge Diversion System. Rainwater collection systems shall be provided with an initial discharge diversion (first flush) system to reduce collection of accumulated roof surface contaminants. The system shall incorporate an adequately sized standpipe or other approved collection container with a floating ball shut-off or other approved separating mechanism providing the minimum collection volume as follows:
  - i. Serving a Low Slope Roof with 2:12 Pitch or Less: 2 gallons (7.5 liters) per 100 square feet ( $9.3\text{m}^2$ ) of projected roof surface.
  - ii. Serving a High Slope Roof with Greater Than 2:12 Pitch: 1 gallon (3.75 liters) per 100 square feet ( $9.3\text{m}^2$ ) of projected roof surface.
- c. The team shall produce construction documents with calculations necessary to show the projected area of roof being discharged into the rainwater collection system, the pitch of the roof, the calculated and provided volume capacity of the initial diversion standpipe, and all associated connecting piping to the point of entry into the potable water piping or gray water recycling system.
- d. Water collected within the initial discharge diversion system shall be permitted to be used as part of a gray water recycling system in accordance with International Residential Code Section P3009. Clear water passing after the initial discharge diversion system shall not be connected to a gray water recycling system unless provided with an air gap or other approved cross contamination backflow prevention device.
- e. Drinking Water Treatment System. Rainwater system piping upstream of an approved drinking water treatment system shall not be connected to any portion of the house's potable water system. Rainwater shall only be permitted to be used within the potable water piping system provided that it is first treated by an approved drinking water treatment system complying with International Residential Code Section P2908. An approved backflow prevention method shall be provided immediately downstream of the drinking water treatment system unless provided integrally within a listed and approved treatment unit.
- f. Roofing Materials. Roof cladding surfaces, gutters and downspouts used for potable rainwater collection systems must be comprised of metal or other impermeable surfaces that are unlikely to release toxic products that will negatively affect water quality. Roofs containing asphalt, wood products or similar materials shall not be used for potable rainwater harvesting systems. Roofs, gutters and downspouts using plastics or flexible membranes shall be permitted when sufficient evidence is submitted by the team to show that the surface materials will not discharge harmful contaminants into the collected rainwater.

## ***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:
- f. Include in its Health and Safety Plan an explanation of how it will ensure safety during the movement of qualifying features.
- g. Demonstrate the successful execution of the safety plan for qualifying features at some point before public exhibit hours begin.
- h. Continue to demonstrate the successful execution of the safety plan for qualifying features during public exhibit hours.
- i. 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.

# **APPENDIX E**

# **REFERENCE SHEETS**

# MonoX<sup>®</sup> ACe

PerfectAC<sup>™</sup> module  
LG300A1C-B3



## 60 cell

LG AC module is a high-efficiency module developed by LG Electronics. Our R&D concentrates on developing a product that is not only efficient, but strives to increase practical value for customers. The end result is a module which uses highly efficient n-type materials, an elaborate process control adopting a semiconductor processing solution and a double-sided structure.



### Trusted Company

LG AC Module has been developed by an electronics company with an extensive technical history and has a product limited warranty by a financially stable brand.



### All-in-one Design

LG AC Module combines the module and inverter in a single unit. It provides a clean appearance, reduced cable work and increased energy yield.



### Highest AC output

The LG AC module features the world's highest output among the products. It means more power generation per square foot.

\*305W AC output for single phase



### Monitoring Anywhere

LG provides advanced Web-based solution and stable environment with in-house server operation. Users can monitor power generation through the Internet.

#### About LG Electronics

LG Electronics is a multinational corporation committed to expanding its capacity with solar energy business as its future growth engine. Our a solar energy source research program was launched in 1985, backed by LG Group's rich experience in semi-conductors, LCD, chemistry and electronic materials industry. We successfully released the first MonoX<sup>™</sup> series to the market in 2010 which exported to 32 countries in 2 years. In 2013, MonoX<sup>™</sup> NeON won "Intersolar Award", which proved its leading innovation in the industry.



# MonoX<sup>®</sup> ACe

PerfectAC™ module  
LG300A1C-B3

## Mechanical Properties

|                                      |  |
|--------------------------------------|--|
| Cells                                | 6 x 10   |
| Cell Vendor                          | LG   |
| Cell Type                            | Monocrystalline                                |
| Cell Dimensions                      | 156.5 x 156.5 mm / 6 x 6 in                    |
| # of Busbar                          | 3  |
| Dimensions (L x W x H)               | 1640 x 1000 x 35 mm<br>64.57 x 39.37 x 1.38 in |
| Weight                               | 18.0 ± 0.5 kg                                  |
| Maximum Static Load                  | 50 psf   |
| Cooling                              | Natural convection - No fans                   |
| Enclosure Environmental Rating       | Outdoor - NEMA type 6                          |
| Ambient Temperature Range            | -40°C to + 65°C                                |
| Operating Temperature Range          | -40°C to + 90°C                                |
| Glass                                | High transmission tempered glass               |
| Frame                                | Anodized aluminum                              |
| Inverter Model (Utility Interactive) | LM305UE-G1                                     |

## Certifications and Warranty

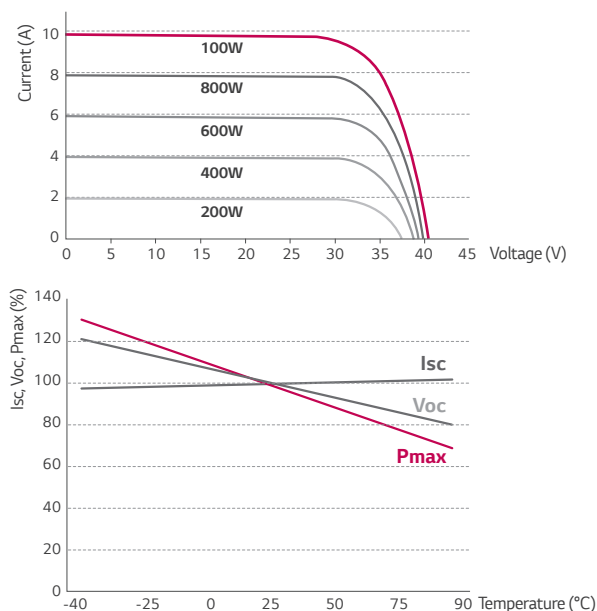
|   |  |
|---|--|
| Certifications  | UL 1703, UL 1741, IEEE 1547,<br>FCC Part 15 Class B, ISO9001<br>CAN/CSA-C22.2 NO. 107.1-01 |
| Limited Product Warranty                                    | 10 years   |
| Output Warranty of Pmax(DC)<br>(Measurement Tolerance ± 3%) | Linear warranty*   |

\* 1) 1st year: 98%, 2) After 2nd year: 0.7%p annual degradation, 3) 81.2% for 25 years

## Temperature Coefficients(DC)

|      |            |
|------|------------|
| NOCT | 45 ± 2 °C  |
| Pmpp | -0.41 %/°C |
| Voc  | -0.29 %/°C |
| Isc  | 0.04 %/°C  |

## Characteristic Curves(DC)



## DC Electrical Properties

|   |        |
|---|--------|
| Power (STC*)  | 300 W  |
| Module Efficiency (%)   | 18.3   |
| Efficiency Reduction<br>(from 1000 W/m <sup>2</sup> to 200 W/m <sup>2</sup> ) | <2.0 % |

## Inverter Electrical Properties

|   | @240VAC          | @208VAC |
|---|------------------|---------|
| Rated Continuous Output Power (W)                 | 305              | 300     |
| CEC Weighted Efficiency (%)                       | 96.5             | 96.0    |
| Rated Output Current (A)                          | 1.27             | 1.44    |
| Nominal Voltage Range (V)                         | 211-264          | 187-229 |
| Nominal Frequency / Range (Hz)                    | 60.0 / 57.0-60.5 |         |
| Power Factor                                      | > 0.95           |         |
| Max. Branch Circuit Over Current Protection (Aac) | 20               |         |

## AC Electrical Properties

|                              | @240VAC | @208VAC |
|------------------------------|---------|---------|
| AC Continuous Output Power** | 285 W   |         |
| Number of Maximum AC Modules | 12 ea   | 11 ea   |

\* STC(Standard Test Condition): Irradiance 1000W/m<sup>2</sup>, module temperature 25°C, AM 1.5

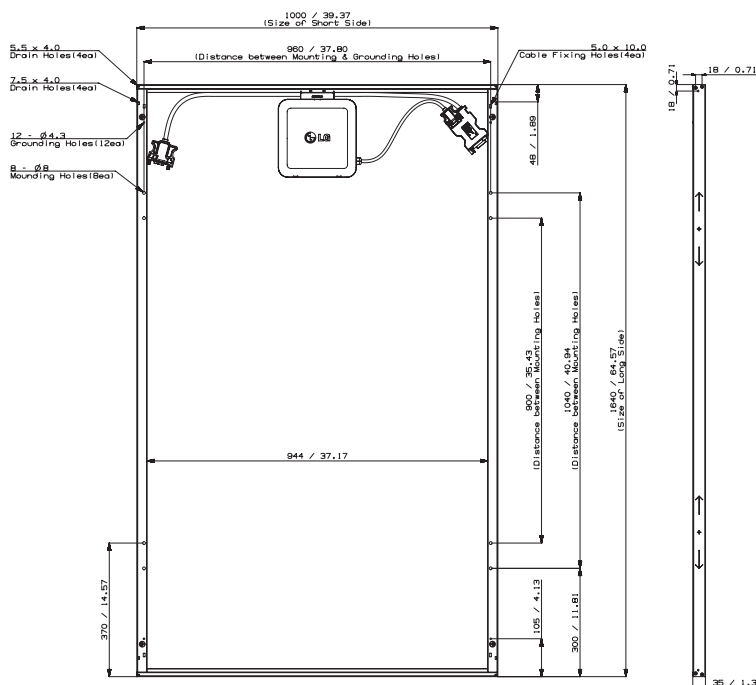
\* The nameplate power output is measured and determined by LG Electronics at its sole and absolute discretion.

\*\* Power(DC) x Weighted Efficiency(%); Figure above accounts for 5W power tolerance.

## Features

|               |               |
|---------------|---------------|
| Communication | Broadband PLC |
| Monitoring    | Web Based     |

## Dimensions (mm/in)



North American Solar Business Team  
LG Electronics USA, Inc.  
1000 Sylvan Avenue  
Englewood Cliffs, NJ 07632  
www.lgsolarusa.com

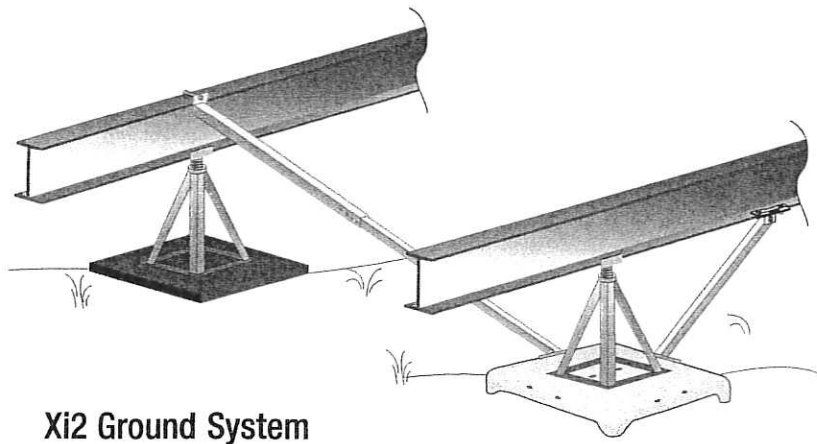
Product specifications are subject to change without notice.  
"LG Life's Good" is a registered trademark of LG Corp.  
All other trademarks are the property of their respective owners.  
DS-A-60-C-US-F-EN-40827  
Copyright © 2014 LG Electronics. All rights reserved.  
09/01/2014







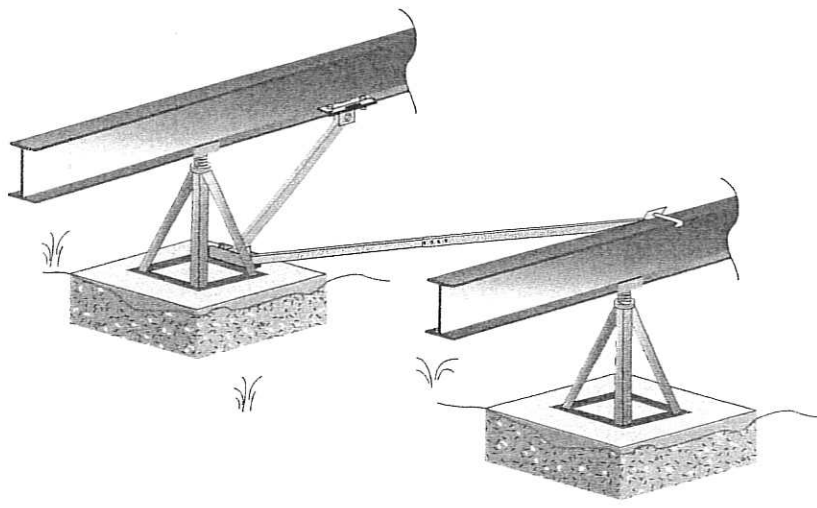
**Xi2 Foundation System**  
**Installation Instructions for California**  
**for Ground & Concrete Systems**  
**California Residential Code (CRC)2013**  
**Wind 85 mph, Exposure C;**  
**Seismic Design Category C & D**  
**By Tie Down Engineering**



**Xi2 Ground System**



**Engineer Approval**



**Xi2 Concrete System**

**State Approval**  
 MANUFACTURED HOME/MOBILE HOME  
 FOUNDATION SYSTEM  
 HEALTH AND SAFETY CODE, SECTION 18551  
 APPROVED

SUBJECT TO CORRECTIONS NOTED

APPROVAL DOES NOT AUTHORIZE OR APPROVE ANY  
 OMISSIONS OR DEVIATION FROM REQUIREMENTS OF  
 APPLICABLE STATE LAWS AND REGULATIONS  
 State of California  
 Department of Housing and Community Development

DIVISION OF CODES AND STANDARDS

BY K. Johnson DATE 10-27-14  
 SPA NO. SPA 121-1F (signature)  
 This Plan Approval Expires 10-27-16

FITZ A, AE, AH





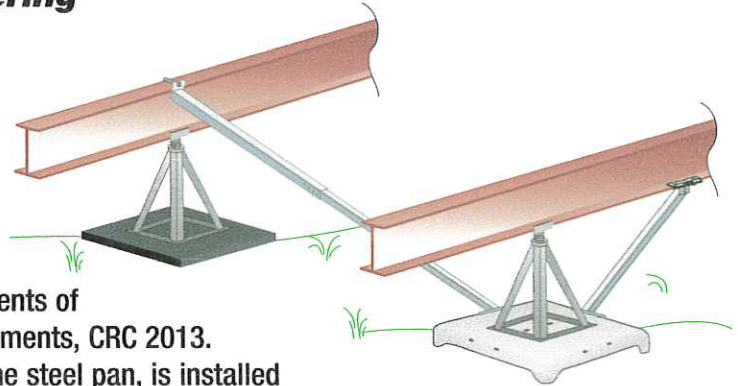
# **Xi2 Foundation System**

## **Installation Instructions for California**

### **for Ground & Concrete Systems CRC-2013,**

### **85 mph Wind Exposure C; Seismic Category C & D**

**By Tie Down Engineering**



#### **REQUIREMENTS:**

- These plans and specifications meet the requirements of Title 25 Section 1333 and Wind & Seismic Requirements, CRC 2013.
- The Xi2 System, with either a concrete footer or the steel pan, is installed at or in place of one of the piers required by the home manufacturer's set up instructions. The systems must be placed as evenly as possible; when 4 systems are needed they are to be installed on either the first or second pier in from each end of the home and when a 3rd or 5th system is needed it should go approximately at the mid-point of the home. Components of the Xi2 system such as the longitudinal strut and connecting hardware, may extend beyond the pier location.
- Maximum vertical projection at sidewall is 9'. Higher walls may be used when the design loads are adjusted accordingly.
- Main rail spacing must be 75.5" – 99.5" \*Except 95"-99.5" for single section.
- The lateral and longitudinal components of the Xi2 System replace standard frame ties. Additional Vertical anchor ties that are unique to a home's design may be required by the home manufacturer. These locations may include shear walls, marriage line ridge beam support posts, and rim plates. Check manufacturers set-up requirements.
- Maximum pier height is 48". Except 36" maximum for single sections.
- Steel piers must be fastened to the I-beam with clamps provided with steel pier.
- Designed for up to 7:12 roof slope. \* Except 20 degrees max (4.37:12 pitch) for single section.
- Flood Zone: A, AE or AH Zone flood plain (riverine or inland flood area); Max flood velocity - 1 fps: No waves, Bottom of home main beam is at or above BFE; bottom of main beam max 36" above natural grade. Not suitable for V zones, coastal A zones or floodways. Install Tie Down Engineering anchors per table (on page 8) to resist flotation.
- Designed to provide resistance to seismic Category C & D Earthquake Loads.

#### **Additional Requirements for Concrete Systems**

- Poured concrete must be 2,500 PSI minimum at 28 days.
- Square concrete pads minimum is 18" wide by 12" deep. Round concrete pads minimum is 18" wide by 14" deep. Strip footings minimum is 18" wide by 14' long by 6" deep. Full slab minimum is 4".

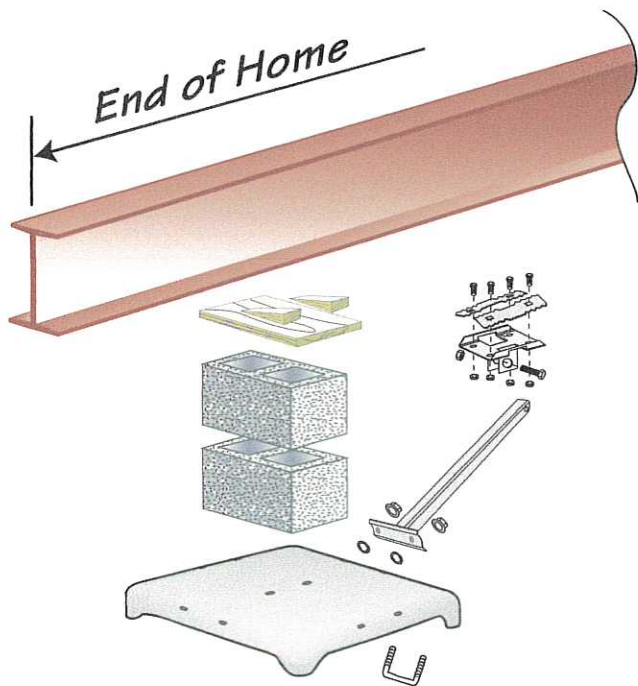
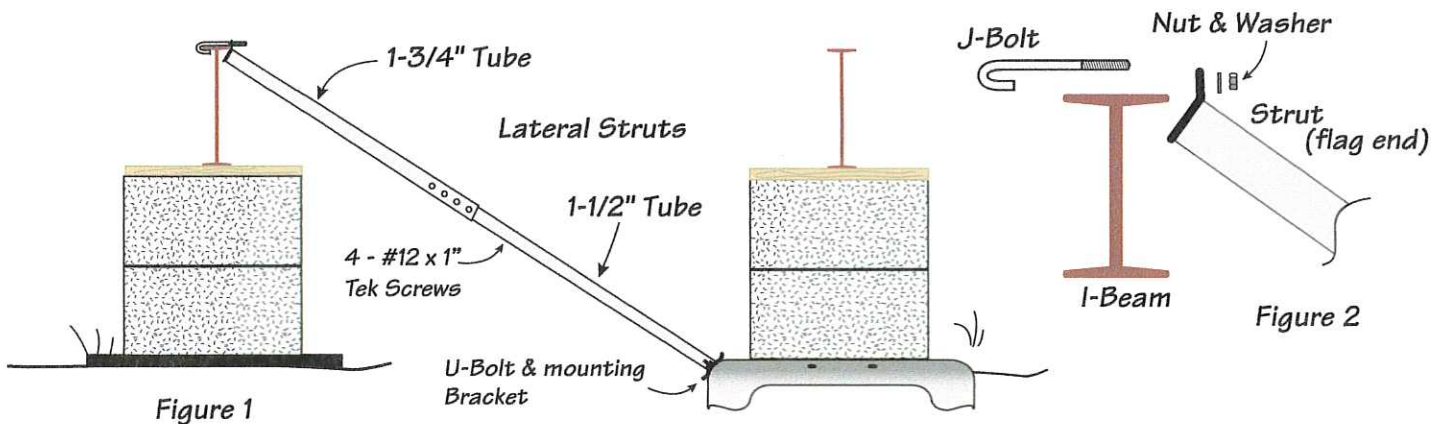
\* Xi2 components exceed HUD code 3280.306g requirements stating "Anchoring equipment exposed to weathering shall have a resistance to weather deterioration at least equivalent to that provided by a coating of zinc on steel of not less than 0.30 ounces per square foot of surface coating...."

KJ



## Installation of Xi2 Ground Systems

1. Identify the number of systems to be used on the home using the chart provided.
2. Identify the location where the systems will be installed.
3. Clear all organic matter and debris from the pad site.
4. Place U-bolts through holes in pan provided.
5. Place pad centered under beam with the lateral strut bracket towards the inside of the home.
6. Press or drive pan into ground until level and flush with prepared surface.
7. Build pier according to State, Local or Home Manufacturers guidelines. (Figure 1)
8. Attach the end of the smaller tube to the inside of pan using U-bolt & nuts provided
9. Attach the flag end of the larger tube to the opposite I-beam using the "J" bolt over the top of the I-beam with the nut & washer provided. (Figure 2)
10. Install a minimum of four (#12 x 1" tek screws) self-tapping screws into the holes provided in the lateral strut so that the two tubes are connected together. (Figure 1)



11. Install frame bracket clamps to I-beam on in side of block/pier. Do not tighten nuts at this time.
12. Attach longitudinal strut to U-bolt in pan using nuts provided.
13. Insert strut in the frame bracket clamp, attach with nut and bolt. Do not tighten at this time.
14. Pull the frame bracket clamp with the fastened strut outward to remove any slack.
15. Tighten all nuts and bolts on the struts and beam clamps.

Page 3 of 8

# Xi2 Ground Parts Detail

## Xi2 Ground Lateral System

Part Number 59306

Includes: 5' Strut, pad & hardware kit (#59329-1 includes all nuts and bolts).

## Longitudinal Hardware Kit

Part Number 59331

Includes: 2 I-beam brackets & 2 U-bolts with all nuts and bolts.

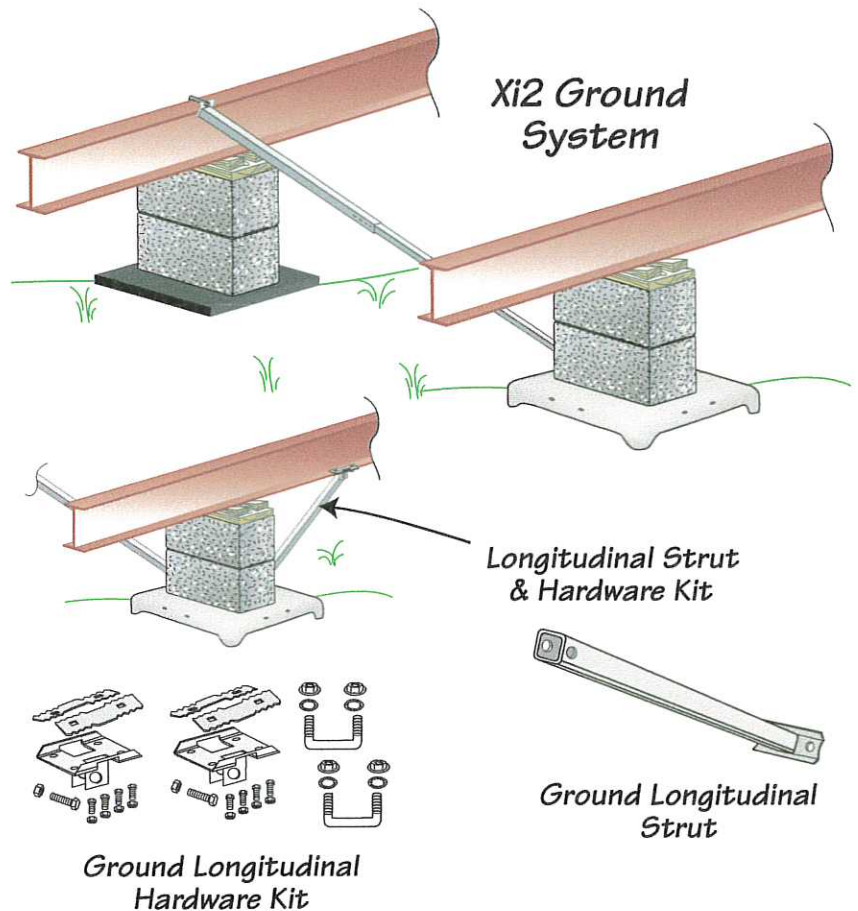
## Lateral and Longitudinal Combination

Part Number 59333

Includes: 5' Strut, Pad, Longitudinal Strut (#59329), Lateral and Longitudinal Hardware Kit with all nuts and bolts.

## Struts for Longitudinal Systems

| Part No. | Strut Length | Pier Height Up To: |
|----------|--------------|--------------------|
| 59330-44 | 44"          | 4 Blocks or 32"    |
| 59330-65 | 65"          | 6 Blocks or 48"    |



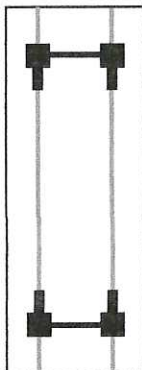
# Xi2 Stabilization Pier Placement for Ground or Concrete



Xi2 Pier Placement

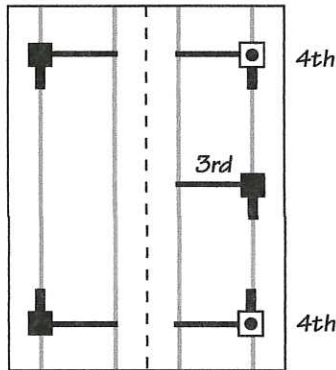


Extra Pier Placement



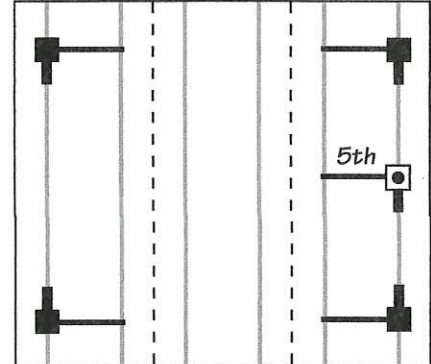
Single Section Home

0 - 80' (76' Box) 4 Xi2 Systems



Double Section Home

0 - 62' 3 Xi2 Systems\*  
63' - 80' 4 Xi2 Systems



Triple Section Home

0 - 62' 4 Xi2 Systems  
63' - 80' 5 Xi2 Systems

\*2 Xi2 systems can be placed at either end of the home.

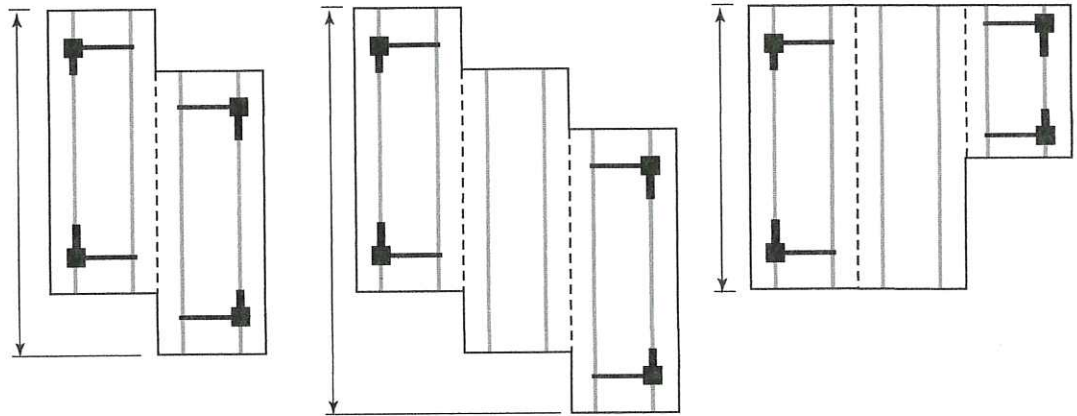


*Handwritten mark*



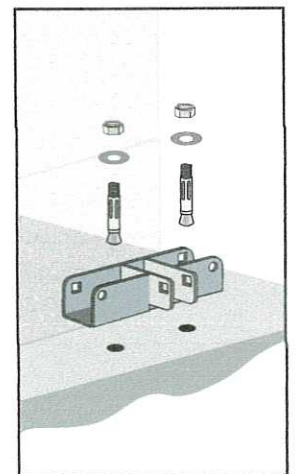
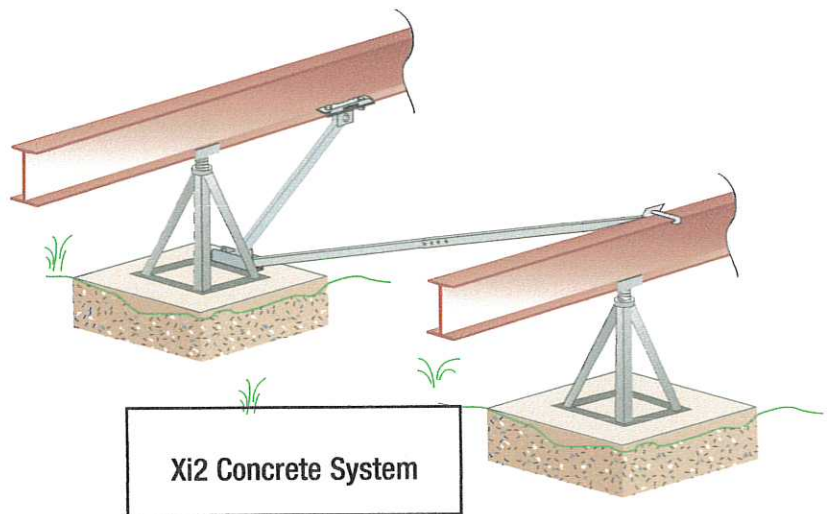
# Offset Placement

Diagrams represent examples of double and triple section offsets. Total size is determined by the length of unit plus offset.



## Installation of Xi2 Concrete Systems

1. Identify the number of systems to be used on the home using the chart provided.
2. Identify the location where the systems will be installed.
3. Build pier according to State, Local or Home Manufacturers guidelines.
4. Drill two 3/8" x 3" deep holes in the concrete using holes in galvanized bracket as a guide. Attach bracket to concrete pad using 3/8" x 3-1/2" wedge anchors provided. Place nut & washer on anchor, leave enough room for 1 to 2 threads showing on top of bolt. Using a hammer, tap the wedge bolts into hole through bracket, leaving nut & washer flush with bracket. Using a 9/16" socket wrench, tighten wedge/anchor bolt, securing bracket to the concrete.
5. Attach the end of the smaller tube to the bracket mounted on the pad, using the grade 5, 1/2" x 2-1/2" bolt/nut provided.
6. Attach the flag end of the larger tube to the opposite I-beam using the "J" bolt over the top of the I-beam with the nut & washer provided. (Figure 1 next page)
7. Install a minimum of four (#12 x 1" tek screws) self-tapping screws into the holes provided in the lateral strut so that the two tubes are connected together
8. Install frame bracket clamps on I-beam on the inside of block/pier.
9. Insert strut in frame bracket clamp and attach with nut & bolt. Attach opposite end to concrete bracket.
10. Pull the frame bracket clamp with fastened strut outward to remove any slack.
11. Tighten all nuts and bolts on system.



# Xi2 Lateral Concrete Systems

Part #59307

Includes: 5' Strut, Bracket, & Hardware Kit #59315-1 with all nuts and bolt.

Longitudinal Struts for "Concrete Systems"

| Part No. | Length | Pier Height    |
|----------|--------|----------------|
| #59013   | 44"    | up to 4 Blocks |
| #59015   | 65"    | up to 6 Blocks |

Longitudinal Hardware Kit

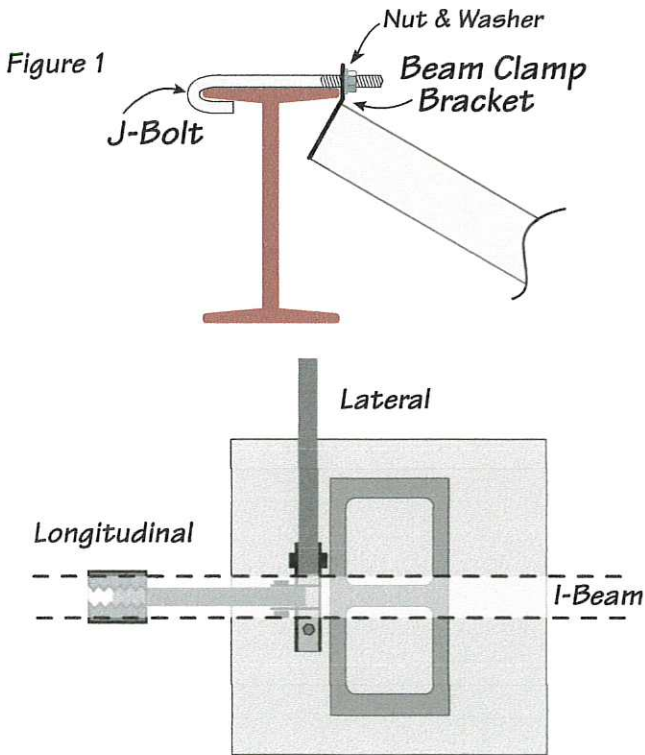
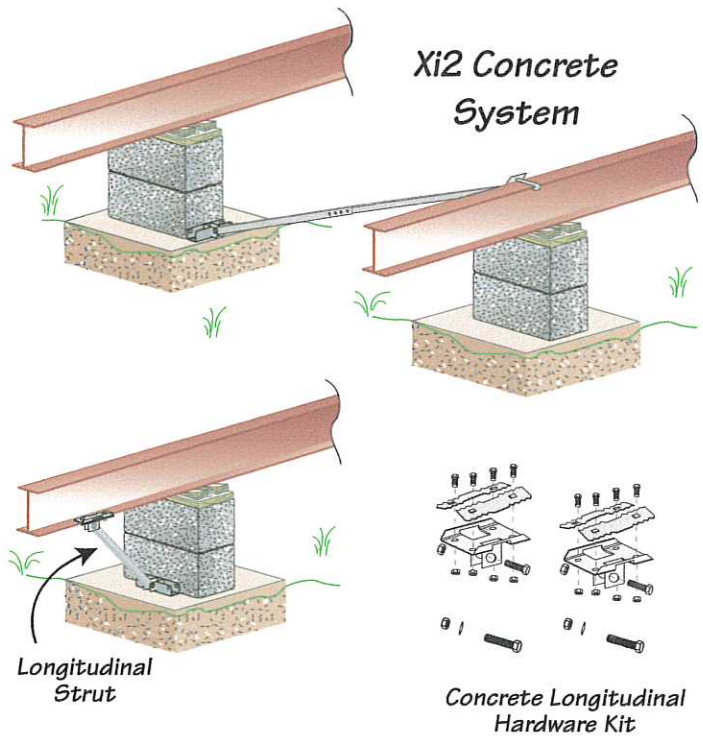
Part #59263

(Includes 2 sets per kit: I-beam bracket, nuts, bolts and washers)

Lateral and Longitudinal Combination

Part #59332

Includes: 5' Strut, Longitudinal Strut (#59364), Lateral and Longitudinal Hardware Kit with all nuts and bolts.



Xi2 Installation Placement

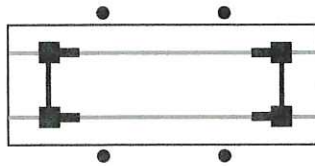


KS



## FEMA Flood Zones A, AE & AH

Anchor placement to be the same on single or multiple sections. Evenly spaced from the end of unit, between Xi2 placements.



When using concrete anchors in Lieu of ground auger anchors, the Mass of Concrete Per Anchor from chart would be: 21.1 Cu. Ft.

(Example: 3' x 3' x 2.5' = 22.5' Cu. Ft., 2' dia. x 3.5' = 22' Cu. Ft.)

To Reduce the Mass of Concrete, increase the number of tie downs proportionally.

To Reduce concrete to 11 cu. ft. (Example: 2.25' x 2.25' x 2.25' = 11.4 Cu. Ft.) double the required number of tie downs.

| Flotation Anchors<br>Single Section | Total<br>Anchors Per Side |
|-------------------------------------|---------------------------|
| 12' x 40' - 16' x 80'               | 2                         |
| <b>Multiple Section</b>             |                           |
| 20' x 40' - 20' x 64'               | 2                         |
| 24' x 40' - 24' x 56'               | 2                         |
| Over 56'                            | 2                         |
| 28' x 40' - 28' x 48'               | 2                         |
| 28' x 49' - 28' x 72'               | 2                         |
| Over 72'                            | 2                         |
| 32' x 56' - 32' x 64'               | 2                         |
| Over 64'                            | 2                         |

### Concrete Anchors

Concrete must be 2500 PSI minimum slab with a 4" minimum thickness and must allow 4725 lbs. of vertical tension on anchor without lifting. Minimum distance from the anchor shaft to one edge of the slab is 4" from one edge and 6" from any other edge. MIJ2 anchor is designed to be installed into the concrete at the time it is being poured. Slab must be 8" minimum thickness at location under anchor to allow 5" embedment of "J" rod anchor. MICS2 anchor is designed to be installed in dry concrete. Drill a 5/8" x 3" hole in the slab place expansion bolt in hole, place washer and nut over bolt and tighten until maximum expansion is achieved. Remove nut and washer and place anchor head over exposed bolt and place washer and nut back on threaded bolt and tighten nut.

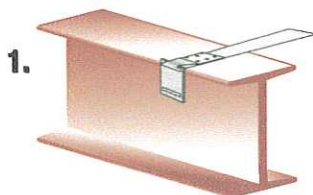
### Ground Anchors

All Frame tie ground anchors must be stabilized to prevent horizontal slicing through the soil.

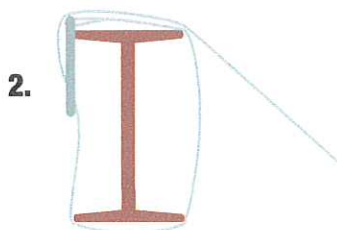
1. Position anchor at a slight back angle so that when Fully installed, anchor will be inside skirting wall.
2. For vertical or stabilized (Deepset) anchors, fully drive anchor into the ground. Horizontal (Frame Tie) anchors install 2/3 of way in ground and install stabilizer plate vertically within 3"-4" of the shaft, parallel to home.
3. Drive anchor fully into ground until head rests on plate and attach strap. Pretension strap to pull anchor against plate with head slightly over top.

### Frame Tie with Buckle

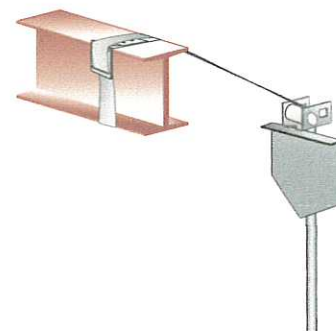
1. Install strap by pushing the end between the inside of The frame "I" beam and floor.
2. Position the buckle at the upper end of the "I" beam frame. Wrap the end of the strap around the "I" beam. Thread the end of the strap through the slot in the buckle as shown. Push the end of the strap in between the "I" beam and floor.
3. Pull the strap, making certain the buckle stays in position. Thread loose end of strap through the slotted tensioning bolt attached to the tension head of anchor. Tighten slotted bolt a minimum of 4-5 turns until all slack in strap is removed.



1.



2.



3.

Stabilizer  
Plate

Deepset  
Anchor

MIJ2  
"J" Anchor

MICS2

## Soil Classification Chart

| Soil Class | Soil Description                               | Recommended Anchors and Stabilizers |       |   |
|------------|--|-------------------------------------|-------|---|
|            |  | Model #                             | STK#  | Description   |
| 2          | Sedimentary and Foliated Rock                  | MI2255/8                            | 59090 | 30" x 5/8" rod / 2 - 4" helix                             |
|            |  | MI2233/4                            | 59095 | 30" x 3/4" rod / 2 - 4" helix                             |
|            |  |                                     | 59292 | Stabilizer Plate  |
| 3          | Sandy Gravel and/or Gravel<br>(GW and GP)      | MI2H5/8                             | 59080 | 48" x 5/8" rod / 1 - 6" helix                             |
|            |  | MI2H3/4                             | 59085 | 48" x 3/4" rod / 1 - 6" helix                             |
|            |  | Deepset                             | 59091 | 30" x 3/4" rod / 2 - 4" helix with stabilizer cap         |
|            |  |                                     | 59292 | Stabilizer Plate  |
| 4          | Sand, Silty Sand, Clayed Sand,<br>Silty Gravel | MI2H5/8                             | 59080 | 48" x 5/8" rod / 1 - 6" helix                             |
|            |  | MI2H3/4                             | 59085 | 48" x 3/4" rod / 1 - 6" helix                             |
|            |  | Deepset                             | 59092 | 36" x 3/4" rod / 1 - 4" & 1 - 6 helix with stabilizer cap |
|            |  | MI48                                | 59086 | 48" x 3/4" rod / 2 - 4" helix                             |
|            |  | MI42                                | 59128 | 42" x 3/4" rod / 2 - 4" helix                             |
|            |  |                                     | 59292 | Stabilizer Plate  |

Higher class anchors can be used in lower class soils. Example; Class 4 anchors can be used in Class 3 soils.

The required flotation anchors shown in the table are in addition to any other anchors or hold down devices required by the manufacturer. See requirements, bullet 5, page 2 of 8.

## Xi2 Hardware Breakdown

### #59329-1 Hardware for 59306 Lateral System

|   |        |   |
|---|--------|---|
| 1 | 84533Z | U-Bolt 1/2-13 x 2.63 x 2.19 thread 1-3/4 zinc |
| 4 | 10556  | Tek Screw #12 x 1"                            |
| 1 | 10631Z | J Bolt 1/2 x 5-1/2 grade 5 zinc               |
| 2 | 10640  | Push Nut 1/2                                  |
| 1 | 12107  | Flat Washer 1x2" SS                           |
| 1 | 10646Y | Hex Nut 1/2-13 grade 5 zinc                   |
| 2 | 10519  | Hex Nut 1/2" w/ Serr flange                   |

### #59331 Longitudinal Hardware for 59306

|    |         |   |
|----|---------|---|
| 2  | 59272-1 | Beam Clamp Base                               |
| 4  | 59272-2 | Beam Clamp Top Flange                         |
| 8  | 10926   | Carriage Bolt 1/2-12 x 1-1/4 Full Thread      |
| 10 | 10646Y  | Hex Nut 1/2-13 grade 5 zinc                   |
| 2  | 10801   | Carriage Bolt 1/2-12 x 2-1/2 Grade 5          |
| 2  | 84533Z  | U-Bolt 1/2-13 x 2.63 x 2.19 thread 1-3/4 zinc |
| 4  | 10640   | Push Nut 1/2                                  |
| 4  | 10519   | Hex Nut 1/2" w/ Serr flange                   |

### #59329 Hardware for 59333 Lateral and Longitudinal combination

|   |         |   |
|---|---------|---|
| 1 | 59329-1 | Hardware Kit                                  |
| 1 | 59272-1 | Beam Clamp Base                               |
| 2 | 59272-2 | Beam Clamp Top Flange                         |
| 4 | 10926   | Carriage Bolt 1/2-12 x 1-1/4 full thread      |
| 5 | 10646Y  | Hex Nut 1/2-13 Grade 5 zinc                   |
| 1 | 10801   | Carriage Bolt 1/2-12 x 2-1/2 Grade 5 zinc     |
| 1 | 84533Z  | U-Bolt 1/2-13 x 2.63 x 2.19 Thread 1-3/4 zinc |
| 2 | 10640   | Push Nut 1/2                                  |
| 2 | 10519   | Hex Nut 1/2" w/Serr Flange                    |

### #59315-1 Hardware for Lateral System

|   |        |                                       |
|---|--------|---------------------------------------|
| 1 | 10631Z | J Bolt 1/2 x 5-1/2 Grade 5 zinc       |
| 1 | 12107  | Flat Washer 1/2" SS                   |
| 4 | 10556  | Tek Screw #12 x 1"                    |
| 2 | 10646Y | Hex Nut 1/2x-13 Grade 5 zinc          |
| 1 | 10826  | Carriage Bolt 1/2-12 x 3 Grade 5 zinc |

### #59027 Hardware Kit for 59307 Lateral System

|   |         |                         |
|---|---------|-------------------------|
| 2 | 59264   | 3 Way Concrete Bracket  |
| 4 | 10530   | Wedge Anchor 3/8 x 3.50 |
| 1 | 59315-1 | Hardware Kit            |

### #59263 Longitudinal Hardware for 59307

|    |         |   |
|----|---------|---|
| 2  | 59272-1 | Beam Clamp Base                               |
| 4  | 59272-2 | Beam Clamp Top Flange                         |
| 8  | 10926   | Carriage Bolt 1/2-13 x 1-1/4 Full Thread zinc |
| 12 | 10646Y  | Hex Nut 1/2-13 Grade 5 zinc                   |
| 4  | 10801   | Carriage Bolt 1/2-13 x 2-1/2 Grade 5 zinc     |

### #59364 Hardware for 59332 Lateral and Longitudinal combination

|   |         |   |
|---|---------|---|
| 1 | 59264   | 3 Way Concrete Bracket                        |
| 2 | 10530   | Wedge Anchor 3/8 x 3.50                       |
| 1 | 59315-1 | Lateral Hardware Kit                          |
| 1 | 59272-1 | Beam Clamp Base                               |
| 2 | 59272-2 | Beam Clamp Top Flange                         |
| 4 | 10926   | Carriage Bolt 1/2-13 x 1-1/4 Full Thread zinc |
| 2 | 10801   | Carriage Bolt 1/2-13 x 2-1/2 Grade 5 zinc     |
| 6 | 10646Y  | Hex Nut 1/2-13 Grade 5 zinc                   |



K-L





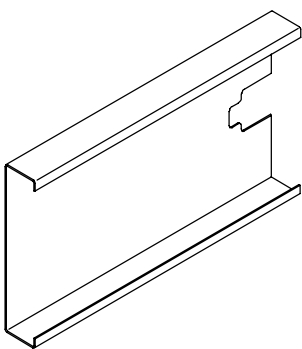
# PRODUCT TECHNICAL GUIDE

Steel Stud Manufacturers Association



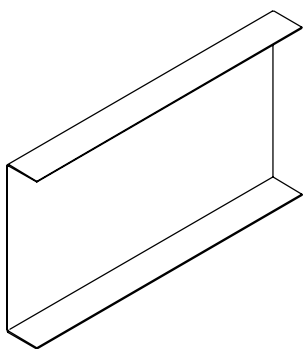
## Note:

For sections available in both 33 and 50 ksi, the specifier must clearly indicate which yield point is required when ordering. For example: 600S162-54 (50 ksi).

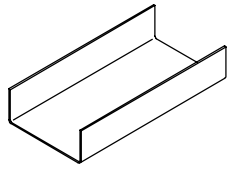


"S" - C-STUD/ JOIST S-SECTIONS\*

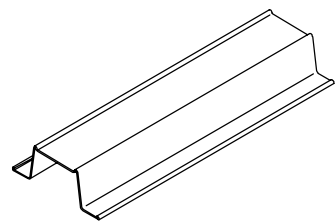
\* For "S" members, see table on page 5 for stiffening lip length.



"T" - TRACK T-SECTIONS



"U" - CHANNEL U-SECTIONS



"F" - FURRING CHANNEL F-SECTIONS

## Nomenclature Example

All SSMA products have a four-part identification code that identifies the web depth, flange width, style, and mil thickness.

### Member Web Depth

(Example: 6" =  $600 \times \frac{1}{100}$  inch)  
 All member depths are given in  $\frac{1}{100}$  inch.  
 For all "T" sections, member depth is the inside to inside dimension.

### Flange Width

(Example:  $1\frac{5}{8}$ " =  $1.625$ "  $\approx 162 \times \frac{1}{100}$  inch)  
 All flange widths are given in  $\frac{1}{100}$  inch.



### Style

(Example: Stud or Joist section = S)  
 Nomenclature uses the following four characters to designate the profile:  
**S** = Stud or Joist Sections  
**T** = Track Sections  
**U** = Channel Sections  
**F** = Furring Channel Sections

### Mil Thickness

(Example:  $0.054$ " = 54 mils; 1 mil =  $\frac{1}{1000}$  inch)  
 Mil thickness is the minimum base steel thickness measured in  $\frac{1}{1000}$  inch. Minimum base steel thickness represents 95 percent of the design thickness.

|  |                |   |                   |
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## Mission Statement

The SSMA's mission is to be the unified voice of the steel framing manufacturing industry, by being the leader in supporting the development and maintenance of quality product standards and specifications, and by creating growth opportunities for cold-formed steel through research, marketing, and education.

## Introduction

The increasing environmental concerns in the world today have caused us all to examine the way we live. These issues have affected every aspect of our lives, including the materials we use in construction. The use of cold-formed steel members benefit the environment, contractor, designer, and developer more than other material.

Steel is not only a recyclable product, but also a stronger product that allows for longer clear-spans. Cold-formed steel is lighter to provide ease of handling, and is a dimensionally stable product, giving a "straight" wall with which to work. It doesn't suffer fluctuation in price, making it easier to bid a project. Quality control is stressed in all phases of the manufacturing process so the highest possible quality is delivered to the jobsite. The structural shapes manufactured are easily used for nonstructural and structural wall assemblies, floor and ceiling joist assemblies, trusses, and panelized systems.

SSMA in collaboration with the American Iron and Steel Institute (AISI) has developed and adopted a standard designator system for identifying cold-formed steel framing members. Using a standard system will eliminate the confusion caused by individual manufacturers' varied designators.

## Technical Assistance

Professional technical assistance is available through SSMA or individual manufacturers' technical departments.

## Code Approval

SSMA structural and nonstructural cold-formed framing product specifications meet the stringent requirements of International Code Council Evaluation Services in conjunction with SSMA ICC-ES evaluation report (ESR-3064P). The product specification and documented quality control system & procedures are verified during regular inspections by ICC-ES, the leader in the technical evaluations for code compliance of the building products.

## Material Specifications

Structural and nonstructural members are coated to meet the minimum code requirements. Higher corrosion protection coatings such as G90 are available upon request. Products manufactured by SSMA members are cold-formed from corrosion protected steel coils or sheets and meet the following specifications requirements:

| Product Type  | Material Specifications             | Min Yield | Min Tensile      | Minimum Metallic Coating Designation  |
|---|-------------------------------------|-----------|------------------|---|
| Nonstructural Products<br>ASTM C645                 | ASTM A653, SS Grade 33              | 33 ksi    | 45 ksi           | G40   |
|   | ASTM A1003, Grade 33 (NS33)         | 33 ksi    | ... <sup>A</sup> | G40 <sup>1</sup> , A40 <sup>1</sup> , AZ50 <sup>2</sup> , GF30 <sup>3</sup> , T1-25 <sup>4</sup> , T2-100 <sup>4</sup> , 60G/60G <sup>5</sup> |
| Structural Products<br>ASTM C955<br>(CP60 Coatings) | ASTM A653, SS Grade 33              | 33 ksi    | 45 ksi           | G60   |
|   | ASTM A1003, Grade 33 Type H (ST33H) | 33 ksi    | 45 ksi           | G60 <sup>1</sup> , A60 <sup>1</sup> , AZ50 <sup>2</sup> , GF30 <sup>3</sup>   |
|   | ASTM A653, SS Grade 50 Class 1      | 50 ksi    | 65 ksi           | G60   |
|   | ASTM A1003, Grade 50 Type H (ST50H) | 50 ksi    | 65 ksi           | G60 <sup>1</sup> , A60 <sup>1</sup> , AZ50 <sup>2</sup> , GF30 <sup>3</sup>   |
|   | ASTM A653 HSLA Grade 50             | 50 ksi    | 65 ksi           | G60   |

<sup>1</sup>A653 Standard for steel sheet, zinc coated (galvanized) or zinc-iron alloy-coated (galvannealed) by the hot-dip process

<sup>2</sup>A792 Standard for steel sheet, 55% aluminum-zinc alloy-coated by the hot-dip process

<sup>3</sup>A875 Standard for steel sheet, zinc-5% aluminum alloy-coated by the hot-dip process

<sup>4</sup>A463 Standard for steel sheet, aluminum coated by the hot-dip process

<sup>5</sup>A879 Standard for steel sheet, zinc coated by the electrolytic process for application requiring designation of the coating mass on each surface

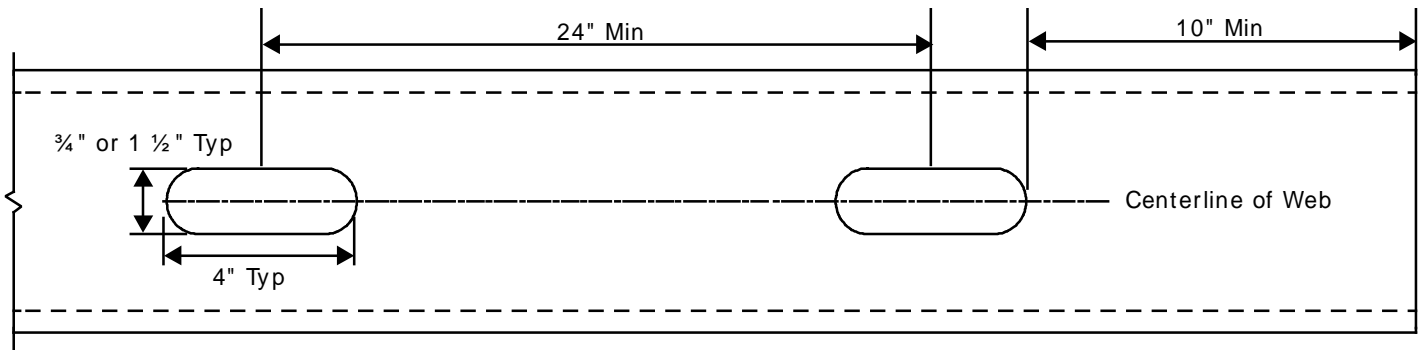
<sup>A</sup>No tensile requirements for nonstructural steel in accordance with ASTM A1003 standards

## Disclaimer

All data, specifications, and details contained in this publication are intended as a general guide for using SSMA members' products. These products should not be used in design or construction without an independent evaluation by a qualified engineer or architect to verify the suitability of a particular product for use in a specific application. The SSMA and its members assume no liability for product failure resulting from the use or misapplication of computations, detail drawings, and specifications contained herein. This publication contains the latest information available at the time of printing with respect to the referenced building codes and standards. The SSMA and its members reserve the right to make modifications and/or change materials of any of their products without prior notice or obligation. For the latest information regarding a particular manufacturer's products, contact that manufacturer. All SSMA manufacturers may not produce all of the products contained in this catalog. Please contact individual manufacturer to verify product availability.

## General Notes for All Tables

- The values in this catalog are based on the 2007 edition of North American Specification for the Design of Cold-Formed Steel Structural Members, AISI S100-07 as referenced by 2009 International Building Code (IBC) and AISI S100-07 with Supplement S2-10 as referenced by 2012 IBC.
- Where AISI S100 is referenced, it is the North American Specification for the Design of Cold-Formed Steel Structural Members, S100-07 and AISI S100-07 with Supplement S2-10, as applicable with U.S. provisions.
- The structural properties included in this catalog have been computed based on allowable strength design (ASD) method.
- Distortional buckling calculations are based on  $K\phi = 0$ .
- The effective moment of inertia for deflection is calculated at a stress that results in a section modulus such that the stress times the section modulus at that stress is equal to the allowable moment. AISI S100 Procedure I for serviceability determination has been used.
- Various sections may be manufactured with yield points of 33 or 50 kips per square inch (ksi). The yield point used for calculations is indicated in the tables.
- For sections available in both 33 and 50 ksi, the specifier must clearly indicate which yield point is required. For example: 362S162-54 (50 ksi).
- Conditions with loads that exceed the 10 psf limit for nonstructural members require an approved CP60 coating.
- When provided, factory punchouts will be located along the center line of the webs of the stud members and will have a minimum center-to-center spacing of 24". Punchouts for members greater than 2 1/2" deep are a maximum of 1 1/2" wide x 4 1/2" long. Members with depths 2 1/2" and smaller are maximum 3/4" wide x 4 1/2" long. Any configuration or combination of holes that fit within the punchout width and length limitations mentioned above shall be permitted; other punchout configurations and locations not in compliance with limitations listed above must be approved by a design professional. Values herein are based on punchout configuration and location as illustrated below.
- The 10" end distance shown may be altered if calculations are in conformance with code.



### Steel Thickness Table

| Designation Thickness (mil) | Minimum Thickness <sup>1</sup> (in) | Design Thickness <sup>1</sup> (in) | Design Inside Corner Radii <sup>2</sup> (in) | Reference Only Gauge No. |
|-----------------------------|-------------------------------------|------------------------------------|--|--------------------------|
| 18                          | 0.0179                              | 0.0188                             | 0.0843                                       | 25                       |
| 27                          | 0.0269                              | 0.0283                             | 0.0796                                       | 22                       |
| 30                          | 0.0296                              | 0.0312                             | 0.0781                                       | 20 – Drywall             |
| 33                          | 0.0329                              | 0.0346                             | 0.0764                                       | 20 – Structural          |
| 43                          | 0.0428                              | 0.0451                             | 0.0712                                       | 18                       |
| 54                          | 0.0538                              | 0.0566                             | 0.0849                                       | 16                       |
| 68                          | 0.0677                              | 0.0713                             | 0.1069                                       | 14                       |
| 97                          | 0.0966                              | 0.1017                             | 0.1525                                       | 12                       |
| 118                         | 0.1180                              | 0.1242                             | 0.1863                                       | 10                       |

### Stiffening Lip Length Table

| Member | Flange Width | Stiffening Lip Length (in) |
|--------|--------------|----------------------------|
| S125   | 1 1/4"       | 0.188                      |
| S137   | 1 3/8"       | 0.375                      |
| S162   | 1 5/8"       | 0.500                      |
| S200   | 2"           | 0.625                      |
| S250   | 2 1/2"       | 0.625                      |
| S300   | 3"           | 0.625                      |
| S350   | 3 1/2"       | 1.000                      |

<sup>1</sup>Minimum thickness represents 95% of the design thickness and is the minimum acceptable thickness delivered to the jobsite based on AISI S100-07 Section A2.4.

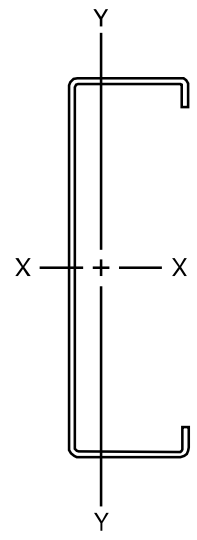
<sup>2</sup>The tables in this catalog are calculated based on inside corner radii listed in this table. The inside corner radius is the maximum of  $\frac{1}{32} - t/2$  or  $1.5t$ , truncated after the fourth decimal place ( $t =$  design thickness). Centerline bend radius is calculated by adding half of the design thickness to listed corner radius.

## Gross Properties

- $I_x$ : Moment of inertia of the cross section about the x-axis.
- $S_x$ : Section modulus about the x-axis.
- $R_x$ : Radius of gyration of cross section about the x-axis.
- $I_y$ : Moment of inertia of cross section about the y-axis.
- $R_y$ : Radius of gyration of cross section about the y-axis.

## Effective Properties

- $I_{xe}$ : Effective moment of inertia about the x-axis.
- $S_{xe}$ : Effective section modulus about the x-axis.
- $M_{al}$ : Allowable moment based on local buckling.
- $M_{ad}$ : Allowable moment based on distortional buckling, assuming  $K\phi = 0$ .
- $M_a$ : Allowable moment for track and channel members, based on local buckling only.
- $V_{ag}$ : Allowable strong axis shear away from punchout, calculated in accordance with AISI S100 Section C3.2.1.
- $V_{anet}$ : Allowable strong axis shear at the punchout, calculated in accordance with AISI S100 Section C3.2.2.



## Torsional and Other Properties

- $J$ : St. Venant torsional constant. The numbers shown in the tables for  $J$  have been multiplied by 1,000. The actual values can be obtained by dividing the listed numbers by 1,000.
- $C_w$ : Torsional warping constant.
- $X_o$ : Distance from the shear center to the centroid along the principal x-axis.
- $m$ : Distance from shear center to mid-plane of web.
- $R_o$ : Polar radius of gyration of cross section about the shear center.
- $\beta$ :  $1 - (X_o/R_o)^2$
- $L_u$ : Critical unbraced length for lateral-torsional buckling. Members are considered fully braced when unbraced length is less than  $L_u$ .
- $K\phi$ : Distortional buckling moment ( $M_{ad}$ ) is calculated without the beneficial effect of sheathing to rotational stiffness.  $K\phi = 0$ .

## Web Depth (h) to Thickness (t) Ratios <sup>2,3,4</sup>

| Mil Thickness           | 18 mil |                  | 27 mil |                  | 30 mil |                  | 33 mil |                  | 43 mil |                  | 54 mil |                  | 68 mil |                  | 97 mil |     | 118 mil |     |
|-------------------------|--------|------------------|--------|------------------|--------|------------------|--------|------------------|--------|------------------|--------|------------------|--------|------------------|--------|-----|---------|-----|
| Design Thickness (in)   | 0.0188 |                  | 0.0283 |                  | 0.0312 |                  | 0.0346 |                  | 0.0451 |                  | 0.0566 |                  | 0.0713 |                  | 0.1017 |     | 0.1242  |     |
| Inside Bend Radius (in) | 0.0843 |                  | 0.0796 |                  | 0.0781 |                  | 0.0764 |                  | 0.0712 |                  | 0.0849 |                  | 0.1069 |                  | 0.1525 |     | 0.1863  |     |
| Depth (in)              | h (in) | h/t              | h (in) | h/t              | h (in) | h/t              | h (in) | h/t              | h (in) | h/t              | h (in) | h/t              | h (in) | h/t              | h (in) | h/t | h (in)  | h/t |
| 1.625                   | 1.419  | 75               | 1.409  | 50               | 1.406  | 45               | 1.403  | 41               | 1.392  | 31               | 1.342  | 24               | 1.269  | 18               | 1.117  | 11  | 1.004   | 8   |
| 2.5                     | 2.294  | 122              | 2.284  | 81               | 2.281  | 73               | 2.278  | 66               | 2.267  | 50               | 2.217  | 39               | 2.144  | 30               | 1.992  | 20  | 1.879   | 15  |
| 3.5                     | 3.294  | 175              | 3.284  | 116              | 3.281  | 105              | 3.278  | 95               | 3.267  | 72               | 3.217  | 57               | 3.144  | 44               | 2.992  | 29  | 2.879   | 23  |
| 3.625                   | 3.419  | 182              | 3.409  | 120              | 3.406  | 109              | 3.403  | 98               | 3.392  | 75               | 3.342  | 59               | 3.269  | 46               | 3.117  | 31  | 3.004   | 24  |
| 4                       | 3.794  | 202 <sup>1</sup> | 3.784  | 134              | 3.781  | 121              | 3.778  | 109              | 3.767  | 84               | 3.717  | 66               | 3.644  | 51               | 3.492  | 34  | 3.379   | 27  |
| 5.5                     | 5.294  | -                | 5.284  | 187              | 5.281  | 169              | 5.278  | 153              | 5.267  | 117              | 5.217  | 92               | 5.144  | 72               | 4.992  | 49  | 4.879   | 39  |
| 6                       | 5.794  | -                | 5.784  | 204 <sup>1</sup> | 5.781  | 185              | 5.778  | 167              | 5.767  | 128              | 5.717  | 101              | 5.644  | 79               | 5.492  | 54  | 5.379   | 43  |
| 8                       | 7.794  | -                | 7.784  | -                | 7.781  | 249 <sup>1</sup> | 7.778  | 225 <sup>1</sup> | 7.767  | 172              | 7.717  | 136              | 7.644  | 107              | 7.492  | 74  | 7.379   | 59  |
| 10                      | 9.794  | -                | 9.784  | -                | 9.781  | -                | 9.778  | -                | 9.767  | 217 <sup>1</sup> | 9.717  | 172              | 9.644  | 135              | 9.492  | 93  | 9.379   | 76  |
| 12                      | 11.794 | -                | 11.784 | -                | 11.781 | -                | 11.778 | -                | 11.767 | -                | 11.717 | 207 <sup>1</sup> | 11.644 | 164              | 11.492 | 113 | 11.379  | 92  |
| 14                      | 13.794 | -                | 13.784 | -                | 13.781 | -                | 13.778 | -                | 13.767 | -                | 13.717 | 242 <sup>1</sup> | 13.644 | 192              | 13.492 | 133 | 13.379  | 108 |
| 16                      | 15.794 | -                | 15.784 | -                | 15.781 | -                | 15.778 | -                | 15.767 | -                | 15.717 | -                | 15.644 | 220 <sup>1</sup> | 15.492 | 152 | 15.379  | 124 |

<sup>1</sup>h/t exceeds 200  
<sup>2</sup>h value used for h/t calculation is the flat width of the web. For S members, this is the out-to-out member size, minus twice the thickness, minus twice the inside bend radius.  
<sup>3</sup>h/t values exceeding 260 are marked with a dash (-).  
<sup>4</sup>h/t values in this table apply to S (studs and joists) members only and do not apply to tracks and channels.

# Nonstructural (S) Section Properties



## Table Notes

1. The centerline bend radius is based on inside corner radii shown in the steel thickness table on page 5.
2. Effective properties incorporate the strength increase from the cold work of forming as applicable per AISI S100 Section A7.2.
3. Tabulated gross properties are based on the full-unreduced cross section of the studs away from punchouts.
4. For deflection calculations, use the effective moment of inertia.
5. Allowable moment is the lesser of  $M_{at}$  and  $M_{ad}$ . Stud distortional buckling is based on an assumed  $K\phi = 0$ .
6. See page 5 for additional table notes.

| Section                   | Design Thickness (in) | Fy (ksi) | Gross Properties        |                |                       |                       |         |                       | Effective Properties |                        |                        |                    |            |          | Torsional Properties |                           |                       |         |        | Lu (in) |         |      |
|---------------------------|-----------------------|----------|-------------------------|----------------|-----------------------|-----------------------|---------|-----------------------|----------------------|------------------------|------------------------|--------------------|------------|----------|----------------------|---------------------------|-----------------------|---------|--------|---------|---------|------|
|                           |                       |          | Area (in <sup>2</sup> ) | Weight (lb/ft) | Ix (in <sup>4</sup> ) | Sx (in <sup>3</sup> ) | Rx (in) | Iy (in <sup>4</sup> ) | Ry (in)              | Ixe (in <sup>4</sup> ) | Sxe (in <sup>3</sup> ) | Mal (in-k)         | Mad (in-k) | Vag (lb) | Vanet (lb)           | Jx1000 (in <sup>4</sup> ) | Cw (in <sup>6</sup> ) | Xo (in) | m (in) |         | Ro (in) | B    |
| 162S125-18                | 0.0188                | 33       | 0.080                   | 0.27           | 0.038                 | 0.046                 | 0.686   | 0.016                 | 0.447                | 0.034                  | 0.031                  | 0.61               | 0.65       | 302      | 100                  | 0.009                     | 0.009                 | -1.029  | 0.594  | 1.315   | 0.388   | 29.0 |
| 162S125-27                | 0.0283                | 33       | 0.120                   | 0.41           | 0.056                 | 0.068                 | 0.682   | 0.023                 | 0.443                | 0.055                  | 0.053                  | 1.05               | 1.14       | 494      | 106                  | 0.032                     | 0.013                 | -1.017  | 0.587  | 1.302   | 0.390   | 29.1 |
| 162S125-30                | 0.0312                | 33       | 0.131                   | 0.45           | 0.061                 | 0.075                 | 0.681   | 0.026                 | 0.441                | 0.060                  | 0.060                  | 1.19               | 1.29       | 543      | 106                  | 0.043                     | 0.014                 | -1.014  | 0.585  | 1.298   | 0.390   | 29.2 |
| 162S125-33                | 0.0346                | 33       | 0.145                   | 0.49           | 0.067                 | 0.083                 | 0.679   | 0.028                 | 0.440                | 0.066                  | 0.069                  | 1.37               | 1.48       | 601      | 105                  | 0.058                     | 0.016                 | -1.010  | 0.583  | 1.294   | 0.391   | 29.2 |
| 250S125-18                | 0.0188                | 33       | 0.097                   | 0.33           | 0.099                 | 0.079                 | 1.014   | 0.019                 | 0.439                | 0.089                  | 0.059                  | 1.17               | 1.03       | 258      | 196                  | 0.011                     | 0.023                 | -0.904  | 0.543  | 1.427   | 0.599   | 29.0 |
| 250S125-27                | 0.0283                | 33       | 0.144                   | 0.49           | 0.147                 | 0.118                 | 1.009   | 0.027                 | 0.434                | 0.144                  | 0.097                  | 1.92               | 1.83       | 685      | 344                  | 0.039                     | 0.034                 | -0.893  | 0.536  | 1.416   | 0.602   | 28.9 |
| 250S125-30                | 0.0312                | 33       | 0.159                   | 0.54           | 0.161                 | 0.129                 | 1.008   | 0.030                 | 0.433                | 0.159                  | 0.110                  | 2.17               | 2.09       | 832      | 378                  | 0.052                     | 0.037                 | -0.889  | 0.534  | 1.412   | 0.603   | 28.9 |
| 250S125-33                | 0.0346                | 33       | 0.176                   | 0.60           | 0.178                 | 0.142                 | 1.006   | 0.033                 | 0.431                | 0.175                  | 0.125                  | 2.48               | 2.41       | 975      | 399                  | 0.070                     | 0.040                 | -0.885  | 0.532  | 1.408   | 0.605   | 28.9 |
| 250S125-43                | 0.0451                | 33       | 0.227                   | 0.77           | 0.228                 | 0.182                 | 1.001   | 0.041                 | 0.426                | 0.225                  | 0.177                  | 3.49               | 3.43       | 1265     | 394                  | 0.154                     | 0.050                 | -0.873  | 0.525  | 1.396   | 0.608   | 28.9 |
| 250S125-54                | 0.0566                | 33       | 0.280                   | 0.95           | 0.277                 | 0.222                 | 0.994   | 0.049                 | 0.419                | 0.277                  | 0.218                  | 4.98 <sup>2</sup>  | 5.07       | 1553     | 373                  | 0.299                     | 0.060                 | -0.859  | 0.518  | 1.379   | 0.612   | 26.8 |
| 250S125-54                | 0.0566                | 50       | 0.280                   | 0.95           | 0.277                 | 0.222                 | 0.994   | 0.049                 | 0.419                | 0.274                  | 0.209                  | 6.25               | 6.17       | 2353     | 565                  | 0.299                     | 0.060                 | -0.859  | 0.518  | 1.379   | 0.612   | 23.3 |
| 250S125-68                | 0.0713                | 33       | 0.345                   | 1.18           | 0.334                 | 0.267                 | 0.984   | 0.057                 | 0.408                | 0.334                  | 0.266                  | 6.30 <sup>2</sup>  | 6.32       | 1891     | 342                  | 0.585                     | 0.072                 | -0.839  | 0.508  | 1.356   | 0.617   | 26.5 |
| 250S125-68                | 0.0713                | 50       | 0.345                   | 1.18           | 0.334                 | 0.267                 | 0.984   | 0.057                 | 0.408                | 0.334                  | 0.262                  | 7.84               | 8.01       | 2866     | 519                  | 0.585                     | 0.072                 | -0.839  | 0.508  | 1.356   | 0.617   | 23.3 |
| 350S125-18                | 0.0188                | 33       | 0.115                   | 0.39           | 0.215                 | 0.123                 | 1.366   | 0.021                 | 0.423                | 0.203                  | 0.072                  | 1.42               | 1.47       | 180      | 159                  | 0.014                     | 0.050                 | -0.797  | 0.495  | 1.637   | 0.763   | 28.8 |
| 350S125-27                | 0.0283                | 33       | 0.173                   | 0.59           | 0.320                 | 0.183                 | 1.361   | 0.030                 | 0.418                | 0.315                  | 0.130                  | 2.57               | 2.65       | 614      | 359                  | 0.046                     | 0.072                 | -0.787  | 0.489  | 1.627   | 0.766   | 28.7 |
| 350S125-30                | 0.0312                | 33       | 0.190                   | 0.65           | 0.351                 | 0.201                 | 1.359   | 0.033                 | 0.417                | 0.346                  | 0.150                  | 2.96               | 3.04       | 824      | 436                  | 0.062                     | 0.079                 | -0.784  | 0.487  | 1.624   | 0.767   | 28.6 |
| 350S125-33                | 0.0346                | 33       | 0.210                   | 0.72           | 0.387                 | 0.221                 | 1.358   | 0.036                 | 0.415                | 0.382                  | 0.175                  | 3.45               | 3.53       | 1024     | 487                  | 0.084                     | 0.087                 | -0.780  | 0.485  | 1.620   | 0.768   | 28.6 |
| 350S125-43                | 0.0451                | 33       | 0.272                   | 0.93           | 0.498                 | 0.284                 | 1.352   | 0.046                 | 0.410                | 0.495                  | 0.258                  | 5.10               | 5.11       | 1739     | 631                  | 0.184                     | 0.109                 | -0.769  | 0.479  | 1.609   | 0.771   | 28.4 |
| 350S125-54                | 0.0566                | 33       | 0.337                   | 1.15           | 0.608                 | 0.348                 | 1.344   | 0.055                 | 0.402                | 0.608                  | 0.328                  | 6.49               | 6.87       | 2253     | 633                  | 0.360                     | 0.131                 | -0.755  | 0.471  | 1.593   | 0.775   | 28.4 |
| 350S125-54                | 0.0566                | 50       | 0.337                   | 1.15           | 0.608                 | 0.348                 | 1.344   | 0.055                 | 0.402                | 0.604                  | 0.308                  | 9.22               | 9.25       | 3372     | 947                  | 0.360                     | 0.131                 | -0.755  | 0.471  | 1.593   | 0.775   | 22.9 |
| 350S125-68                | 0.0713                | 33       | 0.417                   | 1.42           | 0.739                 | 0.422                 | 1.332   | 0.064                 | 0.391                | 0.737                  | 0.409                  | 9.67 <sup>2</sup>  | 9.98       | 2774     | 592                  | 0.706                     | 0.156                 | -0.737  | 0.462  | 1.571   | 0.780   | 25.7 |
| 350S125-68                | 0.0713                | 50       | 0.417                   | 1.42           | 0.739                 | 0.422                 | 1.332   | 0.064                 | 0.391                | 0.737                  | 0.400                  | 11.97              | 12.54      | 4202     | 897                  | 0.706                     | 0.156                 | -0.737  | 0.462  | 1.571   | 0.780   | 22.8 |
| 362S125-18                | 0.0188                | 33       | 0.118                   | 0.40           | 0.234                 | 0.129                 | 1.409   | 0.021                 | 0.421                | 0.221                  | 0.075                  | 1.48               | 1.52       | 173      | 163                  | 0.014                     | 0.054                 | -0.786  | 0.490  | 1.667   | 0.778   | 28.8 |
| 362S125-27                | 0.0283                | 33       | 0.176                   | 0.60           | 0.347                 | 0.192                 | 1.404   | 0.031                 | 0.416                | 0.342                  | 0.135                  | 2.67               | 2.75       | 592      | 370                  | 0.047                     | 0.079                 | -0.776  | 0.484  | 1.657   | 0.781   | 28.6 |
| 362S125-30                | 0.0312                | 33       | 0.194                   | 0.66           | 0.381                 | 0.210                 | 1.402   | 0.033                 | 0.415                | 0.376                  | 0.156                  | 3.08               | 3.17       | 794      | 449                  | 0.063                     | 0.086                 | -0.773  | 0.482  | 1.654   | 0.782   | 28.6 |
| 362S125-33                | 0.0346                | 33       | 0.215                   | 0.73           | 0.421                 | 0.232                 | 1.400   | 0.037                 | 0.413                | 0.415                  | 0.182                  | 3.59               | 3.67       | 1024     | 521                  | 0.086                     | 0.094                 | -0.769  | 0.480  | 1.650   | 0.783   | 28.5 |
| 362S125-43                | 0.0451                | 33       | 0.278                   | 0.95           | 0.540                 | 0.298                 | 1.395   | 0.046                 | 0.408                | 0.537                  | 0.269                  | 5.31               | 5.33       | 1739     | 676                  | 0.188                     | 0.118                 | -0.758  | 0.473  | 1.639   | 0.786   | 28.4 |
| 362S125-54                | 0.0566                | 33       | 0.344                   | 1.17           | 0.661                 | 0.365                 | 1.386   | 0.055                 | 0.400                | 0.661                  | 0.343                  | 6.78               | 7.19       | 2341     | 705                  | 0.367                     | 0.142                 | -0.744  | 0.466  | 1.623   | 0.790   | 28.3 |
| 362S125-54                | 0.0566                | 50       | 0.344                   | 1.17           | 0.661                 | 0.365                 | 1.386   | 0.055                 | 0.400                | 0.656                  | 0.321                  | 9.62               | 9.65       | 3372     | 1016                 | 0.367                     | 0.142                 | -0.744  | 0.466  | 1.623   | 0.790   | 22.8 |
| 362S125-68                | 0.0713                | 33       | 0.426                   | 1.45           | 0.803                 | 0.443                 | 1.374   | 0.065                 | 0.389                | 0.802                  | 0.430                  | 8.51               | 8.76       | 2884     | 662                  | 0.721                     | 0.169                 | -0.726  | 0.457  | 1.602   | 0.795   | 28.2 |
| 362S125-68                | 0.0713                | 50       | 0.426                   | 1.45           | 0.803                 | 0.443                 | 1.374   | 0.065                 | 0.389                | 0.802                  | 0.418                  | 12.52              | 13.11      | 4370     | 1004                 | 0.721                     | 0.169                 | -0.726  | 0.457  | 1.602   | 0.795   | 22.7 |
| 400S125-18 <sup>1</sup>   | 0.0188                | 33       | 0.125                   | 0.42           | 0.294                 | 0.147                 | 1.536   | 0.021                 | 0.414                | 0.281                  | 0.083                  | 1.64               | 1.68       | 156      | 156                  | 0.015                     | 0.068                 | -0.754  | 0.475  | 1.760   | 0.816   | 28.7 |
| 400S125-27                | 0.0283                | 33       | 0.187                   | 0.64           | 0.438                 | 0.219                 | 1.531   | 0.031                 | 0.410                | 0.431                  | 0.151                  | 2.97               | 3.07       | 533      | 398                  | 0.050                     | 0.098                 | -0.744  | 0.469  | 1.751   | 0.819   | 28.5 |
| 400S125-30                | 0.0312                | 33       | 0.206                   | 0.70           | 0.481                 | 0.240                 | 1.529   | 0.034                 | 0.408                | 0.474                  | 0.174                  | 3.44               | 3.53       | 715      | 484                  | 0.067                     | 0.107                 | -0.741  | 0.467  | 1.748   | 0.820   | 28.5 |
| 400S125-33                | 0.0346                | 33       | 0.228                   | 0.77           | 0.531                 | 0.265                 | 1.527   | 0.038                 | 0.407                | 0.524                  | 0.203                  | 4.01               | 4.10       | 976      | 595                  | 0.091                     | 0.118                 | -0.738  | 0.465  | 1.744   | 0.821   | 28.4 |
| 400S125-43                | 0.0451                | 33       | 0.295                   | 1.00           | 0.682                 | 0.341                 | 1.521   | 0.048                 | 0.402                | 0.680                  | 0.301                  | 5.96               | 5.99       | 1739     | 810                  | 0.200                     | 0.148                 | -0.727  | 0.459  | 1.733   | 0.824   | 28.2 |
| 400S125-54                | 0.0566                | 33       | 0.365                   | 1.24           | 0.835                 | 0.418                 | 1.512   | 0.057                 | 0.394                | 0.835                  | 0.387                  | 7.65               | 8.12       | 2603     | 944                  | 0.390                     | 0.178                 | -0.713  | 0.451  | 1.718   | 0.828   | 28.1 |
| 400S125-54                | 0.0566                | 50       | 0.365                   | 1.24           | 0.835                 | 0.418                 | 1.512   | 0.057                 | 0.394                | 0.830                  | 0.361                  | 10.81              | 10.87      | 3372     | 1223                 | 0.390                     | 0.178                 | -0.713  | 0.451  | 1.718   | 0.828   | 22.7 |
| 400S125-68                | 0.0713                | 33       | 0.452                   | 1.54           | 1.017                 | 0.509                 | 1.499   | 0.066                 | 0.383                | 1.015                  | 0.492                  | 9.72               | 10.05      | 3215     | 895                  | 0.767                     | 0.213                 | -0.695  | 0.442  | 1.696   | 0.832   | 28.0 |
| 400S125-68                | 0.0713                | 50       | 0.452                   | 1.54           | 1.017                 | 0.509                 | 1.499   | 0.066                 | 0.383                | 1.015                  | 0.474                  | 14.18              | 14.84      | 4871     | 1356                 | 0.767                     | 0.213                 | -0.695  | 0.442  | 1.696   | 0.832   | 22.5 |
| 550S125-18 <sup>1,3</sup> | 0.0188                | 33       | 0.153                   | 0.52           | 0.630                 | 0.229                 | 2.029   | 0.023                 | 0.390                | -                      | -                      | -                  | -          | -        | -                    | 0.018                     | 0.140                 | -0.651  | 0.423  | 2.166   | 0.910   | 22.9 |
| 550S125-27                | 0.0283                | 33       | 0.229                   | 0.78           | 0.938                 | 0.341                 | 2.023   | 0.034                 | 0.385                | 0.898                  | 0.246                  | 4.86               | 4.26       | 382      | 382                  | 0.061                     | 0.205                 | -0.641  | 0.417  | 2.157   | 0.912   | 27.9 |
| 550S125-30                | 0.0312                | 33       | 0.252                   | 0.86           | 1.031                 | 0.375                 | 2.021   | 0.037                 | 0.384                | 0.996                  | 0.266                  | 5.65               | 4.95       | 512      | 512                  | 0.082                     | 0.224                 | -0.639  | 0.415  | 2.154   | 0.912   | 27.9 |
| 550S125-33                | 0.0346                | 33       | 0.279                   | 0.95           | 1.139                 | 0.414                 | 2.019   | 0.041                 | 0.382                | 1.111                  | 0.335                  | 6.62               | 5.78       | 699      | 699                  | 0.112                     | 0.246                 | -0.635  | 0.413  | 2.151   | 0.913   | 27.8 |
| 550S125-43                | 0.0451                | 33       | 0.362                   | 1.23           | 1.468                 | 0.534                 | 2.013   | 0.052                 | 0.377                | 1.458                  | 0.500                  | 9.88               | 8.61       | 1550     | 1199                 | 0.246                     | 0.309                 | -0.625  | 0.407  | 2.141   | 0.915   | 27.6 |
| 550S125-54                | 0.0566                | 33       | 0.450                   | 1.53           | 1.805                 | 0.656                 | 2.002   | 0.061                 | 0.369                | 1.805                  | 0.647                  | 12.79              | 11.92      | 2739     | 1666                 | 0.481                     | 0.374                 | -0.613  | 0.401  | 2.126   | 0.917   | 27.3 |
| 550S125-54                | 0.0566                | 50       | 0.450                   | 1.53           | 1.805                 | 0.656                 | 2.002   | 0.061                 | 0.369                | 1.791                  | 0.606                  | 18.13              | 15.75      | 3093     | 1881                 | 0.481                     | 0.374                 | -0.613  | 0.401  | 2.126   | 0.917   | 22.1 |
| 550S125-68                | 0.0713                | 33       | 0.559                   | 1.90           | 2.209                 | 0.803                 | 1.987   | 0.072                 | 0.358                | 2.205                  | 0.801                  | 18.94 <sup>2</sup> | 18.59      | 4347     | 2057                 | 0.948                     | 0.448                 | -0.597  | 0.392  | 2.106   | 0.920   | 24.6 |
| 550S125-68                | 0.0713                | 50       | 0.559                   | 1.90           | 2.209                 | 0.803                 | 1.987   | 0.072                 | 0.358                | 2.205                  | 0.791                  | 23.68              | 21.98      | 5350     | 2532                 | 0.948                     | 0.448                 | -0.597  | 0.392  | 2.106   | 0.920   | 21.8 |
| 600S125-18 <sup>1,3</sup> | 0.0188                | 33       | 0.162                   | 0.55           | 0.778                 | 0.259                 | 2.189   | 0.024                 | 0.382                | -                      | -                      | -                  | -          | -        | -                    | 0.019                     | 0.172                 | -0.623  | 0.408  | 2.308   | 0.927   | 22.7 |
| 600S125-27 <sup>1</sup>   | 0.0283                | 33       | 0.243                   | 0.83           | 1.160                 | 0.387                 | 2.183   | 0.035                 | 0.377                | 1.09                   |                        |                    |            |          |                      |                           |                       |         |        |         |         |      |





# Structural (S) Section Properties

| Section    | Design Thickness (in) | Fy (ksi) | Gross Properties        |                |                       |                       |         |                       |         |                        | Effective Properties   |                    |            |          |            |                           | Torsional Properties  |         |        |         |       |      | Lu (in) |
|------------|-----------------------|----------|-------------------------|----------------|-----------------------|-----------------------|---------|-----------------------|---------|------------------------|------------------------|--------------------|------------|----------|------------|---------------------------|-----------------------|---------|--------|---------|-------|------|---------|
|            |                       |          | Area (in <sup>2</sup> ) | Weight (lb/ft) | Ix (in <sup>4</sup> ) | Sx (in <sup>3</sup> ) | Rx (in) | Iy (in <sup>4</sup> ) | Ry (in) | Ixe (in <sup>4</sup> ) | Sxe (in <sup>3</sup> ) | Mal (in-k)         | Mad (in-k) | Vag (lb) | Vanet (lb) | Jx1000 (in <sup>4</sup> ) | Cw (in <sup>6</sup> ) | Xo (in) | m (in) | Ro (in) | β     |      |         |
| 250S137-33 | 0.0346                | 33       | 0.197                   | 0.67           | 0.203                 | 0.163                 | 1.015   | 0.052                 | 0.515   | 0.203                  | 0.158                  | 3.11               | 3.10       | 975      | 399        | 0.079                     | 0.076                 | -1.141  | 0.677  | 1.612   | 0.499 | 35.6 |         |
| 250S137-43 | 0.0451                | 33       | 0.255                   | 0.87           | 0.261                 | 0.208                 | 1.010   | 0.067                 | 0.511   | 0.261                  | 0.205                  | 4.53 <sup>2</sup>  | 4.60       | 1265     | 394        | 0.173                     | 0.096                 | -1.129  | 0.670  | 1.599   | 0.501 | 33.6 |         |
| 250S137-54 | 0.0566                | 33       | 0.316                   | 1.07           | 0.318                 | 0.255                 | 1.004   | 0.080                 | 0.504   | 0.318                  | 0.255                  | 5.76 <sup>2</sup>  | 5.75       | 1553     | 373        | 0.337                     | 0.115                 | -1.115  | 0.663  | 1.583   | 0.504 | 33.4 |         |
| 250S137-54 | 0.0566                | 50       | 0.316                   | 1.07           | 0.318                 | 0.255                 | 1.004   | 0.080                 | 0.504   | 0.318                  | 0.244                  | 8.22 <sup>2</sup>  | 8.34       | 2353     | 565        | 0.337                     | 0.115                 | -1.115  | 0.663  | 1.583   | 0.504 | 27.1 |         |
| 250S137-68 | 0.0713                | 33       | 0.390                   | 1.33           | 0.386                 | 0.309                 | 0.994   | 0.095                 | 0.495   | 0.386                  | 0.309                  | 7.19 <sup>2</sup>  | 7.19       | 1891     | 342        | 0.661                     | 0.138                 | -1.096  | 0.653  | 1.561   | 0.507 | 33.1 |         |
| 250S137-68 | 0.0713                | 50       | 0.390                   | 1.33           | 0.386                 | 0.309                 | 0.994   | 0.095                 | 0.495   | 0.386                  | 0.308                  | 10.65 <sup>2</sup> | 10.67      | 2866     | 519        | 0.661                     | 0.138                 | -1.096  | 0.653  | 1.561   | 0.507 | 26.8 |         |
| 250S137-97 | 0.1017                | 33       | 0.533                   | 1.81           | 0.506                 | 0.405                 | 0.975   | 0.120                 | 0.475   | 0.506                  | 0.405                  | 10.01              | 10.01      | 2506     | 283        | 1.839                     | 0.176                 | -1.057  | 0.633  | 1.514   | 0.513 | 33.1 |         |
| 250S137-97 | 0.1017                | 50       | 0.533                   | 1.81           | 0.506                 | 0.405                 | 0.975   | 0.120                 | 0.475   | 0.506                  | 0.405                  | 14.75              | 14.75      | 3798     | 429        | 1.839                     | 0.176                 | -1.057  | 0.633  | 1.514   | 0.513 | 26.5 |         |
| 250S162-33 | 0.0346                | 33       | 0.223                   | 0.76           | 0.235                 | 0.188                 | 1.027   | 0.087                 | 0.624   | 0.235                  | 0.180                  | 3.55               | 3.56       | 975      | 399        | 0.089                     | 0.146                 | -1.470  | 0.859  | 1.898   | 0.401 | 44.1 |         |
| 250S162-43 | 0.0451                | 33       | 0.289                   | 0.98           | 0.302                 | 0.242                 | 1.022   | 0.111                 | 0.620   | 0.302                  | 0.240                  | 5.22 <sup>2</sup>  | 5.25       | 1265     | 394        | 0.196                     | 0.184                 | -1.457  | 0.852  | 1.885   | 0.402 | 42.1 |         |
| 250S162-54 | 0.0566                | 33       | 0.358                   | 1.22           | 0.370                 | 0.296                 | 1.016   | 0.135                 | 0.613   | 0.370                  | 0.296                  | 6.57 <sup>2</sup>  | 6.57       | 1553     | 373        | 0.383                     | 0.223                 | -1.443  | 0.845  | 1.868   | 0.403 | 41.8 |         |
| 250S162-54 | 0.0566                | 50       | 0.358                   | 1.22           | 0.370                 | 0.296                 | 1.016   | 0.135                 | 0.613   | 0.370                  | 0.284                  | 9.42 <sup>2</sup>  | 9.46       | 2353     | 565        | 0.383                     | 0.223                 | -1.443  | 0.845  | 1.868   | 0.403 | 33.9 |         |
| 250S162-68 | 0.0713                | 33       | 0.443                   | 1.51           | 0.450                 | 0.360                 | 1.007   | 0.162                 | 0.605   | 0.450                  | 0.360                  | 8.21 <sup>2</sup>  | 8.21       | 1891     | 342        | 0.752                     | 0.268                 | -1.424  | 0.835  | 1.846   | 0.405 | 41.7 |         |
| 250S162-68 | 0.0713                | 50       | 0.443                   | 1.51           | 0.450                 | 0.360                 | 1.007   | 0.162                 | 0.605   | 0.450                  | 0.357                  | 12.11 <sup>2</sup> | 12.21      | 2866     | 519        | 0.752                     | 0.268                 | -1.424  | 0.835  | 1.846   | 0.405 | 33.7 |         |
| 250S162-97 | 0.1017                | 33       | 0.61                    | 2.07           | 0.596                 | 0.477                 | 0.989   | 0.209                 | 0.586   | 0.596                  | 0.477                  | 11.45              | 11.45      | 2506     | 283        | 2.102                     | 0.346                 | -1.386  | 0.815  | 1.801   | 0.408 | 41.9 |         |
| 250S162-97 | 0.1017                | 50       | 0.61                    | 2.07           | 0.596                 | 0.477                 | 0.989   | 0.209                 | 0.586   | 0.596                  | 0.477                  | 16.93              | 16.93      | 3798     | 429        | 2.102                     | 0.346                 | -1.386  | 0.815  | 1.801   | 0.408 | 33.5 |         |
| 250S200-33 | 0.0346                | 33       | 0.258                   | 0.88           | 0.279                 | 0.223                 | 1.040   | 0.154                 | 0.773   | 0.276                  | 0.197                  | 3.90               | 4.09       | 975      | 399        | 0.103                     | 0.302                 | -1.926  | 1.108  | 2.321   | 0.312 | 56.0 |         |
| 250S200-43 | 0.0451                | 33       | 0.334                   | 1.14           | 0.358                 | 0.287                 | 1.036   | 0.198                 | 0.769   | 0.358                  | 0.278                  | 5.49               | 5.66       | 1265     | 394        | 0.227                     | 0.382                 | -1.914  | 1.101  | 2.308   | 0.312 | 56.1 |         |
| 250S200-54 | 0.0566                | 33       | 0.415                   | 1.41           | 0.440                 | 0.352                 | 1.030   | 0.241                 | 0.763   | 0.44                   | 0.352                  | 7.65               | 7.65       | 1553     | 373        | 0.443                     | 0.464                 | -1.899  | 1.093  | 2.291   | 0.313 | 53.7 |         |
| 250S200-54 | 0.0566                | 50       | 0.415                   | 1.41           | 0.440                 | 0.352                 | 1.030   | 0.241                 | 0.763   | 0.44                   | 0.321                  | 9.60               | 10.11      | 2353     | 565        | 0.443                     | 0.464                 | -1.899  | 1.093  | 2.291   | 0.313 | 45.5 |         |
| 250S200-68 | 0.0713                | 33       | 0.515                   | 1.75           | 0.537                 | 0.430                 | 1.022   | 0.293                 | 0.754   | 0.537                  | 0.430                  | 9.57               | 9.57       | 1891     | 342        | 0.872                     | 0.561                 | -1.881  | 1.084  | 2.270   | 0.313 | 53.7 |         |
| 250S200-68 | 0.0713                | 50       | 0.515                   | 1.75           | 0.537                 | 0.430                 | 1.022   | 0.293                 | 0.754   | 0.537                  | 0.417                  | 13.84              | 14.27      | 2866     | 519        | 0.872                     | 0.561                 | -1.881  | 1.084  | 2.270   | 0.313 | 43.4 |         |
| 250S200-97 | 0.1017                | 33       | 0.711                   | 2.42           | 0.718                 | 0.575                 | 1.005   | 0.386                 | 0.736   | 0.718                  | 0.575                  | 13.36              | 13.36      | 2506     | 283        | 2.452                     | 0.735                 | -1.843  | 1.063  | 2.224   | 0.314 | 54.2 |         |
| 250S200-97 | 0.1017                | 50       | 0.711                   | 2.42           | 0.718                 | 0.575                 | 1.005   | 0.386                 | 0.736   | 0.718                  | 0.575                  | 19.82              | 19.82      | 3798     | 429        | 2.452                     | 0.735                 | -1.843  | 1.063  | 2.224   | 0.314 | 43.4 |         |
| 250S250-43 | 0.0451                | 33       | 0.379                   | 1.29           | 0.426                 | 0.341                 | 1.060   | 0.336                 | 0.941   | 0.426                  | 0.297                  | 5.87               | 6.24       | 1265     | 394        | 0.257                     | 0.638                 | -2.404  | 1.359  | 2.791   | 0.258 | 66.8 |         |
| 250S250-54 | 0.0566                | 33       | 0.471                   | 1.60           | 0.524                 | 0.419                 | 1.055   | 0.412                 | 0.935   | 0.524                  | 0.379                  | 7.49               | 8.22       | 1553     | 373        | 0.503                     | 0.778                 | -2.389  | 1.351  | 2.774   | 0.258 | 67.3 |         |
| 250S250-54 | 0.0566                | 50       | 0.471                   | 1.60           | 0.524                 | 0.419                 | 1.055   | 0.412                 | 0.935   | 0.521                  | 0.341                  | 10.22              | 11.02      | 2353     | 565        | 0.503                     | 0.778                 | -2.389  | 1.351  | 2.774   | 0.258 | 54.1 |         |
| 250S250-68 | 0.0713                | 33       | 0.586                   | 1.99           | 0.643                 | 0.514                 | 1.047   | 0.503                 | 0.926   | 0.643                  | 0.495                  | 10.79              | 11.19      | 1891     | 342        | 0.993                     | 0.944                 | -2.371  | 1.341  | 2.752   | 0.258 | 64.6 |         |
| 250S250-68 | 0.0713                | 50       | 0.586                   | 1.99           | 0.643                 | 0.514                 | 1.047   | 0.503                 | 0.926   | 0.643                  | 0.446                  | 13.35              | 14.59      | 2866     | 519        | 0.993                     | 0.944                 | -2.371  | 1.341  | 2.752   | 0.258 | 54.5 |         |
| 250S250-97 | 0.1017                | 33       | 0.813                   | 2.77           | 0.864                 | 0.692                 | 1.031   | 0.670                 | 0.908   | 0.864                  | 0.69                   | 15.60              | 15.62      | 2506     | 283        | 2.803                     | 1.245                 | -2.332  | 1.32   | 2.707   | 0.258 | 65.6 |         |
| 250S250-97 | 0.1017                | 50       | 0.813                   | 2.77           | 0.864                 | 0.692                 | 1.031   | 0.670                 | 0.908   | 0.864                  | 0.663                  | 22.31              | 23.26      | 3798     | 429        | 2.803                     | 1.245                 | -2.332  | 1.32   | 2.707   | 0.258 | 52.4 |         |
| 350S137-33 | 0.0346                | 33       | 0.232                   | 0.79           | 0.441                 | 0.252                 | 1.380   | 0.059                 | 0.503   | 0.441                  | 0.223                  | 4.41               | 4.54       | 1024     | 487        | 0.093                     | 0.153                 | -1.016  | 0.621  | 1.786   | 0.676 | 34.8 |         |
| 350S137-43 | 0.0451                | 33       | 0.300                   | 1.02           | 0.568                 | 0.324                 | 1.375   | 0.075                 | 0.498   | 0.568                  | 0.307                  | 6.07               | 6.38       | 1739     | 631        | 0.204                     | 0.193                 | -1.005  | 0.615  | 1.774   | 0.679 | 34.7 |         |
| 350S137-54 | 0.0566                | 33       | 0.372                   | 1.27           | 0.696                 | 0.398                 | 1.367   | 0.090                 | 0.492   | 0.696                  | 0.385                  | 7.61               | 7.86       | 2253     | 633        | 0.398                     | 0.233                 | -0.991  | 0.607  | 1.759   | 0.683 | 34.7 |         |
| 350S137-54 | 0.0566                | 50       | 0.372                   | 1.27           | 0.696                 | 0.398                 | 1.367   | 0.090                 | 0.492   | 0.696                  | 0.366                  | 10.95              | 11.42      | 3372     | 947        | 0.398                     | 0.233                 | -0.991  | 0.607  | 1.759   | 0.683 | 28.0 |         |
| 350S137-68 | 0.0713                | 33       | 0.461                   | 1.57           | 0.849                 | 0.485                 | 1.357   | 0.107                 | 0.482   | 0.849                  | 0.474                  | 11.04              | 11.31      | 2774     | 592        | 0.782                     | 0.28                  | -0.973  | 0.598  | 1.738   | 0.687 | 31.8 |         |
| 350S137-68 | 0.0713                | 50       | 0.461                   | 1.57           | 0.849                 | 0.485                 | 1.357   | 0.107                 | 0.482   | 0.849                  | 0.472                  | 14.12              | 14.53      | 4202     | 897        | 0.782                     | 0.28                  | -0.973  | 0.598  | 1.738   | 0.687 | 27.9 |         |
| 350S137-97 | 0.1017                | 33       | 0.635                   | 2.16           | 1.130                 | 0.646                 | 1.334   | 0.136                 | 0.462   | 1.13                   | 0.629                  | 15.54              | 15.95      | 3765     | 511        | 2.189                     | 0.361                 | -0.935  | 0.579  | 1.693   | 0.695 | 31.1 |         |
| 350S137-97 | 0.1017                | 50       | 0.635                   | 2.16           | 1.130                 | 0.646                 | 1.334   | 0.136                 | 0.462   | 1.13                   | 0.629                  | 22.9               | 23.49      | 5704     | 775        | 2.189                     | 0.361                 | -0.935  | 0.579  | 1.693   | 0.695 | 25.2 |         |
| 350S162-33 | 0.0346                | 33       | 0.258                   | 0.88           | 0.508                 | 0.290                 | 1.404   | 0.098                 | 0.617   | 0.508                  | 0.257                  | 5.08               | 5.22       | 1024     | 487        | 0.103                     | 0.277                 | -1.324  | 0.796  | 2.026   | 0.573 | 42.7 |         |
| 350S162-43 | 0.0451                | 33       | 0.334                   | 1.14           | 0.654                 | 0.374                 | 1.400   | 0.125                 | 0.612   | 0.654                  | 0.357                  | 7.05               | 7.31       | 1739     | 631        | 0.227                     | 0.350                 | -1.312  | 0.789  | 2.014   | 0.575 | 42.6 |         |
| 350S162-54 | 0.0566                | 33       | 0.415                   | 1.41           | 0.804                 | 0.460                 | 1.392   | 0.152                 | 0.606   | 0.804                  | 0.447                  | 8.83               | 9.08       | 2253     | 633        | 0.443                     | 0.426                 | -1.298  | 0.782  | 1.998   | 0.578 | 42.7 |         |
| 350S162-54 | 0.0566                | 50       | 0.415                   | 1.41           | 0.804                 | 0.460                 | 1.392   | 0.152                 | 0.606   | 0.804                  | 0.426                  | 12.74              | 13.05      | 3372     | 947        | 0.443                     | 0.426                 | -1.298  | 0.782  | 1.998   | 0.578 | 34.5 |         |
| 350S162-68 | 0.0713                | 33       | 0.515                   | 1.75           | 0.985                 | 0.563                 | 1.383   | 0.184                 | 0.597   | 0.985                  | 0.551                  | 12.56 <sup>2</sup> | 12.83      | 2774     | 592        | 0.872                     | 0.514                 | -1.280  | 0.772  | 1.977   | 0.581 | 39.7 |         |
| 350S162-68 | 0.0713                | 50       | 0.515                   | 1.75           | 0.985                 | 0.563                 | 1.383   | 0.184                 | 0.597   | 0.985                  | 0.549                  | 16.44              | 16.84      | 4202     | 897        | 0.872                     | 0.514                 | -1.280  | 0.772  | 1.977   | 0.581 | 34.5 |         |
| 350S162-97 | 0.1017                | 33       | 0.711                   | 2.42           | 1.320                 | 0.754                 | 1.362   | 0.238                 | 0.578   | 1.32                   | 0.738                  | 17.71              | 18.11      | 3765     | 511        | 2.452                     | 0.672                 | -1.242  | 0.752  | 1.932   | 0.587 | 39.1 |         |
| 350S162-97 | 0.1017                | 50       | 0.711                   | 2.42           | 1.320                 | 0.754                 | 1.362   | 0.238                 | 0.578   | 1.32                   | 0.738                  | 26.18              | 26.76      | 5704     | 775        | 2.452                     | 0.672                 | -1.242  | 0.752  | 1.932   | 0.587 | 31.7 |         |
| 350S200-33 | 0.0346                | 33       | 0.292                   | 0.99           | 0.598                 | 0.342                 | 1.431   | 0.175                 | 0.773   | 0.597                  | 0.283                  | 5.59               | 5.95       | 1024     | 487        | 0.117                     | 0.541                 | -1.76   | 1.039  | 2.396   | 0.461 | 53.7 |         |
| 350S200-43 | 0.0451                | 33       | 0.379                   | 1.29           | 0.771                 | 0.441                 | 1.426   | 0.224                 | 0.768   | 0.771                  | 0.41                   | 8.09               | 8.36       | 1739     | 631        | 0.257                     | 0.687                 | -1.748  | 1.032  | 2.383   | 0.462 | 53.7 |         |
| 350S200-54 | 0.0566                | 33       | 0.471                   | 1.60           | 0.95                  | 0.543                 | 1.420   | 0.274                 | 0.762   | 0.95                   | 0.53                   | 10.47              | 10.73      | 2253     | 633        | 0.503                     | 0.838                 | -1.733  | 1.024  | 2.367   | 0.464 | 53.8 |         |
| 350S200-54 | 0.0566                | 50       | 0.471                   | 1.60           | 0.95                  | 0.543                 | 1.420   | 0.274                 | 0.762   | 0.95                   | 0.47                   | 14.07              | 14.86      | 3372     | 947        | 0.503                     | 0.838                 | -1.733  | 1.024  | 2.367   | 0.464 | 43.5 |         |
| 350S200-68 | 0.0713                | 33       | 0.586                   | 1.99           | 1.1                   |                       |         |                       |         |                        |                        |                    |            |          |            |                           |                       |         |        |         |       |      |         |



# Structural (S) Section Properties



| Section    | Design Thickness (in) | Fy (ksi) | Gross Properties        |                |                       |                       |         |                       |         | Effective Properties   |                        |                    |            |          | Torsional Properties |                           |                       |         |        | Lu (in) |         |      |
|------------|-----------------------|----------|-------------------------|----------------|-----------------------|-----------------------|---------|-----------------------|---------|------------------------|------------------------|--------------------|------------|----------|----------------------|---------------------------|-----------------------|---------|--------|---------|---------|------|
|            |                       |          | Area (in <sup>2</sup> ) | Weight (lb/ft) | Ix (in <sup>4</sup> ) | Sx (in <sup>3</sup> ) | Rx (in) | Iy (in <sup>4</sup> ) | Ry (in) | Ixe (in <sup>4</sup> ) | Sxe (in <sup>3</sup> ) | Mal (in-k)         | Mad (in-k) | Vag (lb) | Vanet (lb)           | Jx1000 (in <sup>4</sup> ) | Cw (in <sup>6</sup> ) | Xo (in) | m (in) |         | Ro (in) | β    |
| 362S137-33 | 0.0346                | 33       | 0.236                   | 0.80           | 0.479                 | 0.264                 | 1.424   | 0.059                 | 0.501   | 0.479                  | 0.232                  | 4.59               | 4.73       | 1024     | 521                  | 0.094                     | 0.165                 | -1.003  | 0.615  | 1.813   | 0.694   | 34.7 |
| 362S137-43 | 0.0451                | 33       | 0.306                   | 1.04           | 0.616                 | 0.340                 | 1.419   | 0.075                 | 0.497   | 0.616                  | 0.320                  | 6.32               | 6.65       | 1739     | 676                  | 0.207                     | 0.208                 | -0.991  | 0.608  | 1.801   | 0.697   | 34.6 |
| 362S137-54 | 0.0566                | 33       | 0.379                   | 1.29           | 0.756                 | 0.417                 | 1.411   | 0.091                 | 0.490   | 0.756                  | 0.402                  | 7.94               | 8.24       | 2341     | 705                  | 0.405                     | 0.251                 | -0.978  | 0.601  | 1.785   | 0.700   | 34.6 |
| 362S137-54 | 0.0566                | 50       | 0.379                   | 1.29           | 0.756                 | 0.417                 | 1.411   | 0.091                 | 0.490   | 0.756                  | 0.381                  | 11.42              | 11.91      | 3372     | 1016                 | 0.405                     | 0.251                 | -0.978  | 0.601  | 1.785   | 0.700   | 27.9 |
| 362S137-68 | 0.0713                | 33       | 0.470                   | 1.60           | 0.922                 | 0.509                 | 1.401   | 0.109                 | 0.480   | 0.922                  | 0.498                  | 9.84               | 10.05      | 2884     | 662                  | 0.797                     | 0.302                 | -0.959  | 0.592  | 1.764   | 0.704   | 34.6 |
| 362S137-68 | 0.0713                | 50       | 0.470                   | 1.60           | 0.922                 | 0.509                 | 1.401   | 0.109                 | 0.480   | 0.922                  | 0.493                  | 14.77              | 15.24      | 4370     | 1004                 | 0.797                     | 0.302                 | -0.959  | 0.592  | 1.764   | 0.704   | 27.8 |
| 362S137-97 | 0.1017                | 33       | 0.648                   | 2.20           | 1.229                 | 0.678                 | 1.377   | 0.137                 | 0.46    | 1.229                  | 0.662                  | 16.36              | 16.75      | 3922     | 577                  | 2.233                     | 0.390                 | -0.922  | 0.573  | 1.720   | 0.713   | 30.9 |
| 362S137-97 | 0.1017                | 50       | 0.648                   | 2.20           | 1.229                 | 0.678                 | 1.377   | 0.137                 | 0.46    | 1.229                  | 0.662                  | 24.1               | 24.67      | 5943     | 875                  | 2.233                     | 0.390                 | -0.922  | 0.573  | 1.720   | 0.713   | 25.1 |
| 362S162-33 | 0.0346                | 33       | 0.262                   | 0.89           | 0.551                 | 0.304                 | 1.450   | 0.099                 | 0.616   | 0.551                  | 0.268                  | 5.29               | 5.43       | 1024     | 521                  | 0.105                     | 0.297                 | -1.308  | 0.789  | 2.048   | 0.592   | 42.6 |
| 362S162-43 | 0.0451                | 33       | 0.340                   | 1.16           | 0.710                 | 0.392                 | 1.445   | 0.127                 | 0.611   | 0.710                  | 0.372                  | 7.34               | 7.62       | 1739     | 676                  | 0.230                     | 0.376                 | -1.297  | 0.782  | 2.036   | 0.594   | 42.5 |
| 362S162-54 | 0.0566                | 33       | 0.422                   | 1.44           | 0.873                 | 0.481                 | 1.438   | 0.154                 | 0.604   | 0.873                  | 0.466                  | 9.22               | 9.51       | 2341     | 705                  | 0.451                     | 0.457                 | -1.283  | 0.774  | 2.020   | 0.597   | 42.5 |
| 362S162-54 | 0.0566                | 50       | 0.422                   | 1.44           | 0.873                 | 0.481                 | 1.438   | 0.154                 | 0.604   | 0.873                  | 0.444                  | 13.28              | 13.59      | 3372     | 1016                 | 0.451                     | 0.457                 | -1.283  | 0.774  | 2.020   | 0.597   | 34.4 |
| 362S162-68 | 0.0713                | 33       | 0.524                   | 1.78           | 1.069                 | 0.590                 | 1.429   | 0.186                 | 0.596   | 1.069                  | 0.579                  | 11.43              | 11.65      | 2884     | 662                  | 0.887                     | 0.552                 | -1.264  | 0.765  | 1.998   | 0.600   | 42.7 |
| 362S162-68 | 0.0713                | 50       | 0.524                   | 1.78           | 1.069                 | 0.590                 | 1.429   | 0.186                 | 0.596   | 1.069                  | 0.574                  | 17.18              | 17.65      | 4370     | 1004                 | 0.887                     | 0.552                 | -1.264  | 0.765  | 1.998   | 0.600   | 34.3 |
| 362S162-97 | 0.1017                | 33       | 0.724                   | 2.46           | 1.435                 | 0.792                 | 1.408   | 0.241                 | 0.577   | 1.435                  | 0.776                  | 18.62              | 19.00      | 3922     | 577                  | 2.496                     | 0.723                 | -1.226  | 0.745  | 1.954   | 0.606   | 38.9 |
| 362S162-97 | 0.1017                | 50       | 0.724                   | 2.46           | 1.435                 | 0.792                 | 1.408   | 0.241                 | 0.577   | 1.435                  | 0.776                  | 27.52              | 28.08      | 5943     | 875                  | 2.496                     | 0.723                 | -1.226  | 0.745  | 1.954   | 0.606   | 31.5 |
| 362S200-33 | 0.0346                | 33       | 0.297                   | 1.01           | 0.648                 | 0.358                 | 1.478   | 0.177                 | 0.772   | 0.647                  | 0.294                  | 5.81               | 6.19       | 1024     | 521                  | 0.118                     | 0.577                 | -1.741  | 1.030  | 2.411   | 0.478   | 53.6 |
| 362S200-43 | 0.0451                | 33       | 0.385                   | 1.31           | 0.836                 | 0.461                 | 1.474   | 0.227                 | 0.767   | 0.836                  | 0.427                  | 8.43               | 8.70       | 1739     | 676                  | 0.261                     | 0.734                 | -1.729  | 1.024  | 2.398   | 0.480   | 53.5 |
| 362S200-54 | 0.0566                | 33       | 0.479                   | 1.63           | 1.030                 | 0.568                 | 1.467   | 0.277                 | 0.761   | 1.030                  | 0.553                  | 10.93              | 11.23      | 2341     | 705                  | 0.511                     | 0.896                 | -1.715  | 1.016  | 2.382   | 0.482   | 53.6 |
| 362S200-54 | 0.0566                | 50       | 0.479                   | 1.63           | 1.030                 | 0.568                 | 1.467   | 0.277                 | 0.761   | 1.030                  | 0.490                  | 14.66              | 15.47      | 3372     | 1016                 | 0.511                     | 0.896                 | -1.715  | 1.016  | 2.382   | 0.482   | 43.3 |
| 362S200-68 | 0.0713                | 33       | 0.595                   | 2.02           | 1.265                 | 0.698                 | 1.458   | 0.337                 | 0.753   | 1.265                  | 0.687                  | 15.29 <sup>2</sup> | 15.54      | 2884     | 662                  | 1.008                     | 1.089                 | -1.696  | 1.006  | 2.360   | 0.484   | 50.6 |
| 362S200-68 | 0.0713                | 50       | 0.595                   | 2.02           | 1.265                 | 0.698                 | 1.458   | 0.337                 | 0.753   | 1.265                  | 0.666                  | 19.95              | 20.51      | 4370     | 1004                 | 1.008                     | 1.089                 | -1.696  | 1.006  | 2.360   | 0.484   | 43.3 |
| 362S200-97 | 0.1017                | 33       | 0.826                   | 2.81           | 1.711                 | 0.944                 | 1.44    | 0.446                 | 0.735   | 1.711                  | 0.928                  | 21.59              | 21.95      | 3922     | 577                  | 2.847                     | 1.441                 | -1.658  | 0.986  | 2.315   | 0.487   | 50.0 |
| 362S200-97 | 0.1017                | 50       | 0.826                   | 2.81           | 1.711                 | 0.944                 | 1.44    | 0.446                 | 0.735   | 1.711                  | 0.928                  | 32.03              | 32.57      | 5943     | 875                  | 2.847                     | 1.441                 | -1.658  | 0.986  | 2.315   | 0.487   | 40.5 |
| 362S250-43 | 0.0451                | 33       | 0.43                    | 1.46           | 0.98                  | 0.541                 | 1.51    | 0.385                 | 0.946   | 0.98                   | 0.449                  | 8.88               | 9.35       | 1739     | 676                  | 0.292                     | 1.230                 | -2.199  | 1.277  | 2.830   | 0.396   | 64.2 |
| 362S250-54 | 0.0566                | 33       | 0.535                   | 1.82           | 1.21                  | 0.668                 | 1.504   | 0.473                 | 0.94    | 1.21                   | 0.582                  | 11.51              | 12.46      | 2341     | 705                  | 0.571                     | 1.506                 | -2.184  | 1.269  | 2.813   | 0.397   | 64.3 |
| 362S250-54 | 0.0566                | 50       | 0.535                   | 1.82           | 1.21                  | 0.668                 | 1.504   | 0.473                 | 0.94    | 1.205                  | 0.514                  | 15.40              | 16.54      | 3372     | 1016                 | 0.571                     | 1.506                 | -2.184  | 1.269  | 2.813   | 0.397   | 52.0 |
| 362S250-68 | 0.0713                | 33       | 0.666                   | 2.27           | 1.49                  | 0.822                 | 1.496   | 0.578                 | 0.931   | 1.49                   | 0.774                  | 16.85              | 17.68      | 2884     | 662                  | 1.129                     | 1.837                 | -2.165  | 1.259  | 2.791   | 0.398   | 61.4 |
| 362S250-68 | 0.0713                | 50       | 0.666                   | 2.27           | 1.49                  | 0.822                 | 1.496   | 0.578                 | 0.931   | 1.49                   | 0.689                  | 20.63              | 22.17      | 4370     | 1004                 | 1.129                     | 1.837                 | -2.165  | 1.259  | 2.791   | 0.398   | 52.0 |
| 362S250-97 | 0.1017                | 33       | 0.927                   | 3.16           | 2.027                 | 1.118                 | 1.478   | 0.772                 | 0.912   | 2.027                  | 1.100                  | 24.85              | 25.26      | 3922     | 577                  | 3.197                     | 2.452                 | -2.126  | 1.239  | 2.746   | 0.400   | 61.0 |
| 362S250-97 | 0.1017                | 50       | 0.927                   | 3.16           | 2.027                 | 1.118                 | 1.478   | 0.772                 | 0.912   | 2.027                  | 1.046                  | 35.17              | 36.93      | 5943     | 875                  | 3.197                     | 2.452                 | -2.126  | 1.239  | 2.746   | 0.400   | 49.3 |
| 362S300-54 | 0.0566                | 33       | 0.592                   | 2.01           | 1.390                 | 0.767                 | 1.533   | 0.734                 | 1.114   | 1.383                  | 0.607                  | 11.99              | 13.22      | 2341     | 705                  | 0.632                     | 2.316                 | -2.659  | 1.522  | 3.265   | 0.337   | 74.5 |
| 362S300-54 | 0.0566                | 50       | 0.592                   | 2.01           | 1.390                 | 0.767                 | 1.533   | 0.734                 | 1.114   | 1.312                  | 0.529                  | 15.83              | 17.34      | 3372     | 1016                 | 0.632                     | 2.316                 | -2.659  | 1.522  | 3.265   | 0.337   | 60.2 |
| 362S300-68 | 0.0713                | 33       | 0.738                   | 2.51           | 1.716                 | 0.947                 | 1.525   | 0.900                 | 1.105   | 1.716                  | 0.811                  | 16.02              | 17.65      | 2884     | 662                  | 1.250                     | 2.833                 | -2.640  | 1.512  | 3.243   | 0.337   | 74.9 |
| 362S300-68 | 0.0713                | 50       | 0.738                   | 2.51           | 1.716                 | 0.947                 | 1.525   | 0.900                 | 1.105   | 1.684                  | 0.716                  | 21.44              | 23.42      | 4370     | 1004                 | 1.250                     | 2.833                 | -2.640  | 1.512  | 3.243   | 0.337   | 60.4 |
| 362S300-97 | 0.1017                | 33       | 1.029                   | 3.50           | 2.343                 | 1.292                 | 1.509   | 1.213                 | 1.086   | 2.343                  | 1.217                  | 26.95              | 28.61      | 3922     | 577                  | 3.548                     | 3.803                 | -2.600  | 1.491  | 3.196   | 0.338   | 71.6 |
| 362S300-97 | 0.1017                | 50       | 1.029                   | 3.50           | 2.343                 | 1.292                 | 1.509   | 1.213                 | 1.086   | 2.32                   | 1.150                  | 34.42              | 36.41      | 5943     | 875                  | 3.548                     | 3.803                 | -2.600  | 1.491  | 3.196   | 0.338   | 60.9 |
| 400S137-33 | 0.0346                | 33       | 0.249                   | 0.85           | 0.603                 | 0.301                 | 1.556   | 0.061                 | 0.496   | 0.603                  | 0.259                  | 5.12               | 5.29       | 976      | 595                  | 0.099                     | 0.204                 | -0.965  | 0.597  | 1.897   | 0.741   | 34.5 |
| 400S137-43 | 0.0451                | 33       | 0.323                   | 1.10           | 0.776                 | 0.388                 | 1.551   | 0.078                 | 0.491   | 0.776                  | 0.359                  | 7.09               | 7.47       | 1739     | 810                  | 0.219                     | 0.257                 | -0.954  | 0.591  | 1.885   | 0.744   | 34.3 |
| 400S137-54 | 0.0566                | 50       | 0.401                   | 1.36           | 0.953                 | 0.477                 | 1.542   | 0.094                 | 0.484   | 0.953                  | 0.428                  | 12.82              | 13.38      | 3372     | 1223                 | 0.428                     | 0.311                 | -0.940  | 0.583  | 1.870   | 0.747   | 27.7 |
| 400S137-68 | 0.0713                | 33       | 0.497                   | 1.69           | 1.165                 | 0.582                 | 1.531   | 0.112                 | 0.475   | 1.165                  | 0.567                  | 11.21              | 11.51      | 3215     | 895                  | 0.842                     | 0.375                 | -0.922  | 0.574  | 1.849   | 0.751   | 34.2 |
| 400S137-68 | 0.0713                | 50       | 0.497                   | 1.69           | 1.165                 | 0.582                 | 1.531   | 0.112                 | 0.475   | 1.165                  | 0.558                  | 16.70              | 17.44      | 4871     | 1356                 | 0.842                     | 0.375                 | -0.922  | 0.574  | 1.849   | 0.751   | 27.6 |
| 400S137-97 | 0.1017                | 33       | 0.686                   | 2.33           | 1.557                 | 0.779                 | 1.507   | 0.142                 | 0.454   | 1.557                  | 0.764                  | 18.88              | 19.23      | 4394     | 797                  | 2.365                     | 0.486                 | -0.885  | 0.555  | 1.806   | 0.760   | 30.5 |
| 400S137-97 | 0.1017                | 50       | 0.686                   | 2.33           | 1.557                 | 0.779                 | 1.507   | 0.142                 | 0.454   | 1.557                  | 0.764                  | 27.81              | 28.33      | 6658     | 1207                 | 2.365                     | 0.486                 | -0.885  | 0.555  | 1.806   | 0.760   | 24.8 |
| 400S162-33 | 0.0346                | 33       | 0.275                   | 0.94           | 0.692                 | 0.346                 | 1.586   | 0.103                 | 0.611   | 0.692                  | 0.299                  | 5.91               | 6.07       | 976      | 595                  | 0.110                     | 0.363                 | -1.263  | 0.768  | 2.118   | 0.644   | 42.3 |
| 400S162-43 | 0.0451                | 33       | 0.357                   | 1.21           | 0.892                 | 0.446                 | 1.581   | 0.131                 | 0.606   | 0.892                  | 0.417                  | 8.23               | 8.54       | 1739     | 810                  | 0.242                     | 0.460                 | -1.252  | 0.761  | 2.106   | 0.647   | 42.2 |
| 400S162-54 | 0.0566                | 33       | 0.443                   | 1.51           | 1.098                 | 0.549                 | 1.574   | 0.159                 | 0.600   | 1.098                  | 0.526                  | 10.39              | 10.84      | 2603     | 944                  | 0.473                     | 0.560                 | -1.238  | 0.754  | 2.090   | 0.649   | 42.2 |
| 400S162-54 | 0.0566                | 50       | 0.443                   | 1.51           | 1.098                 | 0.549                 | 1.574   | 0.159                 | 0.600   | 1.098                  | 0.498                  | 14.90              | 15.25      | 3372     | 1223                 | 0.473                     | 0.560                 | -1.238  | 0.754  | 2.090   | 0.649   | 34.1 |
| 400S162-68 | 0.0713                | 33       | 0.550                   | 1.87           | 1.346                 | 0.673                 | 1.564   | 0.192                 | 0.591   | 1.346                  | 0.658                  | 13.00              | 13.30      | 3215     | 895                  | 0.933                     | 0.677                 | -1.220  | 0.745  | 2.069   | 0.653   | 42.2 |
| 400S162-68 | 0.0713                | 50       | 0.550                   | 1.87           | 1.346                 | 0.673                 | 1.564   | 0.192                 | 0.591   | 1.346                  | 0.648                  | 19.41              | 20.15      | 4871     | 1356                 | 0.933                     | 0.677                 | -1.220  | 0.745  | 2.069   | 0.653   | 34.0 |
| 400S162-97 | 0.1017                | 33       | 0.762                   | 2.59           | 1.812                 | 0.906                 | 1.542   | 0.249                 | 0.572   | 1.812                  | 0.892                  | 21.40              | 21.75      | 4394     | 797                  | 2.628                     | 0.889                 | -1.182  | 0.725  | 2.025   | 0.659   | 38.3 |
| 400S162-97 | 0.1017                | 50       | 0.762                   | 2.59           | 1.812                 | 0.90                  |         |                       |         |                        |                        |                    |            |          |                      |                           |                       |         |        |         |         |      |



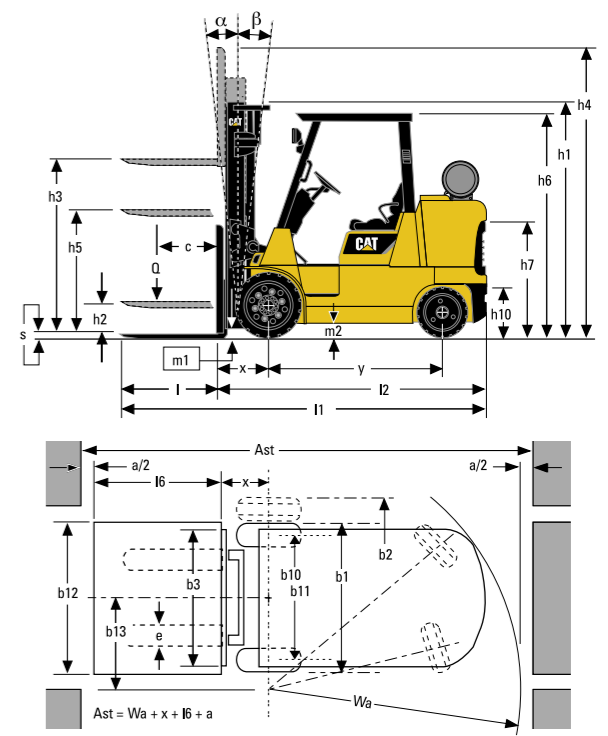
**GC35K - GC40K/40K STR - GC45K STR**  
**GC45K SWB - GC55K/55K STR**  
**GC60K - GC70K/70K STR**

Specifications

**Engine powered lift trucks**

3.5 - 7.0 tonnes

| Characteristics     |   |                  | Cat Lift Trucks | Cat Lift Trucks | Cat Lift Trucks | Cat Lift Trucks | Cat Lift Trucks |      |  | Cat Lift Trucks | Cat Lift Trucks | Cat Lift Trucks | Cat Lift Trucks | Cat Lift Trucks |
|---------------------|---|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|------|--|-----------------|-----------------|-----------------|-----------------|-----------------|
|                     |   |                  | GC35K           | GC40K           | GC40K STR       | GC45K SWB       | GC45K STR       |      |  | GC55K           | GC55K STR       | GC60K           | GC70K           | GC70K STR       |
| 1.01                | Manufacturer (abbreviation)   |                  | LP Gas          | LP Gas          | LP Gas          | LP Gas          | LP Gas          |      |  | LP Gas          | LP Gas          | LP Gas          | LP Gas          | LP Gas          |
| 1.02                | Manufacturer's model designation  |                  | Seated          | Seated          | Seated          | Seated          | Seated          |      |  | Seated          | Seated          | Seated          | Seated          | Seated          |
| 1.03                | Power source: (battery, diesel, LP gas, petrol)                                   |                  | Q (kg)          | 3500            | 4000            | 4000            | 4500            | 4500 |  | 5500            | 5500            | 6000            | 7000            | 7000            |
| 1.04                | Operator type: pedestrian, (operator)-standing, -seated                           |                  | c (mm)          | 500             | 500             | 500             | 600             | 600  |  | 600             | 600             | 600             | 600             | 600             |
| 1.05                | Load capacity   |                  | x (mm)          | 450             | 450             | 450             | 465             | 465  |  | 480             | 480             | 530             | 530             | 530             |
| 1.06                | Load centre distance  |                  | y (mm)          | 1575            | 1575            | 1575            | 1575            | 1575 |  | 1780            | 1780            | 1830            | 1830            | 1830            |
| 1.08                | Load distance, axle to fork face  |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 1.09                | Wheelbase   |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| Weight              |   |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 2.01                | Truck weight, without load / including battery (simplex mast, lowest lift height) | kg               | 5240            | 5570            | 5655            | 6470            | 6510            |      |  | 7190            | 7550            | 8760            | 9480            | 9920            |
| 2.02                | Axle loading with maximum load, front/rear (simplex mast, lowest lift height)     | kg               | 7670/1030       | 8440/1160       | 8310/930        | 9520/1480       | 9755/1250       |      |  | 11260/1140      | 11435/1535      | 13040/1760      | 14590/1910      | 15000/2030      |
| 2.03                | Axle loading without load, front/rear (simplex mast, lowest lift height)          | kg               | 2050/3150       | 2025/3575       | 2240/3370       | 1925/4575       | 2080/4385       |      |  | 2425/4775       | 2655/4865       | 3300/5500       | 3300/6200       | 3600/6400       |
| Wheels, Drive Train |   |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 3.01                | Tyres: V=solid, L=pneumatic, SE=solid pneumatic - front/rear                      |                  | V/V             | V/V             | V/V             | V/V             | V/V             |      |  | V/V             | V/V             | V/V             | V/V             | V/V             |
| 3.02                | Tyre dimensions, front  |                  | 22x9x16         | 22x9x16         | 22x9x16         | 22x9x16         | 22x9x16         |      |  | 22x12x16        | 22x12x16        | 28x12x22        | 28x12x22        | 28x12x22        |
| 3.03                | Tyre dimensions, rear   |                  | 18x7x12.1       | 18x7x12.1       | 18x7x12.1       | 18x7x12.1       | 18x7x12.1       |      |  | 18x8x12.1       | 18x8x12.1       | 22x8x16         | 22x8x16         | 22x8x16         |
| 3.05                | Number of wheels, front/rear (x=driven)   |                  | 2x/2            | 2x/2            | 2x/2            | 2x/2            | 2x/2            |      |  | 2x/2            | 2x/2            | 2x/2            | 2x/2            | 2x/2            |
| 3.06                | Track width (centre of tyres), front  | b10 (mm)         | 940             | 940             | 940             | 940             | 940             |      |  | 1015            | 1015            | 1130            | 1130            | 1130            |
| 3.07                | Track width (centre of tyres), rear   | b11 (mm)         | 980             | 980             | 980             | 980             | 980             |      |  | 965             | 965             | 1160            | 1160            | 1160            |
| Dimensions          |   |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 4.01                | Mast tilt, forwards/backwards   | $\alpha/\beta$ ° | 5/10            | 5/10            | 5/10            | 5/10            | 5/10            |      |  | 5/10            | 5/10            | 6/9             | 6/9             | 6/9             |
| 4.02                | Height with mast lowered (see tables)   | h1 (mm)          | 2120            | 2120            | 2120            | 2120            | 2120            |      |  | 2120            | 2120            | 2150            | 2150            | 2150            |
| 4.03                | Free lift (see tables)  | h2 (mm)          | 150             | 150             | 150             | 160             | 160             |      |  | 160             | 160             | 165             | 165             | 165             |
| 4.04                | Lift height (see tables)  | h3 (mm)          | 3000            | 3000            | 3000            | 2850            | 2850            |      |  | 2840            | 2840            | 2295            | 2295            | 2295            |
| 4.05                | Overall height with mast raised   | h4 (mm)          | 4270            | 4270            | 4270            | 4120            | 4120            |      |  | 4120            | 4120            | 3580            | 3580            | 3580            |
| 4.07                | Height to top of overhead guard   | h6 (mm)          | 2205            | 2205            | 2205            | 2205            | 2205            |      |  | 2205            | 2205            | 2255            | 2255            | 2255            |
| 4.08                | Seat height   | h7 (mm)          | 1200            | 1200            | 1200            | 1200            | 1200            |      |  | 1200            | 1200            | 1285            | 1285            | 1285            |
| 4.19                | Overall length  | l1 (mm)          | 3730            | 3770            | 3630            | 3840            | 3715            |      |  | 4130            | 3875            | 4170            | 4170            | 3950            |
| 4.20                | Length to fork face (includes fork thickness)                                     | l2 (mm)          | 2510            | 2550            | 2411            | 2620            | 2495            |      |  | 2910            | 2655            | 2950            | 2950            | 2730            |
| 4.21                | Overall width   | b1/b2 (mm)       | 1180            | 1180            | 1180            | 1180            | 1180            |      |  | 1320            | 1320            | 1440            | 1440            | 1440            |
| 4.22                | Fork dimensions (thickness, width, length)  | s / e / l (mm)   | 50x150x1220     | 50x150x1220     | 50x150x1220     | 50x150x1220     | 50x150x1220     |      |  | 60x150x1220     | 60x150x1220     | 65x150x1220     | 65x150x1220     | 65x150x1220     |
| 4.23                | Fork carriage to DIN 15 173 A/B/no  |                  | 3A              | 3A              | 3A              | 3A              | 3A              |      |  | 4A              | 4A              | 4A              | 4A              | 4A              |
| 4.24                | Fork carriage width   | b3 (mm)          | 1125            | 1125            | 1125            | 1125            | 1125            |      |  | 1125            | 1125            | 1295            | 1295            | 1295            |
| 4.31                | Ground clearance under mast, with load  | m1 (mm)          | 100             | 100             | 100             | 100             | 100             |      |  | 100             | 100             | 100             | 100             | 100             |
| 4.32                | Ground clearance at centre of wheelbase, with load (forks lowered)                | m2 (mm)          | 150             | 150             | 150             | 150             | 150             |      |  | 150             | 150             | 200             | 200             | 200             |
| 4.33                | Working aisle width with 1000 x1200 mm pallets, crosswise                         | Ast (mm)         | 3885            | 3935            | 3741            | 4005            | 3899            |      |  | 4230            | 4030            | 4300            | 4300            | 4200            |
| 4.34                | Working aisle width with 800 x1200 mm pallets, crosswise                          | Ast (mm)         | 3685            | 3735            | 3541            | 3805            | 3699            |      |  | 4030            | 3830            | 4100            | 4100            | 4000            |
| 4.35                | Turning circle radius   | Wa (mm)          | 2235            | 2285            | 2091            | 2340            | 2234            |      |  | 2550            | 2350            | 2570            | 2570            | 2470            |
| Performance         |   |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 5.01                | Travel speed, with/without load   | km/h             | 19.0/19.5       | 19.0/19.5       | 19.0/19.5       | 18.5/19.5       | 18.5/19.5       |      |  | 18.0/19.5       | 18.0/19.5       | 21.0/23.0       | 20.5/23.0       | 20.5/22.5       |
| 5.02                | Lifting speed, with/without load  | m/s              | 0.54/0.57       | 0.54/0.57       | 0.54/0.57       | 0.39/0.42       | 0.39/0.42       |      |  | 0.39/0.42       | 0.39/0.42       | 0.36/0.39       | 0.36/0.39       | 0.36/0.39       |
| 5.03                | Lowering speed, with/without load   | m/s              | 0.55/0.50       | 0.55/0.50       | 0.55/0.50       | 0.44/0.41       | 0.44/0.41       |      |  | 0.44/0.41       | 0.44/0.41       | 0.54/0.39       | 0.54/0.39       | 0.54/0.39       |
| 5.07                | Gradeability, with/without load   | %                | 37              | 33              | 32              | 27              | -               |      |  | 22.5            | 22              | 24.5            | 21.5            | 20.5            |
| 5.10                | Service brakes (mechanical/hydraulic/electric/pneumatic)                          | %                | Hydraulic       | Hydraulic       | Hydraulic       | Hydraulic       | Hydraulic       |      |  | Hydraulic       | Hydraulic       | Hydraulic       | Hydraulic       | Hydraulic       |
| IC Engine           |   |                  |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 7.01                | Manufacturer / Type   |                  | GM V6           | GM V6           | GM V6           | GM V6           | GM V6           |      |  | GM V6           | GM V6           | GM V6           | GM V6           | GM V6           |
| 7.02                | Rated output to ISO 1585  |                  | 69              | 69              | 69              | 69              | 69              |      |  | 69              | 69              | 69              | 69              | 69              |
| 7.03                | Rated speed to DIN 70 020   | kW               | 2450            | 2450            | 2450            | 2450            | 2450            |      |  | 2450            | 2450            | 2450            | 2450            | 2450            |
| 7.04                | Number of cylinders / cubic capacity  | rpm              | 4300            | 4300            | 4300            | 4300            | 4300            |      |  | 4300            | 4300            | 4300            | 4300            | 4300            |
| Miscellaneous       |   | cm3              |                 |                 |                 |                 |                 |      |  |                 |                 |                 |                 |                 |
| 8.01                | Type of drive control   |                  | Powershift/1    | Powershift/1    | Powershift/1    | Powershift/1    | Powershift/1    |      |  | Powershift/1    | Powershift/1    | Powershift/2    | Powershift/2    | Powershift/2    |
| 8.02                | Maximum operating pressure for attachments  |                  | 155             | 155             | 155             | 155             | 155             |      |  | 155             | 155             | 155             | 155             | 155             |
| 8.03                | Oil flow for attachments  | bar              | 95              | 95              | 95              | 95              | 95              |      |  | 95              | 95              | 115             | 115             | 115             |
| 8.04                | Noise level, value at operator's ear (EN 12053)                                   | l/min            | 83.5            | 83.5            | 83.5            | 83.5            | 83.5            |      |  | 83.5            | 83.5            | 83.5            | 83.5            | 83.5            |
| 8.05                | Towing coupling design / DIN type, ref.   | dB(A)            | Pin             | Pin             | Pin             | Pin             | Pin             |      |  | Pin             | Pin             | Pin             | Pin             | Pin             |



### Lower Cost of Ownership

- Informative display panel reduces costly, unscheduled downtime.
- Easy to access engine allows for quick, easy inspection and maintenance.
- Rugged mast offers good visibility, while tapered fork bars allow good visibility through the carriage.
- Hydraulic cushioning on Triplex masts reduces the risk of load damage.

### Unmatched Productivity

- Powered by a proven engine giving smooth, quiet performance and high torque at low speeds - essential for handling heavy loads.
- Electronically-controlled VORTEC® induction system optimizes fuel and air mixture to give efficient low-end power.
- Short wheelbase and a small turning radius give good maneuverability.
- STR models feature extra-heavy counterweights. This permits a short turning radius, giving greater maneuverability and rearward visibility.
- Vacuum-boosted brake system for easy operation.
- 3.5 - 5.5 tonne models feature a single speed power shift transmission, while 6.0 - 7.0 tonne models feature a two-speed automatic transmission.

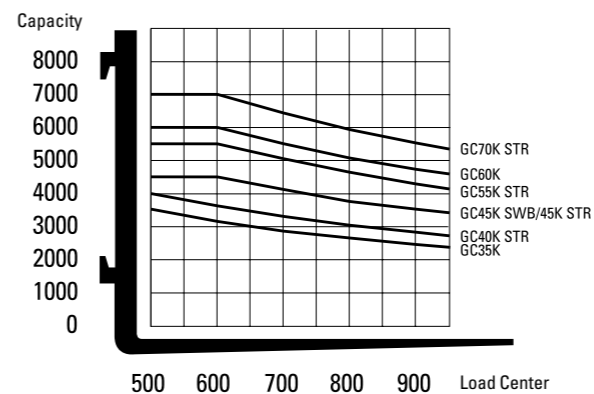
### Safety & Ergonomics

- An open-step frame and easy-to-reach grab bar allow easy entry and exit.
- Noise reduction and vibration damping, reducing operator fatigue.
- Adjustable, full suspension seat enhances operator comfort by resisting shock and vibration from rough and uneven surfaces.
- Adjustable tilt able steering column gives improved operator comfort.
- The hydraulic controls allow precise, short-throw operation.
- The seat activated transmission interlock system disengages the drive function if the operator leaves the seat.

### Options

- Speed limit options
- Foot directional control
- Double element cyclone air cleaner
- Non marking tires
- Dust proof kit for hydraulic tank and pump
- Rear view mirror

Ast = Working aisle width with load  
a = Safety clearance (200 mm)  
l6 = Pallet length (800 or 1000 mm)  
b12 = Pallet width (1200 mm)





# Cat<sup>®</sup> Lift Trucks.

## Your partner in materials handling.

| GC35K - GC40K STR - GC40K |      |      |      |         | GC35K            | GC40K STR        | GC40K            |
|---------------------------|------|------|------|---------|------------------|------------------|------------------|
| Mast Type                 | h3   | h1   | h4   | h2 / h5 | Q @ c = 500mm kg | Q @ c = 500mm kg | Q @ c = 500mm kg |
|                           | mm   | mm   | mm   | mm      |                  |                  |                  |
| Simplex                   | 3000 | 2120 | 4250 | 100     | 3500             | 4000             | 4000             |
|                           | 3300 | 2270 | 4550 | 100     | 3500             | 4000             | 4000             |
|                           | 3700 | 2470 | 4950 | 100     | 3500             | 4000             | 4000             |
|                           | 4000 | 2650 | 5250 | 100     | 3500             | 4000             | 4000             |
|                           | 4500 | 2950 | 5750 | 100     | 3500             | 4000             | 4000             |
|                           | 5000 | 3200 | 6250 | 100     | 3500             | 3850             | 4000             |
|                           | 5250 | 3300 | 6500 | 100     | 3450             | 3500             | 3600             |
|                           | 5500 | 3450 | 6750 | 100     | 2600             | 2600             | 2650             |
| Duplex                    | 6000 | 3700 | 7250 | 100     | 1400             | 1400             | 1450             |
|                           | 3000 | 2120 | 4250 | 870     | 3500             | 4000             | 4000             |
|                           | 3230 | 2270 | 4480 | 1020    | 3500             | 4000             | 4000             |
|                           | 3650 | 2470 | 4900 | 1220    | 3500             | 4000             | 4000             |
| Triplex (*)               | 3910 | 2650 | 5150 | 1430    | 3500             | 4000             | 4000             |
|                           | 4000 | 2000 | 5250 | 750     | 3500             | 4000             | 4000             |
|                           | 4360 | 2120 | 5610 | 870     | 3500             | 3950             | 4000             |
|                           | 4600 | 2200 | 5850 | 950     | 3500             | 3850             | 4000             |
|                           | 5050 | 2350 | 6300 | 1100    | 3400             | 3750             | 3900             |
|                           | 5260 | 2420 | 6510 | 1170    | 3350             | 3700             | 3850             |
|                           | 5500 | 2500 | 6750 | 1250    | 3300             | 3650             | 3800             |
|                           | 6000 | 2700 | 7250 | 1450    | 3000             | 3000             | 3000             |
|                           | 6500 | 2900 | 7750 | 1650    | 2650             | 2650             | 2650             |
|                           | 7000 | 3100 | 8250 | 1850    | 1650             | 1650             | 1650             |

| GC60K - GC70K - GC70K STR |             |      |      |         | GC60K            | GC70K            | GC70K STR        |      |
|---------------------------|-------------|------|------|---------|------------------|------------------|------------------|------|
| Mast Type                 | h3          | h1   | h4   | h2 / h5 | Q @ c = 500mm kg | Q @ c = 500mm kg | Q @ c = 500mm kg |      |
|                           | mm          | mm   | mm   | mm      |                  |                  |                  |      |
| Simplex                   | 2300        | 2150 | 3585 | 100     | 6000             | 7000             | 7000             |      |
|                           | 3000        | 2500 | 4285 | 100     | 6000             | 7000             | 7000             |      |
|                           | 3300        | 2650 | 4585 | 100     | 6000             | 7000             | 7000             |      |
|                           | 3500        | 2750 | 4785 | 100     | 6000             | 7000             | 7000             |      |
|                           | 4000        | 3000 | 5285 | 100     | 6000             | 7000             | 7000             |      |
|                           | 4500        | 3250 | 5785 | 100     | 6000             | 7000             | 7000             |      |
|                           | 5000        | 3600 | 6285 | 100     | 6000             | 7000             | 7000             |      |
|                           | 5500        | 3850 | 6785 | 100     | 6000             | 6900             | 6900             |      |
|                           | 6000        | 4100 | 7285 | 100     | 5850             | 6700             | 6700             |      |
|                           | Triplex (*) | 3700 | 2200 | 4985    | 915              | 6000             | 7000             | 7000 |
|                           |             | 4300 | 2400 | 5585    | 1115             | 6000             | 7000             | 7000 |
| 4700                      |             | 2525 | 5985 | 1240    | 6000             | 7000             | 7000             |      |
| 5000                      |             | 2625 | 6285 | 1340    | 6000             | 7000             | 7000             |      |
| 5500                      |             | 2800 | 6785 | 1515    | 6000             | 6850             | 6850             |      |
| 5860                      |             | 2920 | 7145 | 1635    | 5850             | 6700             | 6700             |      |
| 6500                      |             | 3200 | 7785 | 1915    | 5600             | 6500             | 6500             |      |
| 7050                      |             | 3400 | 8335 | 2115    | 4300             | 4300             | 4300             |      |
| 7520                      |             | 3550 | 8805 | 2265    | 2650             | 2650             | 2650             |      |

## Mast Performance and Capacity

- h1 Height with mast lowered  
 h2 Standard free lift  
 h3 Standard lift height  
 h4 Height with mast raised  
 h5 Full free lift  
 Q Lifting capacity, rated load  
 c Load centre (distance)
- Note: SWB = Short Wheel Base  
 STR = Short Turn Radius
- (Consult your dealer for the maximum back tilt allowed to obtain the capacities specified.)
- (\*) Values applicable for wide axle only.

| GC45K SWB - GC45K STR - GC55K - GC55K STR |           |             |      |         |                  |                  |                  |                  |      |      |
|---|-----------|-------------|------|---------|------------------|------------------|------------------|------------------|------|------|
| Mast Type                                 | h3        | h1          | h4   | h2 / h5 | Q @ c = 500mm kg | Q @ c = 500mm kg | Q @ c = 500mm kg | Q @ c = 500mm kg |      |      |
|   | mm        | mm          | mm   | mm      |                  |                  |                  |                  |      |      |
| Simplex                                   | 2840      | 2120        | 4125 | 100     | 4500             | 4500             | 5500             | 5500             |      |      |
|   | 3300      | 2350        | 4585 | 100     | 4500             | 4500             | 5500             | 5500             |      |      |
|   | 3500      | 2450        | 4785 | 100     | 4500             | 4500             | 5500             | 5500             |      |      |
|   | 4000      | 2800        | 5285 | 100     | 4500             | 4500             | 5500             | 5500             |      |      |
|   | 4500      | 3050        | 5785 | 100     | 4500             | 4500             | 5500             | 5500             |      |      |
|   | 5000      | 3300        | 6285 | 100     | 4500             | 4500             | 5000             | 5350             |      |      |
|   | 5250      | 3400        | 6535 | 100     | 4000             | 4500             | 5500             | 5250             |      |      |
|   | 5500      | 3550        | 6785 | 100     | 2700             | 4400             | 4500             | 4500             |      |      |
|   | 6060      | 3800        | 7285 | 100     | -                | 2600             | 2600             | 2600             |      |      |
|   | Duplex    | 2785        | 2120 | 4080    | 835              | 4500             | 4500             | 5500             | 5500 |      |
|   |           | 3265        | 2350 | 4560    | 1065             | 4500             | 4500             | 5500             | 5500 |      |
| 3465                                      |           | 2450        | 4760 | 1165    | 4500             | 4500             | 5500             | 5500             |      |      |
| 4065                                      |           | 2800        | 5360 | 1515    | 4500             | 4500             | 5500             | 5500             |      |      |
| Triplex (*)                               |           | 4310        | 2120 | 5560    | 870              | 4500             | -                | -                | -    |      |
|   | 4580      | 2210        | 5830 | 960     | 4500             | -                | -                | -                |      |      |
|   | GC45K SWB | 4750        | 2350 | 6000    | 1100             | 4500             | -                | -                | -    |      |
|   |           | 5050        | 2450 | 6300    | 1200             | 4500             | -                | -                | -    |      |
|   |           | 5260        | 2520 | 6510    | 1270             | 4450             | -                | -                | -    |      |
|   |           | 5500        | 2600 | 6750    | 1350             | 4400             | -                | -                | -    |      |
|   |           | 6000        | 2800 | 7250    | 1550             | 3200             | -                | -                | -    |      |
|   |           | 6500        | 3000 | 7750    | 1750             | 2700             | -                | -                | -    |      |
|   |           | 7000        | 3200 | 8250    | 1950             | -                | -                | -                | -    |      |
|   |           | Triplex (*) | 4040 | 2120    | 5325             | 835              | -                | 4500             | 5500 | 5500 |
| 4310                                      |           |             | 2210 | 5595    | 925              | -                | 4500             | 5500             | 5500 |      |
| 4750                                      |           |             | 2350 | 6035    | 1065             | -                | 4500             | 5500             | 5400 |      |
| GC45K STR                                 | 5050      |             | 2450 | 6335    | 1165             | -                | 4500             | 5500             | 5300 |      |
|   | GC55K     |             | 5260 | 2520    | 6545             | 1235             | -                | 4450             | 5400 | 5200 |
|   |           |             | 5500 | 2600    | 6785             | 1315             | -                | 4400             | 5350 | 5150 |
|   |           |             | 6000 | 2800    | 7285             | 1515             | -                | 4250             | 5100 | 5000 |
|   |           |             | 6500 | 3000    | 7785             | 1715             | -                | 4050             | 4250 | 4250 |
|   |           |             | 7000 | 3200    | 8285             | 1915             | -                | 2650             | 2650 | 2650 |

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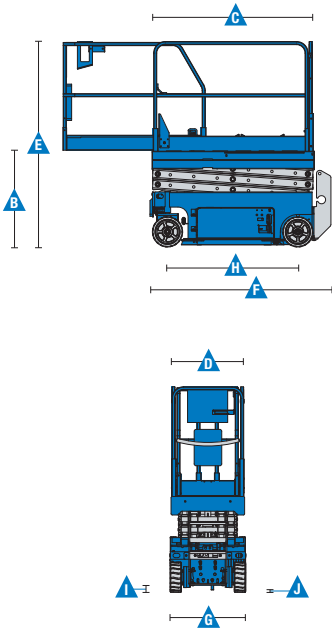
NOTE: Performance specifications may vary depending on standard manufacturing tolerances, vehicle condition, types of tyres, floor or surface conditions, applications, or operating environment. Trucks may be shown with non-standard options. Specific performance requirements and locally available configurations should be discussed with your Cat lift trucks Dealer. Cat Lift Trucks follows a policy of continual product improvement. For this reason, some materials, options and specifications could change without notice.



# Self-Propelled Scissor Lifts

## GS™ -1530 & GS-1930

### Specifications



| Models                                  | GS-1530     |        | GS-1930     |        |
|---|-------------|--------|-------------|--------|
| Measurements                            | US          | Metric | US          | Metric |
| Working height maximum*                 | 21 ft       | 6.57 m | 25 ft       | 7.79 m |
| <b>A</b> Platform height maximum        | 15 ft       | 4.57 m | 19 ft       | 5.79 m |
| <b>B</b> Platform height stowed         | 3 ft 2.2 in | .97 m  | 3 ft 3.5 in | 1.00 m |
| <b>C</b> Platform length - outside      | 5 ft 4 in   | 1.63 m | 5 ft 4 in   | 1.63 m |
| extended                                | 8 ft 4 in   | 2.54 m | 8 ft 4 in   | 2.54 m |
| Slide-out platform extension deck       | 3 ft        | .91 m  | 3 ft        | .91 m  |
| <b>D</b> Platform width - outside       | 2 ft 5 in   | .74 m  | 2 ft 5 in   | .74 m  |
| Guardrail height: fixed rails           | 3 ft 3 in   | .99 m  | 3 ft 3 in   | .99 m  |
| fold down (CE)                          | 3 ft 7 in   | 1.10 m | 3 ft 7 in   | 1.10 m |
| Toeboard height                         | 6 in        | .15 m  | 6 in        | .15 m  |
| <b>E</b> Height-stowed: fixed rails     | 6 ft 5 in   | 1.96 m | 6 ft 7 in   | 2.00 m |
| folding guardrails (CE)                 | 6 ft 8 in   | 2.03 m | 6 ft 11 in  | 2.11 m |
| rails folded                            | 5 ft 8 in   | 1.73 m | 5 ft 9 in   | 1.75 m |
| <b>F</b> Length-stowed                  | 6 ft        | 1.83 m | 6 ft        | 1.83 m |
| Length-stowed extended                  | 9 ft        | 2.74 m | 9 ft        | 2.74 m |
| <b>G</b> Width                          | 2 ft 6 in   | .76 m  | 2 ft 6 in   | .76 m  |
| <b>H</b> Wheelbase                      | 4 ft 4 in   | 1.32 m | 4 ft 4 in   | 1.32 m |
| <b>I</b> Ground clearance-center        | 2.4 in      | .06 m  | 2.4 in      | .06 m  |
| <b>J</b> - with pothole guards deployed | .75 in      | .02 m  | .75 in      | .02 m  |

### Productivity

|                                |                  |                 |                  |                 |
|--------------------------------|------------------|-----------------|------------------|-----------------|
| Maximum platform occupancy**   | 2                | 2               | 2                | 2               |
| Lift capacity                  | 600 lbs          | 272 kg          | 500 lbs          | 227 kg          |
| Lift capacity - extension deck | 250 lbs          | 113 kg          | 250 lbs          | 113 kg          |
| Drive speed - stowed           | 2.5 mph          | 4.0 km/h        | 2.5 mph          | 4.0 km/h        |
| Drive speed - raised           | 0.5 mph          | 0.8 km/h        | 0.5 mph          | 0.8 km/h        |
| Gradeability - stowed***       | 30%              |                 | 25%              |                 |
| Turning radius - inside        | zero             | zero            | zero             | zero            |
| Turning radius - outside       | 5 ft 1 in        | 1.55 m          | 5 ft 1 in        | 1.55 m          |
| Raise / lower speed            | 16 / 29 sec      | 16 / 29 sec     | 16 / 25 sec      | 16 / 25 sec     |
| Controls                       | proportional     |                 | proportional     |                 |
| Drive                          | dual front wheel |                 | dual front wheel |                 |
| Multiple disc brakes           | dual rear wheel  |                 | dual rear wheel  |                 |
| Tires - solid non-marking      | 12 x 4.5 x 8 in  | 30 x 11 x 20 cm | 12 x 4.5 x 8 in  | 30 x 11 x 20 cm |

### Power

|                           |                                     |        |                                     |        |
|---------------------------|-------------------------------------|--------|-------------------------------------|--------|
| Power source              | 24 V DC (four 6 V 225 Ah batteries) |        | 24 V DC (four 6 V 225 Ah batteries) |        |
| Hydraulic system capacity | 3.75 gal                            | 14.2 L | 3.75 gal                            | 14.2 L |

### Weight\*\*\*\*

|            |           |          |           |          |
|------------|-----------|----------|-----------|----------|
| ANSI, CSA  | 2,575 lbs | 1,168 kg | 2,702 lbs | 1,226 kg |
| CE indoor  | 2,718 lbs | 1,233 kg | 3,302 lbs | 1,498 kg |
| AUS indoor | —         | —        | 3,302 lbs | 1,498 kg |

### Standards Compliance

ANSI A92.6, CSA B354.2, CE Compliance, AS 1418.10

\* The metric equivalent of working height adds 2 m to platform height. U.S. adds 6 ft to platform height.  
 \*\* CE/AUS markets: GS-1530 and GS-1930 are indoor use only—2 person maximum occupancy.  
 GS-1532 and GS-1932 are indoor/outdoor use—1 person maximum.  
 \*\*\* Gradeability applies to driving on slopes, see operator's manual for details regarding slope ratings.  
 \*\*\*\* Weight will vary depending on options and/or country standards.

### Features

#### Standard Features

##### Measurements

###### GS-1530

- 21 ft (6.57 m) working height
- Up to 600 lbs (272 kg) lift capacity

###### GS-1930

- 25 ft (7.79 m) working height
- Up to 500 lbs (227 kg) lift capacity

##### Productivity

- 64 x 29 in (1.63 x .74 m) steel platform
- Fixed rail with chain entry gate
- Folding rails with half-height swing gate (CE)
- 36 in (.91 m) extension deck
- Dual front wheel drive
- SmartLink™ - 2 speed lift and proportional drive
- Universal 20 amp smart charger
- Rear recessed charger receptacle
- 25% gradeability
- Platform control with battery charge indicator and diagnostic display
- On-board diagnostic system
- AC power to platform
- Lanyard attachment points
- Manual platform lowering valve
- Emergency stop at both platform and ground controls
- Rear wheel multiple disc brakes
- Front wheel hydraulic dynamic braking
- Brake release
- Swing-out component trays
- Solid non-marking tires
- Pothole guards
- Tilt level sensor with audible alarm
- Descent alarm
- Electronic horn
- Hour meter

##### Power

- 24 V DC (four 6 V 225 Ah batteries)

#### Options & Accessories

##### Productivity Options

- Folding rails with half-height swing gate
- Platform swing gate, half-height
- Air line to platform
- Dual flashing beacons
- Motion alarm
- Automotive horn
- Biodegradable hydraulic fluid

##### Power Options

- Power inverter (120 V/60 Hz) (not available GS™-1932 CE)
- EE rating
- AGM maintenance-free batteries



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