Project Manual

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2011

Team Massachusetts

University of Massachusetts at Lowell
Massachusetts College of Art and Design

Primary Student Contact
Walter Thomas – walter_thomas@student.uml.edu

As-Built Deliverable
August 11, 2011
# Table of Contents

Team Massachusetts ......................................................................................................................................................................... 1

Summary of Changes ......................................................................................................................................................................... 6

Rules Compliance Checklist ............................................................................................................................................................... 9

Structural Calculations .................................................................................................................................................................... 12

  Structural Narrative ............................................................................................................................................................................. 12
  Structural Design Loads ....................................................................................................................................................................... 12
  Lateral Wind Load Analysis .............................................................................................................................................................. 13
  Typical Floor Joist ................................................................................................................................................................................. 15
  Typical Floor Beam .............................................................................................................................................................................. Error! Bookmark not defined.
  Typical Roof Framing Rafter .............................................................................................................................................................. Error! Bookmark not defined.
  Truss Analysis ..................................................................................................................................................................................... Error! Bookmark not defined.
  Roof Rafter with Trellis Load ............................................................................................................................................................ Error! Bookmark not defined.
  Typical Footing Load ....................................................................................................................................................................... Error! Bookmark not defined.

Appendix ...................................................................................................................................................................................... Error! Bookmark not defined.

  Nordic I-Joist Beam-Column Calculations .................................................................................................................................... Error! Bookmark not defined.
  Gravity Load Takedown .................................................................................................................................................................. Error! Bookmark not defined.

Truss Calculations - Complete .......................................................................................................................................................... Error! Bookmark not defined.

Detailed Water Budget .................................................................................................................................................................... 79

Summary of Unlisted Electrical Components ................................................................................................................................... 80

Summary of Reconfigurable Features ............................................................................................................................................ 81

  Storage Wall ....................................................................................................................................................................................... 81
  Operable External Blinds ................................................................................................................................................................. 81

Interconnection Application Form .................................................................................................................................................... Error! Bookmark not defined.

One-Line Electrical Schematic .......................................................................................................................................................... Error! Bookmark not defined.

  Calculations of service/feeder net computed load and neutral load (NCE 220) ........................................................................ Error! Bookmark not defined.
  Plan view of the lot showing the house, decks, ramps, tour paths and the service point ......................................................... Error! Bookmark not defined.
  Elevation view(s) showing the terminal box (contains the service point), meter, and other service equipment ... Error! Bookmark not defined.

Energy Analysis Results and Discussion ........................................................................................................................................... 82

  1. Introduction ............................................................................................................................................................................... Error! Bookmark not defined.
  2. Energy Efficient Design ............................................................................................................................................................. Error! Bookmark not defined.
<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>06</td>
<td>Wood, Plastics, and Composites</td>
<td>112</td>
</tr>
<tr>
<td>06 05 23</td>
<td>Wood, Plastic and Composite Fastenings</td>
<td>112</td>
</tr>
<tr>
<td>06 10 00</td>
<td>Rough Carpentry</td>
<td>112</td>
</tr>
<tr>
<td>06 16 00</td>
<td>Sheathing</td>
<td>112</td>
</tr>
<tr>
<td>06 20 00</td>
<td>Finish Carpentry</td>
<td>112</td>
</tr>
<tr>
<td>06 41 16</td>
<td>Architectural Woodwork</td>
<td>112</td>
</tr>
<tr>
<td>06 46 00</td>
<td>Wood Trim</td>
<td>112</td>
</tr>
<tr>
<td>06 82 00</td>
<td>Glass-Fiber Reinforced Plastic</td>
<td>112</td>
</tr>
<tr>
<td>06</td>
<td>Division 06 – Wood, Plastics, and Composites</td>
<td>112</td>
</tr>
<tr>
<td>07</td>
<td>Thermal and Moisture Protection</td>
<td>112</td>
</tr>
<tr>
<td>07 21 00</td>
<td>Thermal Insulation</td>
<td>112</td>
</tr>
<tr>
<td>07 41 13</td>
<td>Metal Roof Panels</td>
<td>112</td>
</tr>
<tr>
<td>07 46 46</td>
<td>Mineral Fiber Cement Siding</td>
<td>112</td>
</tr>
<tr>
<td>07 61 13</td>
<td>Corrugated Sheet Metal Roofing</td>
<td>112</td>
</tr>
<tr>
<td>07 71 23</td>
<td>Manufactured Gutters and Downspouts</td>
<td>112</td>
</tr>
<tr>
<td>07 91 00</td>
<td>Preformed Joint Seals</td>
<td>112</td>
</tr>
<tr>
<td>08</td>
<td>Division 08 – Openings</td>
<td>112</td>
</tr>
<tr>
<td>08 14 00</td>
<td>Wood Doors and Frames</td>
<td>112</td>
</tr>
<tr>
<td>08 52 00</td>
<td>Wood Windows</td>
<td>112</td>
</tr>
<tr>
<td>08 61 00</td>
<td>Roof Windows</td>
<td>112</td>
</tr>
<tr>
<td>09</td>
<td>Division 09 – Finishes</td>
<td>113</td>
</tr>
<tr>
<td>09 29 00</td>
<td>Gypsum Board</td>
<td>113</td>
</tr>
<tr>
<td>09 30 33</td>
<td>Stone Tiling</td>
<td>113</td>
</tr>
<tr>
<td>09 64 29</td>
<td>Wood Strip and Plank Flooring</td>
<td>113</td>
</tr>
<tr>
<td>09 91 23</td>
<td>Interior Painting</td>
<td>113</td>
</tr>
<tr>
<td>10</td>
<td>Division 10 – Specialties</td>
<td>113</td>
</tr>
<tr>
<td>10 06 10</td>
<td>Schedules for Information Specialties</td>
<td>113</td>
</tr>
<tr>
<td>10 06 20</td>
<td>Interior Specialties</td>
<td>113</td>
</tr>
<tr>
<td>10 22 26.43</td>
<td>Operable Partitions</td>
<td>113</td>
</tr>
<tr>
<td>10 44 16</td>
<td>Fire Extinguisher</td>
<td>113</td>
</tr>
<tr>
<td>10 71 13.13</td>
<td>Exterior Shutters</td>
<td>113</td>
</tr>
<tr>
<td>11</td>
<td>Division 11 – Equipment</td>
<td>113</td>
</tr>
<tr>
<td>11 31 00</td>
<td>Residential Appliances</td>
<td>113</td>
</tr>
<tr>
<td>12</td>
<td>Division 12 – Furnishings</td>
<td>113</td>
</tr>
<tr>
<td>12 36 00</td>
<td>Countertops</td>
<td>113</td>
</tr>
<tr>
<td>12 58 00</td>
<td>Residential Furniture</td>
<td>113</td>
</tr>
<tr>
<td>12 58 29</td>
<td>Beds</td>
<td>113</td>
</tr>
<tr>
<td>12 58 36</td>
<td>Nightstands</td>
<td>113</td>
</tr>
<tr>
<td>21</td>
<td>Division 21 – Fire Suppression</td>
<td>113</td>
</tr>
<tr>
<td>21 13 13</td>
<td>Wet-Pipe Sprinkler System</td>
<td>113</td>
</tr>
<tr>
<td>22</td>
<td>Division 22 – Plumbing</td>
<td>114</td>
</tr>
<tr>
<td>22 05 00</td>
<td>Common Work Results for Plumbing</td>
<td>114</td>
</tr>
<tr>
<td>22 11 16</td>
<td>Domestic Water Piping</td>
<td>114</td>
</tr>
<tr>
<td>22 11 19</td>
<td>Domestic Water Piping Specialties</td>
<td>114</td>
</tr>
<tr>
<td>22 12 19</td>
<td>Facility Potable Water Storage Tanks</td>
<td>114</td>
</tr>
<tr>
<td>22 13 16</td>
<td>Sanitary Waste Piping and Vent Piping</td>
<td>114</td>
</tr>
<tr>
<td>22 13 53</td>
<td>Facility Spetic Tanks</td>
<td>114</td>
</tr>
<tr>
<td>22 33 30.16</td>
<td>Residential, Storage Electric Domestic Water Heaters</td>
<td>114</td>
</tr>
</tbody>
</table>
Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC) ................................................................. 114

23 31 13.16 Round and Flat-Oval Spiral Ducts ................................................................................................. 114
23 33 13 Back Draft Dampers .......................................................................................................................... 114
23 37 13 Diffusers, Registers and Grilles ........................................................................................................ 114
23 40 00 Super Ultra-Low Penetration Filtration ............................................................................................ 114
23 72 00 Air to Air Recovery Equipment .......................................................................................................... 114
23 81 26 Split System Air Conditioner .......................................................................................................... 114
23 84 16 Dehumidifiers ...................................................................................................................................... 114

Division 26 – Electrical ....................................................................................................................................... 114
26 05 19 Low-Voltage Electrical Power Conductors and Cables ................................................................. 114
26 05 33 Raceway and Boxes for Electrical Systems ..................................................................................... 114
26 24 16 Panelboards ....................................................................................................................................... 114
26 27 13 Electricity Metering .......................................................................................................................... 114
26 28 16 Enclosed Switches and Circuit Breakers ............................................................................................ 114
26 31 00 Photovoltaic Collector System .......................................................................................................... 114
26 51 00 Interior Lighting .................................................................................................................................. 114
26 54 00 Exterior Lighting .................................................................................................................................. 114

Division 27 – Communications .......................................................................................................................... 114
27 21 00 Data Communication Network Equipment ..................................................................................... 114
27 21 33 Data Communication Wireless Access Points .................................................................................. 114
27 22 26 Data Communications Laptop ......................................................................................................... 114

Division 28 – Electronic Safety and Security .................................................................................................... 114
28 31 46 Smoke Detection Sensors ................................................................................................................ 114
28 31 49 Carbon-Monoxide Detection Sensors ................................................................................................. 114

Divisions 31 – Earthwork ..................................................................................................................................... 115
31 05 00 Soils for Earthwork ........................................................................................................................... 115

Division 32 – Exterior Improvements ................................................................................................................ 115
32 90 00 Planting ............................................................................................................................................... 115

Division 48 – Electrical Power Generation ....................................................................................................... 115
48 19 16 Electrical Power Generation Inverters ............................................................................................ 115
Summary of Changes  
March 22, 2011 Revisions

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

- Interconnection form reflects new inverter and PV panel - Changed
- One-Line Electrical Schematic Diagram – Added
- Three-Line Electrical Schematic Diagram – Removed
- Calculations of Service / Feeder Net Computed Load and Neutral Load Diagram – Added
- Load Center Schematic Diagram - Added
- 05 14 13 – Architecturally Exposed Structural Aluminum Framing - Changed
- 05 50 00 – Wire Rope Decorative Metal Railings – Removed
- 06 16 00 – Sheathing – Changed
- 06 41 16 – Plastic-Laminate-Clad Architectural Cabinets -Changed
- 06 46 00 – Wood Trim - Changed
- 07 21 00 – Thermal Insulation –Changed
- 07 46 46 - Mineral-Fiber Cement Siding –Changed
- 08 14 00 – Wood Doors and Frames - Changed
- 08 52 00 – Wood Windows – Changed
- 08 61 00 – Roof Windows - Changed
- 09 22 16.13 - Non-Structural Metal Stud Framing - Removed
- 09 29 00 – Gypsum Board Panels – Changed
- 09 30 13 – Ceramic Tiling – Removed
- 09 30 33 – Stone Tiling – Added
- 09 93 13.53 – Exterior Finishing – Removed
- 10 06 20 – Interior Specialties - Changed
- 10 22 26.43 – Operable Partitions – Changed
- 12 17 13 – Etched Glass – Removed
- 12 36 00 – Countertops – Changed
- 22 12 19 – Facility Potable Water Storage Tanks - Changed
- 26 31 00 – Photovoltaic Collector System - Changed
- 48 19 16 – Electrical Power Generation Inverters – Changed
May 5, 2011 Revisions

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

- Detailed Water Budget – Changed
- One-Line Electrical Diagram – Changed
- Calculations of Service/Feeder Net Computed Load & Neutral Load (NCE220) – Changed
- Load Center Schematic - Changed
- 01 54 00 – Construction Aids – Changed
- 06 41 16 – Architectural Woodwork – Removed
- 06 82 00 – Glass-Fiber Reinforced Plastic – Added
- 07 13 13 – Bituminous Sheet Waterproofing - Added
- 11 31 00 – Residential Appliances – Changed
- 12 30 00 – Casework - Added
- 21 13 13 – Wet-Pipe Sprinkler Systems – Changed
- 26 05 19 – Low-Voltage Electrical Power Conductors and Cables - Changed
- 26 05 26 – Grounding & Bonding for Electrical Systems - Added
- 26 05 33 – Raceways and Boxes for Electrical Systems – Changed
- 26 24 16 – Panelboards – Changed
- 26 27 00 – Low-Voltage Distribution Equipment – Added
- 26 27 13 – Electricity Metering – Changed
- 26 28 16 – Enclosed Switches and Circuit Breakers – Changed
- 26 31 00 – Photovoltaic Collector System – Changed
- 26 51 00 – Interior Lighting – Changed
- 26 56 00 – Exterior Lighting – Changed
August 11, 2011 Revisions

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

- Interconnection Application Form - Changed
- One-Line Electrical Schematic - Changed
- Calculations of Service / Feeder Net Computed Load and Neutral Load (NCE 220) - Changed
- Plan View of Lot Showing House, Decks, Ramps, Tour Path and Service Point - Changed
- Elevation View Showing Terminal Box with Service Point, meter and Service Equipment - Changed
- 01 54 00 – Construction Aids – Changed
- 01 74 19 – Construction Waste Management and Disposal – Added
- 05 14 13 – Architecturally Exposed Structural Aluminum - Changed
- 05 50 00 – Metal Fabrications - Changed
- 06 05 23 – Wood, Plastic and Composite Fasteners - Changed
- 06 10 00 – Rough Carpentry - Changed
- 06 82 00 – Glass-Fiber Reinforced Plastic - Added
- 07 13 13 – Bituminous Sheet Waterproofing - Removed
- 07 91 00 - Prefromed Joint Seals - changed
- 09 91 23 – Interior Paint - Changed
- 11 31 00 – Residential Appliances - Changed
- 12 21 13.23 – Horizontal Louver Blinds - Removed
- 21 13 13 – Wet-Pipe Sprinkler Systems - Changed
- 22 07 19 – Plumbing Piping Insulation - Removed
- 22 11 16 – Domestic Water Piping - Changed
- 22 12 19 – Facility Potable Water Storage Tanks - Changed
- 22 13 53 – Facility Septic Tanks - Added
- 22 33 30.26 – Residential, Storage Electric Domestic Water Heaters - Changed
- 23 21 13 – Hydronic Pumps - Removed
- 23 31 13.16 – Round and Flat-Oval Spiral Ducts - Changed
- 23 33 13 – Dampers - Changed
- 23 37 13 – Diffusers, Registers and Grilles - Changed
- 23 72 00 – Air-to-Air Energy Recovery Equipment - Changed
- 23 81 26 – Split-System Air Conditioners - Changed
- 23 84 16 – Dehumidifiers - Changed
- 26 05 19 – Low-Voltage Electrical Power Conductors and Cables - Changed
- 26 05 26 – Grounding and Bonding for Electrical Systems - Changed
- 26 05 33 – Raceway and Boxes for Electrical Systems - Changed
- 26 24 16 – Panelboards - Changed
- 26 27 00 – Low-Voltage Distribution Equipment - Changed
- 26 27 13 – Electricity Metering - Changed
- 26 31 00 – Photovoltaic Collectors - Changed
- 26 51 00 – Interior Lighting – Changed
- 26 56 00 – Exterior Lighting – Changed
- 27 05 13 – Communications Services - Removed
- 27 21 00 – Data Communications Network Equipment - Changed
- 27 21 33 – Data Communications Wireless Access Points - Changed
- 27 22 26 – Data Communications Laptops - Changed
**Rules Compliance Checklist**

<table>
<thead>
<tr>
<th>RULE DESCRIPTION</th>
<th>LOCATION DESCRIPTION</th>
<th>Drawing #</th>
<th>Project Manual Page #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 4-2 Construction Equipment</td>
<td>Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site</td>
<td>O-101,102</td>
<td></td>
</tr>
<tr>
<td>Rule 4-2 Construction Equipment</td>
<td>Specifications for heavy machinery</td>
<td>O-101,102</td>
<td>01 54 00 - 1</td>
</tr>
<tr>
<td>Rule 4-3 Ground Penetration</td>
<td>Drawing(s) showing the locations and depths of all ground penetrations on the competition site</td>
<td>S-101</td>
<td></td>
</tr>
<tr>
<td>Rule 4-4 Impact on the Turf</td>
<td>Drawing(s) showing the location, contact area, and soil-bearing pressure of every component resting directly on the turf</td>
<td>S-101</td>
<td></td>
</tr>
<tr>
<td>Rule 4-5 Generators</td>
<td>Specifications for generators</td>
<td>O-101,102</td>
<td></td>
</tr>
</tbody>
</table>
| 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-101,102,103,104         | 22 05 00 - 1  
22 11 16 - 1  
22 12 19 - 1  
22 33 30.16 - 1  
22 33 30.26 - 3  
23 21 13 - 2 |
| Rule 4-6 Spill Containment | Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event | P-101,102,103,104         | 01 54 00 - 1          |
| 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 | G-201,202                 |                       |
| 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                      |                       |
| Rule 5-2 Solar Envelope Dimensions | Drawing(s) showing the location of all house and site components relative to the solar envelope | G-201,202                 |                       |
| Rule 5-2 | Solar Envelope Dimensions | List of solar envelope exemption requests accompanied by justifications and drawing references | NA | Structural Calculations, 11-24 |
| Rule 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 | S-611 | |
| Rule 6-2 | Finished Square Footage | Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically | G-101 | |
| Rule 6-2 | Finished Square Footage | Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week | NA | |
| Rule 6-3 | Entrance and Exit Routes | Drawing(s) showing the accessible public tour route and the ground surface area that will be covered by organizer-provided walkway material | G-103 | |
| Rule 7-1 | Placement | Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system | L-101 | |
| Rule 7-2 | Watering Restrictions | Drawing(s) showing the layout and operation of greywater irrigation systems | L-102 | |
| Rule 8-1 | PV Technology Limitations | Specifications for photovoltaic components | E-102,602 | 26 31 00 - 1 |
| Rule 8-3 | Batteries | Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices | NA | |
| Rule 8-3 | Batteries | Specifications for all primary and secondary batteries and stand-alone, PV-powered devices | NA | |
| Rule 8-4 | Desiccant Systems | Drawing(s) describing the operation of the desiccant system | M-602 | |
| Rule 8-4 | Desiccant Systems | Specifications for desiccant system components | M-602 | 23 84 16 - 1 |
| Rule 8-5 | Village Grid | Completed interconnection application form. | E-101,102 | |
| 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-101,102 | |
| Rule 8-5 | Village Grid | Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means | E-101,102,603 | 26 31 00 - 2 48 19 16 - 2 26 05 33 - 2 26 27 13 - 1 26 28 16 - 2 |
| Rule 8-5 | Village Grid | One-line electrical diagram | E-601 |
| Rule 8-5 | Village Grid | Calculation of service/feeder net computed load per NEC 220 | E-603 |
| Rule 8-5 | Village Grid | Site plan showing the house, decks, ramps, tour paths, and terminal box | A-101 |
| Rule 8-5 | Village Grid | Elevation(s) showing the meter housing, main utility disconnect, and other service equipment | E-201 |
| Rule 9-1 | Container Locations | Drawing(s) showing the location of all liquid containers relative to the finished square footage | 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. EDT 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 | P-601 |
| Rule 9-3 | Greywater Reuse | Drawing(s) showing the layout and operation of greywater reuse systems | NA |
| Rule 9-4 | Rainwater Collection | Drawing(s) showing the layout and operation of rainwater collection systems | P-101,L-102 |
| Rule 9-6 | Thermal Mass | Drawing(s) showing the locations of liquid-based thermal mass systems | NA |
| Rule 9-6 | Thermal Mass | Specifications for components of liquid-based thermal mass systems | NA |
| Rule 9-7 | Greywater Heat Recovery | Drawing(s) showing the layout and operation of greywater heat recovery systems | NA |
| Rule 9-8 | Water Delivery | Drawing(s) showing the complete sequence of water delivery and distribution events | O-603 |
| Rule 9-8 | Water Delivery | Specifications for the containers to which water will be delivered | P-601 | 23 21 13 - 2 22 12 19 - 1 22 33 30.16 - 1 22 33 30.26 - 3 |
| Rule 9-9 | Water Removal | Drawing(s) showing the complete sequence of water consolidation and | O-603 |
Structural Calculations

Structural Narrative

The unusual stresses of shipping and craning the 4dhome have become dominant factors in the design of our house’s structural system. The house will be divided into four modules which are each designed to be independently structurally sound to withstand the rigors of shipping and craning. The Modules will also need to perform in concert as a sound two bedroom home which will be displayed and demonstrated to tens of thousands of visitors during the 2011 Solar Decathlon.

These varied forces have all been taken into account in the design of our 4Dhome. Central Trusses in the roof structure have been designed to handle the dynamic shipping and craning stresses the modules will endure on their journey and during their assembly on the National Mall. The unique stresses on the main modules will be addressed by the insertion of a series of smaller temporary trusses which will stabilize the open sides during delivery and craning and then will be adapted to serve a second purpose as railings for our decks. These horizontal stresses of braking and acceleration while on the trucks as well as the vertical lifting and racking stresses of craning and the eventual live and dead loads while in use have all been addressed and are continuing to be refined.

The use of these trusses in the roof has allowed us to disperse loads evenly throughout the building, and because we are using them in combination with sheathed TJI construction in the walls, floor and roof we have been able to enhance the thermal efficiency of our design by minimizing the costly effects of thermal bridging. We have also managed to keep the central trusses in our design thin enough to remain elegant and maintain a feeling of openness which will be enhanced by a large skylight and gable roof.

This efficient, robust construction has allowed us to address the rigorous structural stresses placed on our design while meeting Passive House insulation and energy use standards in the creation of a pleasant, structurally sound and comfortable home.

Calculation Results

Project Overview

This project manual provided structural calculations and evaluation of atypical construction methods and loading conditions not covered in applicable building codes. The objective of the structures group is to create a safe and sensible structural design that maximizes efficiency and minimizes thermal bridging. The shipping aspect is a dominant factor in the design of the house’s structural system. The house will be built in four separate modules for shipping. These modules will be craned together for the competition.
Load Summary
The structural design must accommodate multiple phases of loading. Construction is done in a modular building facility. The modules must be able to ship on U.S. highways. The service loads include the three week duration on the National Mall with elevated load criteria and a possible permanent location in Maine, using conservative values. A change in final geographic location will require re-evaluation.
ENGINEERING CONSULTANTS
LeMessurier Consultants
6.30.11

[Signature]

[Seal]

WILLIAM
D.
LOVALLO
STRUCTURAL
No. 36883

COM. REGIST. PROFESSIONAL ENGINEER
Structural Calculations

Submitted By:

LeMessurier Consultants
675 Massachusetts Avenue, Cambridge, MA 02139
Tel: (617)661-1000 Fax: (617)661-7520

Index

- Structural Design Loads ............................................. 1
- Lateral Wind Load Analysis ........................................ 2
- Typical Floor Joist ...................................................... 6
- Typical Floor Beam .................................................... 11
- Typical Roof Framing Rafter ...................................... 17
- Truss Analysis ............................................................ 19
- Roof Rafter with Trellis Load .................................... 28
- Typical Footing Calculation ..................................... 34

Appendix

- Nordic I-Joist Beam-Column Calculation .................. A1
- Gravity Load Takedown .............................................. A5

LeM File No.: 31079
Structural Design Loads

Submitted By:

LeMessurier Consultants
675 Massachusetts Avenue, Cambridge, MA 02139
Tel: (617) 661-1200 Fax: (617) 661-7620

Structural Design Loads – in accordance with ASCE 7-05; Minimum Design Loads for Buildings and Other Structures

1. Dead Loads
   a. Weight of Permanent Building Components..........................As Required

2. Live Loads
   a. First Floor.................................................................................100psf

3. Snow Loads
   a. Ground Snow Load......................................................................65psf
   b. Flat Roof Snow Load, P1...............................................................50psf
   c. Sloped Roof Snow Load, P................................................................50psf
   d. Snow Exposure Factor, Ce..............................................................1.0
   e. Roof Slope Factor, Cr....................................................................1.0
   f. Snow Load Importance Factor, I......................................................1.0
   g. Thermal Factor, Ct..........................................................................1.1

4. Wind Loads
   a. Basic Wind Speed (Boston, MA).......................................................105mph
   b. Importance Factor, I........................................................................1.0
   c. Surface Roughness Category............................................................B
   d. Exposure Category............................................................................B
   e. Analysis Method..............................................................................Method 1 (Simplified Method)
   f. Main Wind Force-Resisting System Design Pressures
      i. Wall Corner.................................................................................19.6psf
      ii. Wall Field..................................................................................15.7psf
      iii. Roof Corner..............................................................................13.5psf
      iv. Roof Field..................................................................................10.8psf
   g. Components and Cladding Pressures (based on effective wind area of 20sf)
      i. Interior Roof Zone......................................................................(+17.6psf/(-)18.8psf
      ii. Roof End/Ridge Zone.................................................................(+17.6psf/(-)22.2psf
      iii. Roof Corner and Ridge End Zone.............................................(+17.6psf/(-)22.2psf
      iv. Wall Interior Zone......................................................................(+18.9psf/(-)20.6psf
      v. Wall End Zone.............................................................................(+18.9psf/(-)24.8psf

LeM File No.: 31079
APPLY PRESSURES NORMAL TO VERTICAL PLANE

\[ a = 0.1(22'-8") = 2.27' \\
0.4(15.5') = 6.20' \\
0.04(22'-8") = 0.91' MIN \\
3'-0" = MIN \\
\]

\[ a = 3'-0" \\
2a = 6'-0" \]

NORTH - SOUTH

TOTAL W (EACH SPAN 10'M/120")

\[ P_B = \frac{6'(0.5x3'-7") (13.5psf)}{1000} \]

\[ = 0.310^k + 0.602^k = 0.912^k \]

\[ P_D = \frac{6'(2'-7") (0.5) (13.5)}{1000} \]

\[ = 0.310^k + 0.946^k + 0.602^k + 0.875^k \]

\[ = 2.23^k \]

\[ P_E = 0.446^k + 0.875^k = 1.32^k \]

\[ V_T = P_B + P_D + P_E \]

\[ = 0.912^k + 2.23^k + 0.875^k \]

\[ = 4.46^k \]
Nordic Lam™ columns shall be in accordance with the recommendations provided by the manufacturer.

5. Fire-rated assemblies:
Fire-rated assemblies shall be constructed in accordance with the recommendations provided by the manufacturer (see link above).

6. Limitations:
   a) Nordic Lam™ beams and columns shall be designed in accordance with the code using the design properties specified in this report.
   b) The dimensions of Nordic Lam™ beams and columns shall follow those specified in Table 1.
   c) Nordic Lam™ beams and columns shall be manufactured in accordance with layup combinations specified in APA Glulam Layup Combinations, Form Y117 SUP (www.apawood.org/publications) or proprietary Nordic Lam™ manufacturing specifications documented in the in-plant manufacturing standard approved by APA.
   d) Nordic Lam™ is produced at the Nordic Engineered Wood, Chibougamau, Quebec facilities under a quality assurance program audited by APA.
   e) This report is subject to re-examination in one year.

7. Identification:
Nordic Lam™ described in this report is identified by a label bearing the manufacturer’s name (Nordic Engineered Wood) and/or trademark, the APA assigned plant number (1057), the product standard (ANSI/AITC A190.1), the APA logo, the combination symbol, the report number PR-L294, and a means of identifying the date of manufacture.

<table>
<thead>
<tr>
<th>Layup</th>
<th>Minimum width, b (in.)</th>
<th>Maximum width, b (in.)</th>
<th>Minimum depth, h (in.)</th>
<th>Maximum depth, h (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20F-E8M1</td>
<td>1-1/2</td>
<td>7-1/2</td>
<td>4 lams</td>
<td>18</td>
</tr>
<tr>
<td>20F-ES/CPG</td>
<td>3-1/8(1)</td>
<td>3-1/2</td>
<td>4 lams</td>
<td>18</td>
</tr>
<tr>
<td>24F-ES1M1</td>
<td>1-1/2</td>
<td>7-1/2</td>
<td>4 lams</td>
<td>36(2)</td>
</tr>
<tr>
<td>24F-ES/NPG</td>
<td>1-1/2</td>
<td>12</td>
<td>4 lams</td>
<td>54(2)</td>
</tr>
<tr>
<td>ES11</td>
<td>1-1/2</td>
<td>7-1/2</td>
<td>2 lams</td>
<td>15</td>
</tr>
<tr>
<td>ES11/NPG</td>
<td>1-1/2</td>
<td>7-1/2</td>
<td>2 lams</td>
<td>15</td>
</tr>
<tr>
<td>ES12</td>
<td>1-1/2</td>
<td>7-1/2</td>
<td>2 lams</td>
<td>15</td>
</tr>
<tr>
<td>ES12/NPG</td>
<td>1-1/2</td>
<td>12</td>
<td>2 lams</td>
<td>54(2)</td>
</tr>
</tbody>
</table>

(1) The minimum width shall be permitted to be 1-1/2 inches when 24F-ES/NPG is trademarked as 20F-ES/CPG.
(2) The maximum depth shall not exceed the tabulated depth or a depth-to-width ratio of 12:1, whichever is smaller.
Nordic Lam™
Nordic Engineered Wood

Products: Nordic Lam™
Nordic Engineered Wood,
1100 Avenue des Canadiens-de-Montréal, Suite 504
Montreal, Québec, Canada H3B 2S2
(514) 871-8528
www.nordicwp.com

1. Basis of the product report:
   - 2009 and 2006 International Building Code (IBC): Sections 104.11 Alternative Materials and 2303.1.3 Structural glued laminated timber
   - ASTM D 3737-07 and D 3737-03 recognized by the 2009 IBC and IRC, and 2006 IBC and IRC, respectively
   - ANSI/IAITC A190.1-07 and A190.1-02 recognized by the 2009 IBC and IRC, and 2006 IBC and IRC, respectively

2. Product description:
   Nordic Lam™ is a Black Spruce structural glued laminated timber manufactured in accordance with 20F-E8M1, 20F-ES/CPG, 24F-E/ES1M1, 24F-ES/NPG, ES11, ES11/NPG, ES12, and ES12/NPG layup combinations developed in accordance with the principle of ASTM D 3737. Nordic Lam™ is used as beams, headers, rafters, purlins, columns, studs, and decking, and is manufactured in nominal widths ranging from 1-1/2 to 12 inches, depths up to 54 inches, and lengths up to 80 feet, in accordance with Table 1.

3. Design properties:
   Table 2 lists the design properties for Nordic Lam™ beams. The allowable spans for Nordic Lam™ beams shall be in accordance with the recommendations provided by the manufacturer (www.nordicwp.com/literatures/N-U121NordicLam.pdf), and with EWS Data File: Glued Laminated Beam Design Tables, Form S475 (www.apawood.org/publications), as applicable.

   Table 3 lists the design properties for Nordic Lam™ columns. The allowable loads for Nordic Lam™ columns shall be in accordance with the recommendations provided by the manufacturer (www.nordicwp.com/literatures/N-U231Columns.pdf), and with EWS Data File: Design of Structural Glued Laminated Timber Columns, Form Y240 (www.apawood.org/publications), as applicable.

4. Product installation:
   Nordic Lam™ beams and columns shall be installed in accordance with the recommendations provided by the manufacturer (www.nordicwp.com/literatures/N-U121NordicLam.pdf) and EWS Technical Note: Glulam Connection Details, Form T300 (www.apawood.org/publications). Permissible field notching and drilling of Nordic Lam™ beams shall be in accordance with the recommendations provided by the manufacturer and with EWS Technical Note: Field Notching and Drilling of Glued Laminated Timber Beams, Form S560 (www.apawood.org/publications). Permissible field notching and drilling of
Nordic Beam 3/4" x 11/2" Nordic Beam

Check Bending Stress

\[ I = \frac{3\frac{1}{4} \times (1\frac{1}{2})^3}{12} = 4.00 \text{ in}^4 \]

\[ S_x = \frac{3\frac{1}{2} \times (1\frac{1}{2})^2}{6} = 8.2 \text{ in}^3 \]

\[ f_y = \frac{95,247 \text{ psi}}{8.2 \text{ in}^3} = 10.40 \text{ ksi} \]

\[ f_B = 2000 \text{ psi} \text{ (lower bound)} > f_y \cdot 10.40 \text{ psi} = 10.40 \text{ ksi} \text{, ok} \]

From Table of Design Values

Check Deflection

\[ w = 100 \text{ psi} (10^{1.7}) = 1058 \text{ in}^4 \]

\[ \Delta = \frac{5 (1058 \text{ in}^4) (6-10 \times 12)}{98 (0.8 \times 10^6 \text{ psi}) (148)} = 0.138 \text{ in} \left( \frac{1}{32} \right) \text{, ok} \]

Check Shear

\[ V = 115 \text{ psi} (10^{1.7}) (6-10^9)(0.5) = 4158 \text{ in}^2 \]

\[ f_y = \frac{4158 \text{ in}^2}{(3\frac{1}{2} \times 11\frac{1}{2})} = 100 \text{ psi} < f_y = 175 \text{ psi} \text{, ok} \]
APA – The Engineered Wood Association is an accredited certification body under ISO 65 by Standards Council of Canada (SCC) and an accredited inspection agency by the International Code Council (ICC) International Accreditation Service (IAS) under ISO/IEC 17020. APA is also an accredited testing organization recognized by IAS and SCC under ISO/IEC 17025. APA is a recognized testing laboratory by Miami-Dade County, and a Product Testing Laboratory, Product Quality Assurance Entity, and Product Validation Entity by the Florida Department of Community Affairs (DCA).

APA – THE ENGINEERED WOOD ASSOCIATION
HEADQUARTERS
7011 So. 19th St. • Tacoma, Washington 98466
Phone: (253) 565-6600 • Fax: (253) 565-7265 • Internet Address: www.apawood.org

PRODUCT SUPPORT HELP DESK
(253) 820-7400 • E-mail Address: help@apawood.org

DISCLAIMER
APA Product Report® is a trademark of APA – The Engineered Wood Association, Tacoma, Washington. The information contained herein is based on the product evaluation in accordance with the references noted in this report. Neither APA, nor its members make any warranty, expressed or implied, or assume any legal liability or responsibility for the use, application of, and/or reference to opinions, findings, conclusions, or recommendations included in this report. Consult your local jurisdiction or design professional to assure compliance with code, construction, and performance requirements. Because APA has no control over quality of workmanship or the conditions under which engineered wood products are used, it cannot accept responsibility of product performance or designs as actually constructed.

© 2011 APA – The Engineered Wood Association
The tabulated values are design values for normal duration of load. All values, except for $E I$ and $K$, shall be permitted to be adjusted for other load durations as permitted by the code.

The maximum vertical load capacity for Nordic Joist without bearing stiffeners is 2,000 lb/ft for joists up to 16-inch deep, 1,850 lb/ft for 16-inch NI-60 and 1,275 lb/ft for 18-inch NI-80x to 24-inch NI-80x.

Bending stiffness (EI) of the I-joint

Moment capacity (M) of the I-joint, which shall not be increased by any repetitive member use factor.

Shear capacity (V) of the I-joint

Intermediate reaction (IR) of the I-joint for a bearing length of 3-1/2 or 5-1/2 inches with or without web stiffeners in accordance with the bearing stiffener recommendations listed in Table 2.

End reaction (ER) of the I-joint for a bearing length of 1-3/4 and 3-1/2 inches with and without web stiffeners. Higher end reactions are permitted. For a bearing length of 4 inches, the end reaction may be set equal to the tabulated shear value. Interpolation of the end reaction between 1-3/4 and 4-inch bearing length is permitted. For joists up to 16-inch deep with end reaction values greater than 1,550 lbf, web stiffeners are required with the exception of NI-90x, which requires bearing stiffeners when end reaction values exceed 1,885 lbf. For 18-inch NI-60 and 18-inch NI-80x to 24-inch NI-80x with end reactions greater than 1,850 lbf, web stiffeners are required.

Coefficient of shear deflection (K). For calculating uniform load and center-point load deflections of the I-joint in a simple-span application, use Equations 1 and 2.

$$
\delta = \frac{5a^4}{384EI} + \frac{a^2 \ell}{K} \quad [1]
$$

$$
\delta = \frac{P \ell^3}{48EI} + \frac{2P \ell}{K} \quad [2]
$$

Where:

- $\delta$ = calculated deflection (in.)
- $a$ = uniform load (lbf/in.)
- $P$ = concentrated load (lbf)
- $\ell$ = design span (in.)
- $EI$ = bending stiffness of the I-joint (lbf-in.$^2$)
- $K$ = coefficient of shear deflection (lbf)

### Table 2. Minimum Dimensions for Web Stiffeners

<table>
<thead>
<tr>
<th>Joist Series</th>
<th>Web Stiffeners</th>
<th>Flange width (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thickness (in.)</td>
<td>Width (in.)</td>
</tr>
<tr>
<td>NI-20</td>
<td>1</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-40</td>
<td>1</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-40x</td>
<td>1</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-60</td>
<td>1</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-70</td>
<td>1-1/2</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-80</td>
<td>1-1/2</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-80x</td>
<td>1-1/2</td>
<td>2-5/16</td>
</tr>
<tr>
<td>NI-90x</td>
<td>1-1/2</td>
<td>2-5/16</td>
</tr>
</tbody>
</table>

(a) Web stiffener length is 1/8 to 1/4 inch less than the clear distance between flanges. Stiffeners 1-inch thick are wood structural panels and stiffeners 1-1/2-inch thick are SPF lumber (specific gravity of 0.42) or denser lumber.

© 2011 APA – The Engineered Wood Association
### Table 1. Design Properties (Allowable Stress Design) for Nordic Joist™

<table>
<thead>
<tr>
<th>Joist Depth (in.)</th>
<th>Joist Series</th>
<th>E (10^9 lbf/in²)</th>
<th>M (lbf·ft)</th>
<th>V (lbf)</th>
<th>3-1/2 (in.)</th>
<th>5-1/2 (in.)</th>
<th>1-3/4 (in.)</th>
<th>3-1/2 (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w/o WS</td>
<td>w/ WS</td>
<td>w/o WS</td>
<td>w/ WS</td>
</tr>
<tr>
<td>7-7/8</td>
<td>NI-40x</td>
<td>138</td>
<td>2,310</td>
<td>880</td>
<td>1,890</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-60</td>
<td>147</td>
<td>3,030</td>
<td>880</td>
<td>1,890</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>204</td>
<td>4,285</td>
<td>880</td>
<td>1,890</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-20</td>
<td>138</td>
<td>2,510</td>
<td>1,080</td>
<td>1,700</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40x</td>
<td>198</td>
<td>2,810</td>
<td>1,170</td>
<td>2,240</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-60</td>
<td>217</td>
<td>3,680</td>
<td>1,170</td>
<td>2,240</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>304</td>
<td>5,215</td>
<td>1,170</td>
<td>2,240</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>9-1/4</td>
<td>NI-20</td>
<td>145</td>
<td>2,590</td>
<td>1,120</td>
<td>1,700</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40</td>
<td>193</td>
<td>2,735</td>
<td>1,120</td>
<td>2,160</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40x</td>
<td>218</td>
<td>2,900</td>
<td>1,200</td>
<td>2,240</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-60</td>
<td>231</td>
<td>3,810</td>
<td>1,200</td>
<td>2,240</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-70</td>
<td>304</td>
<td>5,120</td>
<td>1,200</td>
<td>2,240</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>324</td>
<td>5,385</td>
<td>1,200</td>
<td>2,380</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>9-1/2</td>
<td>NI-20</td>
<td>222</td>
<td>3,156</td>
<td>1,340</td>
<td>1,800</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40x</td>
<td>313</td>
<td>3,635</td>
<td>1,410</td>
<td>2,750</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-60</td>
<td>347</td>
<td>4,630</td>
<td>1,410</td>
<td>2,750</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>484</td>
<td>6,560</td>
<td>1,410</td>
<td>2,750</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>11-1/4</td>
<td>NI-20</td>
<td>253</td>
<td>3,365</td>
<td>1,420</td>
<td>1,800</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40</td>
<td>330</td>
<td>3,546</td>
<td>1,420</td>
<td>2,500</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40x</td>
<td>371</td>
<td>3,760</td>
<td>1,480</td>
<td>2,750</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-60</td>
<td>396</td>
<td>4,935</td>
<td>1,480</td>
<td>2,750</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-70</td>
<td>515</td>
<td>6,635</td>
<td>1,480</td>
<td>2,750</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>547</td>
<td>6,980</td>
<td>1,480</td>
<td>2,900</td>
<td>3,120</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>11-7/8</td>
<td>NI-90x</td>
<td>615</td>
<td>9,465</td>
<td>2,055</td>
<td>4,170</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>14</td>
<td>NI-40</td>
<td>482</td>
<td>4,270</td>
<td>1,710</td>
<td>2,500</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40x</td>
<td>540</td>
<td>4,530</td>
<td>1,730</td>
<td>2,750</td>
<td>3,240</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>16</td>
<td>NI-40</td>
<td>584</td>
<td>5,945</td>
<td>1,730</td>
<td>2,750</td>
<td>3,240</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-70</td>
<td>749</td>
<td>7,990</td>
<td>1,730</td>
<td>2,750</td>
<td>3,240</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>802</td>
<td>8,405</td>
<td>1,730</td>
<td>3,310</td>
<td>3,840</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>18</td>
<td>NI-90x</td>
<td>910</td>
<td>11,415</td>
<td>2,210</td>
<td>4,170</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>20</td>
<td>NI-40</td>
<td>657</td>
<td>4,950</td>
<td>1,970</td>
<td>2,500</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-40x</td>
<td>734</td>
<td>5,250</td>
<td>1,970</td>
<td>2,750</td>
<td>3,240</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>22</td>
<td>NI-40</td>
<td>798</td>
<td>6,856</td>
<td>1,970</td>
<td>2,750</td>
<td>3,240</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-70</td>
<td>916</td>
<td>9,265</td>
<td>1,970</td>
<td>2,750</td>
<td>3,240</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NI-80</td>
<td>1,016</td>
<td>9,745</td>
<td>1,970</td>
<td>3,310</td>
<td>3,840</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>24</td>
<td>NI-90x</td>
<td>1,245</td>
<td>13,100</td>
<td>2,325</td>
<td>4,170</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

For St 1 inch = 25.4 mm, 1 lbf = 4.448 N, 1 lbf·ft = 1.336 N·m, 1 lbf·in² = 0.000287 N·m²

© 2011 APA – The Engineered Wood Association
1. Basis of the product report:
   - ASTM D 5055-05 recognized by the 2009 IBC and IRC, and ASTM D 5055-04 recognized by the 2006 IBC and IRC

2. Product description:
   Nordic Joist™ is made with lumber flanges and OSB webs in accordance with the in-plant manufacturing standard approved by APA.

3. Design properties:
   Table 1 lists the design properties for Nordic Joist. The allowable spans shall be in accordance with the recommendations provided by the manufacturer (www.nordicewp.com/literature/residential-united-states/).

4. Product installation:
   Nordic Joist shall be installed in accordance with the recommendations provided by the manufacturer (see link above). Permissible web holes, web stiffeners and cantilever reinforcements shall be in accordance with the recommendations provided by the manufacturer.

5. Fire-rated assemblies:
   Fire-rated assemblies shall be constructed in accordance with the recommendations provided by the manufacturer (see link above), and with APA Design/Construction Guide: Fire-Rated Systems, Form W305 (www.apawood.org/publications).

6. Limitations:
   a) Nordic Joist shall be designed in accordance with the code using the design properties specified in this report.
   b) Nordic Joist is limited to dry service conditions where the average equilibrium moisture content of sawn lumber is less than 16 percent.
   c) Nordic Joist is produced at the Nordic Engineered Wood, Chibougamau, Québec facilities under a quality assurance program audited by APA.
   d) This report is subject to re-examination in one year.
2011 US DOE Solar Decathlon
Team Massachusetts
Published 08/11/11

**Check Joint Stress**

- **SAY Minimum Width is 2'-0".**
- **DESIGN LIVE = 100 psf**
- **DESIGN DREAD = 15 psf**
- **DL = 85 psf**
- **UL = 115 psf**
- **M = UL * (2'-0") = 0.230 ft.k**
- **M = 0.230 \(\frac{bf}{(10^{-3} \text{in})^2}\)**
- **\(\frac{M}{b} = 3.22 \text{ ksi}\)**

**ASD of N1-60 1 1/8"**

- **M = 9.94 k\(\text{in}\)**
- **M = 3.22 k\(\text{in}\)**

**Check Deflection**

\[
\Delta = \frac{5wL^4}{384EI} + k
\]

\[
W = \frac{100}{115} \left(10 \cdot 230 \text{ psf}\right) \left(12\frac{\text{in}}{L}\right)
\]

\[
\Delta = 0.0167 \times 1000 \text{ in} = 0
\]

From Table 8

\[
E I = 396 \times 10^6 \text{ ft}^3
\]

\[
k = 6.18 \times 10^6 \text{ in}^2
\]

\[
\Delta = \frac{5 \left(16.7 \text{ k\(\text{in}\)}\right) \left(10^{-2} \text{in} \times 12\frac{\text{in}}{L}\right)}{3 \times 89 \left(396 \times 10^6\right)}
\]

\[
\Delta = \frac{16.7 \left(10^{-2} \text{in} \times 12\frac{\text{in}}{L}\right)}{6.18 \times 10^6}
\]

\[
\Delta = 0.167 \times 10^{-2} \text{ in} = 0.189\text{ in}
\]

**Check Joint Strength**

\[
R = 0.230 \left(\frac{18.7 \text{ in}}{10^{-3} \text{ in}}\right) \left(10.5\right) = 1.22 k
\]

\[
V_\text{rel} = 1.40 k > R = V = 1.22 k
\]

Size not.
North-South Wing 5TH

1ST EÖ Li = 22' - 8" - (15' + 5' - 4") = 12.38'

% Full Height 12.33
22'-8" = 54% Co = 0.67

Vmax = 0.67(240)(12.33)(25.1082) = 9.68 k > V = 4.76 k

Uplift, R = 4.76 k / 12.33 = 0.38 k

2ND E

2Li = 22' - 8" - (13' - 11" + 3' - 6") = 15.25'

% Full Height 15.25
22'-8" = 67% Co = 0.63

Vmax = 0.63(240)(15.25)(25.1082) = 5.38 k > V = 4.76 k

Uplift, R = 4.76 k / 15.25 = 0.31 k
CHIEK LATERAL STEMM ON W00 PAPER

V EAST-WEST STEMM (TO 1 LONG W00) = 5.30 k
V NORTH-SOUTH STEMM (TO 1 EACH W00) = 4.46 k

EAST-WEST WIND STORM

V_{w00} = (1200) \sum L_i

L_i = \frac{41'-8" - 3(4'-0")}{} = 29.67"

\% FULL HEIGHT = \frac{29.67}{91.67} = 0.31 71\% 60 = 1.00

V_{60\%}, 71\% \text{SHOWN} = 280 \text{ pce} \geq \text{IBC REQLE FOR 13/32}

V_{w00} = 1.0 \times \frac{280 \text{ pce}}{1000\%} \times 2 \text{ SIDES} = 16.6 k \geq V = 5.30 k

W:\text{UPPER} = \frac{5.30 \text{ k}}{29.67\%} = 1.80 k
LeMessurier Consultants
Structural Engineers

EAST-WEST

$F_0 = \frac{196 (12.1')(6')}{1000} = 1.42 k$  
$F_0 = \frac{15.7 (15.2')(15.33)}{1000} = 1.27 k$  

$V_T (ALL TO 1 SIDE)$  
$V_T = 2(1.42 k) + 2(1.27 k) = 5.38 k$  

CHECK SLIDING

$\mu_s = 0.6$  
$T_{FR} = 0.690$

$D_{DOOR} = \frac{15.7 + (1.4')(22')(8')(41'-5'')}{1000} = 19.9 k$

$D_{DOOR} = \frac{15.7 + (22')(8')(41'-5'')}{1000} = 14.1 k$

$D_{WALLS} = \frac{15.7 + [(22')(8')(2) + 41'-5'']/2]}{1000} = 19.6 k$

$D_T = 98.6 k$

$14.5 k \cdot 0.6(0.6) = 27.2 k > V_I = 5.38 k$

$F_T = 2$
CHECK TYPICAL ROOF NAFFER DEFORMATION

\[ S = \frac{50 \text{ psf}}{11\text{ ft}} = 4.5 \text{ psf} \]

\[ W_s = \frac{+115\text{ k}(6)}{12\text{ ft}} = 82 \text{ k} \]

From Table 18, \( EI = 982 \times 10^6 \text{ k} \text{ in}^2 \)

\[ \Delta_s = \frac{5(82 \text{ k}) (3.4^2) (13.4 \times 12^3)}{384 (982 \times 10^6)} = 0.173 \text{ in} \left( \frac{L}{130f} \right) \therefore \Delta_s \text{ ok} \]

ADD WIND TO ROOF NAFFER

USE \( D + 0.75W + 0.75S \)

USE CORNER NAFFER

**TL:**

\[ TL = 16 + 0.75(12.5) \left( \frac{26}{13.4} \right) + 0.75(50) \left( \frac{11}{13.4} \right) \]

\[ = 16 + 5.7 + 30.8 \]

\[ = 52.5 \text{ k} \approx 53 \text{ k} \]

BY INSPECTION, 53 k \( \leq 57 \text{ k} \)

FROM GRAVITY ANALYSIS.

1. CORNER NAFFER WITH GRAVITY

AND WIND OK.
APA – The Engineered Wood Association is an accredited certification body under ISO 65 by Standards Council of Canada (SCC) and an accredited inspection agency by the International Code Council (ICC) International Accreditation Service (IAS) under ISO/IEC 17020. APA is also an accredited testing organization recognized by IAS and SCC under ISO/IEC 17025. APA is a recognized testing laboratory by Miami-Dade County, and a Product Testing Laboratory, Product Quality Assurance Entity, and Product Validation Entity by the Florida Department of Community Affairs (DCA).

APA – THE ENGINEERED WOOD ASSOCIATION
HEADQUARTERS
7011 So. 19th St. • Tacoma, Washington 98406
Phone: (253) 566-6800 • Fax: (253) 566-7265 • Internet Address: www.apawood.org

PRODUCT SUPPORT HELP DESK
(253) 620-7400 • E-mail Address: help@apawood.org

DISCLAIMER
APA Product Report® is a trademark of APA – The Engineered Wood Association, Tacoma, Washington. The information contained herein is based on the product evaluation in accordance with the references noted in this report. Neither APA, nor its members make any warranty, expressed or implied, or assume any legal liability or responsibility for the use, application of, and/or reference to opinions, findings, conclusions, or recommendations included in this report. Consult your local jurisdiction or design professional to assure compliance with code, construction, and performance requirements. Because APA has no control over quality of workmanship or the conditions under which engineered wood products are used, it cannot accept responsibility of product performance or designs as actually constructed.
<table>
<thead>
<tr>
<th>Combination Symbol</th>
<th>Species</th>
<th>Grade</th>
<th>Module of Elasticity (ksi)</th>
<th>E&lt;sub&gt;fm&lt;/sub&gt; (ksi)</th>
<th>F&lt;sub&gt;ck&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;k&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;y&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;y&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;yy&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;x&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;xx&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;x&lt;/sub&gt; (psf)</th>
<th>F&lt;sub&gt;xx&lt;/sub&gt; (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 11</td>
<td>ES</td>
<td>C4</td>
<td>1.5</td>
<td>0.75</td>
<td>459</td>
<td>975</td>
<td>1,550</td>
<td>1,350</td>
<td>1,750</td>
<td>1,600</td>
<td>1,400</td>
<td>175</td>
<td>1,300</td>
</tr>
<tr>
<td>ES 11/NPG</td>
<td>ES</td>
<td>NPG</td>
<td>1.5</td>
<td>0.75</td>
<td>459</td>
<td>975</td>
<td>1,550</td>
<td>1,350</td>
<td>1,750</td>
<td>1,600</td>
<td>1,400</td>
<td>175</td>
<td>1,300</td>
</tr>
<tr>
<td>ES 12</td>
<td>ES</td>
<td>1 REP</td>
<td>1.8</td>
<td>0.95</td>
<td>569</td>
<td>1,600</td>
<td>2,300</td>
<td>1,700</td>
<td>2,400</td>
<td>2,400</td>
<td>2,200</td>
<td>175</td>
<td>1,900</td>
</tr>
<tr>
<td>ES 12/NPG</td>
<td>ES</td>
<td>NPG</td>
<td>1.8</td>
<td>0.95</td>
<td>569</td>
<td>1,600</td>
<td>2,300</td>
<td>1,700</td>
<td>2,400</td>
<td>2,400</td>
<td>2,200</td>
<td>175</td>
<td>1,900</td>
</tr>
</tbody>
</table>

**Table 3. Design Values for Normal Duration of Load (1)**

(1) The tabulated design values are for normal duration of loading. For other durations of loading, see applicable building code. The tabulated design values are for dry conditions of use. For wet conditions of use, multiply the tabulated values by the factors shown at the bottom of the table.

(2) ES = Eastern species.

(3) The tabulated E<sub>fm</sub> values already include a 5% shear deflection (also known as "apparent E"). The actual modulus of elasticity (E<sub>mod</sub> and E<sub>mod,ref</sub>) shall be permitted to be calculated by multiplying the tabulated E<sub>fm</sub> and E<sub>fm,ref</sub> by 1.15.

(4) The values of F<sub>ck</sub> are based on members 12 inches in depth. For depths less than 12 inches, F<sub>ck</sub> shall be permitted to be increased by multiplying by the size factor, (1.25)<sup>(d)</sup> where d is the beam depth in inches. When d is less than 3 inches, use the size adjustment factor for 3 inches.

(5) For non-prismatic members, notched members, members subject to impact or cyclic loading, or shear design of bending members at connections (NEB 3.4.3.3), the tabulated F<sub>ck</sub> and F<sub>y</sub> values shall be multiplied by 0.72.

(6) The tabulated F<sub>y</sub> values are for members 4 or more lamina. The tabulated F<sub>y</sub> values shall be multiplied by a factor of 0.95 for 3 lamina and 0.94 for 2 lamina.

(7) The values of F<sub>y</sub> are based on members 5-16 inches in width by 12 inches in depth by 21 feet in length. For members with a larger volume, F<sub>y</sub> shall be multiplied by a volume factor, C<sub>y</sub> determined in accordance with applicable building codes using 17/10 as the exponent.

(8) When the member depth is greater than 15 inches, the tabulated F<sub>xx</sub> values shall be multiplied by a factor of 0.88.
Table 2. Design Values for Nordic Laminated Beams for Normal Duration of Load\(^{(1)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Specified(^{(2)})</th>
<th>Outer/ Core</th>
<th>Bending About X-X Axis (Loaded Perpendicular to Wide Faces of Laminations)</th>
<th>Bending About Y-Y Axis (Loaded Parallel to Wide Faces of Laminations)</th>
<th>Axially Loaded</th>
<th>Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bottom of Beam Stressed in Tension (Positive Bending)</td>
<td>Top of Beam Stressed in Tension (Negative Bending)</td>
<td>Top of Beam Stressed in Tension (Positive Bending)</td>
<td>Top of Beam Stressed in Tension (Negative Bending)</td>
<td>Top of Beam Stressed in Tension (Positive Bending)</td>
<td>Top of Beam Stressed in Tension (Negative Bending)</td>
</tr>
<tr>
<td>F(_{ax}) (psi)</td>
<td>F(_{ay}) (psi)</td>
<td>F(_{aw}) (psi)</td>
<td>E(_{aw}) (10(^{3}) psi)</td>
<td>E(_{aw}) (10(^{3}) psi)</td>
<td>F(_{aw}) (psi)</td>
<td>F(_{aw}) (psi)</td>
</tr>
<tr>
<td>20F-ESM1</td>
<td>ES/ES</td>
<td>2,000 2,000</td>
<td>450 450</td>
<td>250 250</td>
<td>1.8 0.95</td>
<td>1,059 315</td>
</tr>
<tr>
<td>25F-EB/PFG</td>
<td>ES/ES</td>
<td>2,000 2,000</td>
<td>450 450</td>
<td>250 250</td>
<td>1.8 0.95</td>
<td>2,000 456</td>
</tr>
<tr>
<td>24F-ES/IM1</td>
<td>ES/ES</td>
<td>2,400 2,400</td>
<td>560 560</td>
<td>250 250</td>
<td>1.8 0.95</td>
<td>2,400 550</td>
</tr>
<tr>
<td>24F-ES/IM1</td>
<td>ES/ES</td>
<td>2,400 2,400</td>
<td>560 560</td>
<td>250 250</td>
<td>1.8 0.95</td>
<td>2,400 550</td>
</tr>
</tbody>
</table>

\(^{(1)}\) The tabulated values are for normal duration of loading. For other durations of loading, see the applicable building code. The tabulated values are for dry conditions of use. For wet conditions of use, multiply the tabulated values by the wet-use factors shown at the bottom of the table.

\(^{(2)}\) ES = Eastern spruce.

\(^{(3)}\) The values of F\(_{aw}\) are based on members 6-18 inches in width by 12 inches in depth by 21 feet in length. For members with a larger volume, F\(_{aw}\) shall be multiplied by a volume factor, C\(_{aw}\), determined in accordance with applicable building code using 1/72 as the exponent.

\(^{(4)}\) The tabulated values already include a 5% shear deflection (also known as "apparent E"). The axial modulus of elasticity, E\(_{aw}\), and F\(_{aw}\), shall be calculated by multiplying E\(_{aw}\) and F\(_{aw}\), by 0.72.

\(^{(5)}\) The values of F\(_{aw}\) are based on members 12 inches in depth. For depths less than 12 inches, F\(_{aw}\) shall be permitted to be increased by multiplying by the size factor, (12d)\(^{(6)}\), where d is the beam depth in inches. When d is less than 3 inches, use the size adjustment factor for 3 inches.

\(^{(6)}\) The tabulated values are for members subject to impact or cyclic loading, or shear design of bending members at connections (NDS 3.4.3.3), the F\(_{aw}\), and F\(_{aw}\), values shall be multiplied by a factor of 0.72.

\(^{(7)}\) The tabulated values are for members subject to impact or cyclic loading, or shear design of bending members at connections (NDS 3.4.3.3), the F\(_{aw}\), and F\(_{aw}\), values shall be calculated by multiplying E\(_{aw}\) and F\(_{aw}\), by 0.72.
D4 SOUTH TRELLIS EAST ELEVATION
1/4" = 1'-0"

Assume pada fail of water

\[ S_A \left( \frac{13^2}{12^2} \right) \frac{62.4}{323} = 9.1 \text{ psf} \]

Use 20 psf to include from 14

\[ TL = 20 \text{ psf} + \left( \frac{8.33}{10.38} \right) 9.1 \text{ psf} = 60 \text{ psi} \]  
concrete

or

\[ TL = 20 \text{ psf} + 0.75 \left( \frac{8.33}{10.38} \right) 9.1 \text{ psf} + 0.75 \left( \frac{5.33}{10.33} \right) 13.5 \text{ psf} = 56 \text{ psi} \]

\[ W = \frac{60 \text{ psf} \left( 19.1" \right)}{1000} = 0.845 \text{ kips} \]

\[ 0.845 \times \frac{6.25}{1.38} \]

\[ 8.26 \times 5.12" \]

\[ 3.1" \]

\[ 6.35" \]
# DESIGN VALUES

## FOR NORDIC LAM™

### DESIGN STRESSES

<table>
<thead>
<tr>
<th>Stress Type</th>
<th>NORDIC LAM</th>
<th>BEAMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRESS GRADE</strong></td>
<td>24F-1.9E</td>
<td>24F-E/ES1M1</td>
</tr>
<tr>
<td><strong>EWS LAYUP COMBINATION</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Bending About X-X Axis
*(Loaded Perpendicular to Wide Face of Laminations)*

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Fiber in Bending</td>
<td>$F_{ex}$</td>
<td>2400 psi</td>
</tr>
<tr>
<td>Shear Parallel to Grain</td>
<td>$F_{sv}$</td>
<td>250 psi</td>
</tr>
<tr>
<td>Compression Perpendicular to Grain</td>
<td>$F_{cpp}$</td>
<td>580 psi</td>
</tr>
<tr>
<td>Shear-Free Modulus of Elasticity</td>
<td>$E_s$</td>
<td>$1.9 \times 10^6$ psi</td>
</tr>
<tr>
<td>Apparent Modulus of Elasticity</td>
<td>$E_{app}$</td>
<td>$1.8 \times 10^6$ psi</td>
</tr>
</tbody>
</table>

#### Bending About Y-Y Axis
*(Loaded Parallel to Wide Face of Laminations)*

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Fiber in Bending</td>
<td>$F_{ey}$</td>
<td>1100 psi</td>
</tr>
<tr>
<td>Shear Parallel to Grain</td>
<td>$F_{ey}$</td>
<td>175 psi</td>
</tr>
<tr>
<td>Compression Perpendicular to Grain</td>
<td>$F_{cpp}$</td>
<td>300 psi</td>
</tr>
<tr>
<td>Shear-Free Modulus of Elasticity</td>
<td>$E_y$</td>
<td>$1.6 \times 10^6$ psi</td>
</tr>
<tr>
<td>Apparent Modulus of Elasticity</td>
<td>$E_{app}$</td>
<td>$1.5 \times 10^6$ psi</td>
</tr>
</tbody>
</table>

#### Axially Loaded

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Parallel to Grain</td>
<td>$F_c$</td>
<td>1150 psi</td>
</tr>
<tr>
<td>Tension Parallel to Grain</td>
<td>$F_t$</td>
<td>1050 psi</td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>$E$</td>
<td>$1.6 \times 10^6$ psi</td>
</tr>
</tbody>
</table>

---

(1) The tabulated design values are for dry conditions of use. For wet conditions of use, multiply the tabulated values by the wet service factors, $C_w$ (NDS-05, 3.3.3).

(2) The tabulated design values are for normal duration of loading. For other durations of loading, see applicable building code.

(3) Nordic Lam bending members are symmetrical throughout the depth of the member (balanced layout).

(4) The tabulated design values in bending ($F_c$) shall be multiplied by a volume effect factor, $C_v$. The volume factor formula is:

\[
C_v = (12d)^{0.57} \times (5.125b)^{0.57} \times (21.4)^{0.57} \times 1.0,
\]

where $d =$ beam depth (in.), $b =$ beam width (in.), and $L =$ beam length (ft).

(5) For notched members, members subject to impact or cyclic loading, or shear design of bending members at connections (NDS-05 3.3.3), the design value for shear ($F_v$) shall be multiplied by a factor of 0.72.

(6) The tabulated "apparent E" values already include a 5% shear deflection.

(7) The values of $F_c$ shall be permitted to be increased by multiplying the size factor, $(12d)^{0.57}$, where $d$ is the beam depth in inches.


(9) The specific gravity for dowel-type fastener design is 0.41. Member weight shall be based on density of 35 pcf.

Refer to the Nordic Lam Design/Construction Guide for more information.
\[
P'c = F_c \cdot C_p \cdot C_d = 1150 \cdot (0.8)(1.1)(1.0) = 1012 \text{ psi}
\]

\[
f_c = \frac{P}{A} = \frac{12,300 \text{ lb}}{(14)(3.5^\prime)} = 271 \text{ psi} \quad \therefore f_c = 1012 \text{ psi}
\]

\[
\frac{f_c}{P_c} = \frac{271}{1012} = 0.268 < 1.0
\]

**NOO BENDING STRESS**

\[
M = 36,200 \text{ lb-ft} \cdot \text{in}
\]

\[
S = \frac{3.5(14)^2}{6} = 114.3^\prime^3
\]

\[
f_b = \frac{26,200}{114.3} = 3.17 \text{ psi}
\]

\[
F_b = 0.8(1.1)(2400 \text{ psi}) = 212 \text{ psi}
\]

\[
\frac{f_b}{F_b} = \frac{3.17}{212} = 0.150
\]

**TORSION STRESS**

\[
\sigma_{TN} = 0.268^2 + 0.150 = 0.222 < 1.0 \quad \therefore \text{TORUS STRESS OK}
\]
CHECK TRUSS MEMBERS

Top chord: AXIAL + BENDING

\[ F_c = 1150 \text{ psi} \]
\[ E_m = 1.6 \times 10^6 \text{ psi} \]
\[ C_0 = 1.0 \quad C_4 = 1.0 \quad C_0' = 1.0 \]

\[ C_m = 0.80 \text{ compression member} \]
\[ E_m' = 0.90 \text{ modulus of elasticity} \]

\[ C_p = 1.1 \text{ compression member} \]
\[ k_e = 1.0 \]

\[ k_{el} = \frac{110 (8.67') (12''/)}{14''} = 7.43 \text{ STRAND - 600 ENDS} \]
\[ k_{el} = \frac{1.0 (2') (14'')}{3.2''} = 6.85 \text{ weak} \]

\[ E_m'' = E_m/C_m = 1.6 \times 10^6 (0.9) = 1.44 \times 10^6 \text{ psi} \]
\[ F_c' = F_c C_m C_p = 1150 \text{ psi} (0.8)(1.1) = 1012 \text{ psi} \]
\[ F_{E1} = \frac{0.822 (1.44 \times 10^6 \text{ psi})}{(7.43)} = 21,442 \text{ psi} \]
\[ F' = \frac{21,442 \text{ psi}}{1012 \text{ psi}} = 21.2 \]

\[ C = 0.9 \text{ - structure lean} \]

\[ C_p = \frac{1 + F'}{2c} = \left( \frac{(1.10 + F')}{2c} \right)^{0.5} = \frac{1 + 21.2}{2(0.9)} + \left[ \left( \frac{1 + 21.2}{2(0.9)} \right)^2 \right] \frac{21.2}{2(0.9)} \]
\[ = 0.995 \text{ USE } C_0 = 1.0 \]
COMBINATION = DEAD + LIVE

Bending Moment

\( M = 36.2 \text{ k} \cdot \text{ft} \)

\( M = 17.9 \text{ k} \cdot \text{ft} \)

\( M = 9.1 \text{ k} \cdot \text{ft} \)
COMBINATION = 0.090 + LIVE

AXIAL FORCES

MAX AXIAL

TP CHORD (3½"x1½") : 13.3 k (c)
Bot CHORD (3½"x7") : 13.3 k (T)
0.194in x VELOCITY (3½", 60) : 10.0 k (c)

(3½"x7½") : 11.4 k (c)
**RIDGE TRUSS ANALYSIS**

**Top Cargo Load**

**Calculate Ridge Load**

\[ L_{Ridge} = (13.3)^2 + (11)^2 \]  
\[ = 18.2' \]

\[ TL = 16 \text{ psf} \left( \frac{13.2'}{11'} \right) + 50 \text{ psf} = 69.2 \text{ psf} \]

\[ R_{Ridge} = \frac{69.2 \text{ psf} (11')}{2^2/1000} = 0.381 \% \]

**Bottom Cargo Load**

\[ \frac{11'(0.5)(15 \text{ psf})}{1000} = 0.083 \]

\[ S = 50 \text{ psf} \]

\[ D = 16 \text{ psf} \]

\[ D = 15 \text{ psf} \]

**F.F. (0)**

\[ 2'-3" \]

\[ T.O. W.W. \]

\[ 2'-0" \]

\[ 11'-0" \]

\[ 11'-0" \]
1105-033 SOLAR DECATHLON

Team Massachusetts

Published 08/11/11

LOADING (psf)
TCCL 93.0
TCCL 25.0
BCCL 0.0
BCCL 10.0

SPACING
5-5-11

CSI
TC 0.48
BC 0.07
Wis 1.00

DEFL
Vert(TL) -0.29 10-11 >199 240
Vert(TL) -0.53 10-11 >195 180
Horz(TL) 0.16 8 n/a n/a

LUMBER
TOP CHORD Nordic 24F 3.5" x 14"
BOT CHORD Nordic 24F 3.5" x 7.5"
WEBS Nordic 24F 3.5" x 3.5" except
6-8: 2X4 Nordic 24F 3.5" x 7.5"

REACTANTS (lb/lst)
13=138770.7-4 (min.) 13=138770.7-4 (min.)
Max Uplift 10=1862(LG)(3); 6=1862(LG)(3)

FORCES (lb)
TOP CHORD 1=13=1187396, 1.2=6984, 8=1545332510, 3.4=2193882386, 4.6=194582511, 5.6=1281441718, 7.8=718295, 7.8=18712391
BOT CHORD 1=13=11859703, 1.2=6984, 8=1545332510, 3.4=2193882386, 4.6=194582511, 5.6=1281441718, 7.8=718295, 7.8=18712391
WEBS 1=13=11859703, 1.2=6984, 8=1545332510, 3.4=2193882386, 4.6=194582511, 5.6=1281441718, 7.8=718295, 7.8=18712391

BRACING
TOP CHORD 2=0-0 ac purlins (6=6-0 max.), except end verticals
BOT CHORD Brace at joint 10 and 12
Attatch 4x4 lateral brace with (2)
3/8 x 8 lag screws through truss
bottom chord and into end grain of 4x4 brace.

NOTES
1) 3/4" bolts (ASTM A 307) shall be placed in maximum 13/16" and minimum 25/32" distance holes. Holes shall be accurately aligned in main members and side plates. Bolts shall not be forcibly driven. All bolts shall have a full nut with full thread contact.
2) Do not over-tighten bolts. Tighten bolts to snug fit plus quarter turn maximum.
3) Weld: ASCE 7-05; 120mph; TCCL 6.0; BCCL 6.0; 120; Cat II; Exp C; enclosed; MWFRS (low-rise). Lumber DCL=1.60 plate grip DCL=1.80
4) Provide mechanical connection (by others) of truss to bearing plate capable of withstanding 1062 lb uplift at joint 13 and 1062 lb uplift at joint 8.
5) This truss is designed in accordance with the 2009 International Building Code.
6) 3/4" bolts shall be spaced at 3" o.c. in a row.
End distance shall be 5.25" from center line of fast bolt to end of member.
1/4" plate shall be a minimum of 2.5" wide. Plate and shall be 1.25" from center line of last bolt. Center line of bolts in the top chord and bottom chord shall be 3.75 up from the bottom edge of the top and bottom chords. Center line of bolts in all webs and end verticals shall be center line of the members.
1/4" thick steel gusset plates are drawn to scale.
A = 40"^2 \\
\sin \theta \cdot \frac{1.2 \, k (\text{wind})}{40} = 30 \, \text{psf} \Rightarrow \\
P_c = 951 \, \text{psf} \quad \frac{30}{951} = 0.0315 \\
M = 14.4 \, \text{k"} \\
S = 66.7 \, \text{in}^2 \quad \frac{F_b}{216} = 216 \, \text{psf} \\
F_b = 2112 \, \text{psf} \\
\frac{216}{2112} = 0.102 \quad \frac{0.0315 + 0.102}{0.0315} = 0.0327
\[ \frac{V_{bot}}{4''} = 19.4 \text{kips} \]

\[ \frac{V_{bot}}{4''} = 18 \text{kips} \]

\[ V_{wall} = 1.2 \text{kips (O.A.)} = 4.0 \text{kips} \]

Load 1: Bending Z
\[
\text{\# of rafters needed} = \frac{M}{M_a} = \frac{9.60}{9.27} = 1.04
\]

Load 1: Bending Z
## Nordic

**Model #:** Solar Decathlon  
**Job Number:** 1106-033

<table>
<thead>
<tr>
<th>Page #</th>
<th>Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Index</td>
</tr>
<tr>
<td>2</td>
<td>Worst Case Loading for Wall I-Joist</td>
</tr>
<tr>
<td>3</td>
<td>11-7/8&quot; NI-40x I-Joist Calculation for Worst Case</td>
</tr>
<tr>
<td>4</td>
<td>Wind Load Supplement</td>
</tr>
<tr>
<td>5</td>
<td>Snow Load Supplement</td>
</tr>
</tbody>
</table>

Index 1106-033
Appendix
Check Footing-bearing

Interior Footing:

Column size = 8.4 k
\[ \frac{4.2 k \times 2}{2k} = 4.2 \text{ ft} \]

Min. floor size = \[ \frac{4.2}{2k} \] = 2.10 sq ft

Exterior Footing:

\[ R = 9.2 k + 3.6 k = 7.0 k \]

Min. floor size = \[ \frac{7.0}{2k} \] = 3.55 sq ft

21.0 sq ft
### Wind Load (Method 1)

<table>
<thead>
<tr>
<th>Basic Wind Speed</th>
<th>$V_{ss}$</th>
<th>110 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance Factor</td>
<td>$I$</td>
<td>1</td>
</tr>
<tr>
<td>Exposure Category</td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>

#### Case A

<table>
<thead>
<tr>
<th>Case</th>
<th>Formula</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$3'\times 9'\times 21.6 lb\times 7'=$</td>
<td>408.24 lb</td>
</tr>
<tr>
<td>B</td>
<td>$3'\times 4.5'\times 14.8 lb\times 7'=$</td>
<td>139.86 lb</td>
</tr>
<tr>
<td>C</td>
<td>$39'\times 4.5'\times 17.2 lb\times 7'=$</td>
<td>2113.02 lb</td>
</tr>
<tr>
<td>D</td>
<td>$39'\times 9'\times 11.8 lb\times 7'=$</td>
<td>2899.26 lb</td>
</tr>
<tr>
<td>E</td>
<td>$3'\times 11'\times 1.7 lb\times 7'=$</td>
<td>39.27 lb</td>
</tr>
<tr>
<td>F</td>
<td>$3'\times 11'\times 13.1 lb\times 7'=$</td>
<td>-302.61 lb</td>
</tr>
<tr>
<td>G</td>
<td>$39'\times 11'\times 0.6 lb\times 0.7=$</td>
<td>180.18 lb</td>
</tr>
<tr>
<td>H</td>
<td>$39'\times 11'\times 11.3 lb\times 0.7=$</td>
<td>-3393.39 lb</td>
</tr>
</tbody>
</table>
## Footings

<table>
<thead>
<tr>
<th>Footing Type</th>
<th>(corner) Wall 1</th>
<th>2.75 ft x 11.5 ft x 14.57 psf= 460.7763</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(corner) Wall 2</td>
<td>3.4 ft x 8 ft x 14.57 psf= 396.304</td>
</tr>
<tr>
<td>2'x2'</td>
<td>Floor</td>
<td>2.75 ft x 3.4 ft x 114.0 psf= 1066.087</td>
</tr>
<tr>
<td></td>
<td>Roof Dead</td>
<td>3.45 ft x 3.4 ft x 15.78 psf= 185.0403</td>
</tr>
<tr>
<td></td>
<td>Roof Live</td>
<td>3.4 ft x 2.75 ft x 30 psf=</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Footing Type</th>
<th>(S and N wall) Wall</th>
<th>6.8 ft x 8 ft x 14.57 psf= 792.608</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(S and N wall) Floor</td>
<td>6.8 ft x 5.5 ft x 114 psf= 4263.6</td>
</tr>
<tr>
<td>2.5'x2.5'</td>
<td>Roof Live</td>
<td>6.8 ft x 11 ft x 30 psf= 2244</td>
</tr>
<tr>
<td></td>
<td>Roof Dead</td>
<td>6.8 ft x 13.8 ft x 15.78 psf=</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Footing Type</th>
<th>(E and W wall) Wall</th>
<th>5.5 ft x 11.5 ft x 14.57 psf= 921.5525</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(E and W wall) Floor</td>
<td>5.5 ft x 6.6 ft x 114 psf= 4138.2</td>
</tr>
<tr>
<td>2'x2'</td>
<td>Roof Live</td>
<td>5.5 ft x 6.6 ft x 30 psf=</td>
</tr>
<tr>
<td></td>
<td>Roof Dead</td>
<td>6.6 ft x 6.6 ft x 15.78 psf= 687.159</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Footing Type</th>
<th>(Center spine) Floor</th>
<th>6.9 ft x 11 ft x 114 psf= 8652.6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total for Footing Type A: 2108.208 lbs/ 4 ft = 527.052 lbf/ft²

Total for Footing Type B: 7300.208 lbs/ 6.25 ft = 1168.03328 lbf/ft²

Total for Footing Type C: 5746.912 lbs/ 6.25 ft = 919.50584 lbf/ft²

Total for Footing Type D: 8652.6 lbf/ft²/ 6.25 ft = 1384.416 lbf/ft²
### Roof Joists
- **Type**: 14" NI-40x
- **Sloped Length**: 14'
- **Slope**: 33.69 Degrees
- **Spacing**: 24"OC
- **Allowable load**: 117plf

**Roof weighs**
- 45.8 psf or 91.55 plf on joists

### Floor Joists
- **Type**: 11 7/8"NI-80
- **Span**: 10'
- **Spacing**: 24"OC
- **Allowable load**: 227plf

**Floor weighs**
- 114.0 psf or 228.04 plf on joist

### Wall Joists
- Are being calculated by Nordic
By Sections
Shell Load

<table>
<thead>
<tr>
<th>Level 2</th>
<th>Section A (Roof Section)</th>
<th>Section B (Roof Section)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (sf)</td>
<td>Flat Load (psf)</td>
</tr>
<tr>
<td>Roof</td>
<td>539.5</td>
<td>15.775</td>
</tr>
<tr>
<td>Floor</td>
<td>0</td>
<td>14.0</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>70</td>
<td>14.57</td>
</tr>
<tr>
<td>Glazing</td>
<td>4.52</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>9495.37</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Section C (Ground Section)</th>
<th>Section D (Ground Section)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (sf)</td>
<td>Flat Load (psf)</td>
</tr>
<tr>
<td>Roof</td>
<td>0</td>
<td>15.775</td>
</tr>
<tr>
<td>Floor</td>
<td>456.5</td>
<td>14.0</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>444.5</td>
<td>14.57</td>
</tr>
<tr>
<td>Glazing</td>
<td>61.51</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>12472.37</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glazing Area</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.52</td>
<td>4.84</td>
<td>25.43</td>
<td>3.85</td>
<td>8.53</td>
</tr>
<tr>
<td></td>
<td>4.84</td>
<td>20.62</td>
<td>25.43</td>
<td>9.67</td>
</tr>
<tr>
<td></td>
<td>20.62</td>
<td>165.33</td>
<td>8.53</td>
<td>3.85</td>
</tr>
</tbody>
</table>

|              | 4.52 | 61.51 | 165.33 |
### Trellis Roof

| Component          | Description                                      | Weight  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Panels</td>
<td>Sun Power</td>
<td>2.64 psf</td>
</tr>
<tr>
<td>Bracing</td>
<td>Clamps</td>
<td>2 psf</td>
</tr>
<tr>
<td>Timbers</td>
<td>Dual 2X6 Douglas Fir Timbers 8' O.C.</td>
<td>0.57 psf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.21 psf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 psf</td>
</tr>
</tbody>
</table>

| Solar Water        | 1 Sun Drum Panel                                 | 26 Pounds |

### Deck

| Component         | Description                                      | Weight  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Member</td>
<td>Pressure Treated 4X4s 4' O.C.</td>
<td>0.85 psf</td>
</tr>
<tr>
<td>Secondaries</td>
<td>Pressure Treated 2X4s 16&quot; O.C.</td>
<td>1.66 psf</td>
</tr>
<tr>
<td>Decking</td>
<td>Pressure Treated 1X4s</td>
<td>2.5 psf</td>
</tr>
<tr>
<td>Detailing</td>
<td>Douglas Fir 1X4's 4' O.C.</td>
<td>0.24 psf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.25 psf</td>
</tr>
</tbody>
</table>
### Gravity Loads

#### Roof

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofing</td>
<td>Standing Seam Metal</td>
<td>1.5</td>
</tr>
<tr>
<td>Strapping</td>
<td>2.5x3/4&quot; Fir Strapping 18&quot; O.C.</td>
<td>0.8</td>
</tr>
<tr>
<td>Sheathing</td>
<td>ZIP System 5/8&quot; OSB</td>
<td>2</td>
</tr>
<tr>
<td>Framing</td>
<td>NI-40x 14&quot; Joists</td>
<td>1.575</td>
</tr>
<tr>
<td>Insulation</td>
<td>10&quot; Fiberglass</td>
<td>1.4</td>
</tr>
<tr>
<td>Sheathing</td>
<td>5/8&quot; OSB</td>
<td>2</td>
</tr>
<tr>
<td>Chaseway framing</td>
<td>3&quot;x2&quot; Pine Strapping 18&quot; O.C.</td>
<td>1</td>
</tr>
<tr>
<td>Insulation</td>
<td>4 layers Urethane foam (w/skin)</td>
<td>2</td>
</tr>
<tr>
<td>Ceiling</td>
<td>5/8&quot; Gypsum</td>
<td>2</td>
</tr>
<tr>
<td>Incidentally</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

#### Floors

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish</td>
<td>Hardwood flooring</td>
<td>4</td>
</tr>
<tr>
<td>Subflooring</td>
<td>1/2&quot; OSB</td>
<td>1.9</td>
</tr>
<tr>
<td>Framing</td>
<td>NI-60 11 7/8&quot; Joists</td>
<td>1.5</td>
</tr>
<tr>
<td>Insulation</td>
<td>4 layers Urethane foam (w/skin)</td>
<td>2</td>
</tr>
<tr>
<td>Insulation</td>
<td>8&quot; Fiberglass</td>
<td>1.12</td>
</tr>
<tr>
<td>Sheathing</td>
<td>Zip System 5/8&quot; OSB</td>
<td>2</td>
</tr>
<tr>
<td>Incidentally</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

#### Exterior Walls

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Finish</td>
<td>8&quot; Cambia planks 1/2&quot; thick</td>
<td>2</td>
</tr>
<tr>
<td>Rain Screen</td>
<td>2x2 Strapping 24 O.C.</td>
<td>1.05</td>
</tr>
<tr>
<td>Sheathing</td>
<td>Zip System 5/8&quot; OSB</td>
<td>2</td>
</tr>
<tr>
<td>Insulation</td>
<td>4 layers Urethane foam (w/skin)</td>
<td>0.4</td>
</tr>
<tr>
<td>Insulation</td>
<td>8&quot; Fiberglass</td>
<td>1.12</td>
</tr>
<tr>
<td>Framing</td>
<td>NI-60 11 7/8&quot; Joists</td>
<td>1.5</td>
</tr>
<tr>
<td>Sheathing</td>
<td>5/8&quot; OSB</td>
<td>2</td>
</tr>
<tr>
<td>Chaseway Framing</td>
<td>3&quot;x2&quot; Pine Strapping 18&quot; O.C.</td>
<td>1</td>
</tr>
<tr>
<td>Interior Finish</td>
<td>5/8&quot; Gypsum</td>
<td>2</td>
</tr>
<tr>
<td>Incidentally</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

#### Interior Walls

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish</td>
<td>5/8&quot; Gypsum X 2 Sides</td>
<td>2</td>
</tr>
<tr>
<td>Framing</td>
<td>2x4 Framing</td>
<td>1.25</td>
</tr>
<tr>
<td>Incidentally</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

#### Incidentally

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Load (psf)</th>
</tr>
</thead>
</table>

**Gravity Loads (Continued)**
ASCE 7-05 SNOW LOADS

Snow Loads for Hip and Gable Roofs

Flat Roof Snow Load (Ps):
\[ Pf = 0.7(Ce)(Ct)(I)(pg) \] (psf)

- **Exposure Factor (Ce):** 1.0
- **Thermal Factor (Ct):** 1.0
- **Importance Factor (I):** 1.0
- **Ground Snow Load (pg):** 50.0

Table 7-2 ASCE 7-05 page 82
Table 7-3 ASCE 7-05 page 83
Table 7-4 ASCE 7-05 page 83

Horizontal Distance Eave to Ridge (W): 11.0 feet
Roof Surface type: 1. ASCE 7-05 Section 7.4 page 81
Enter Roof Slope: 8/12
Roof Slope in degrees: 33.7°

\[ Pf = 63.0 \] psf

Section 7.3 and 7.3.4 minimums page 81

Sloped-Roof Snow Loads (Ps):
\[ Ps = (Ce)(PF) \] (psf)

- **Roof Slope Factor (Ce):** 0.90774031

Sloped Roof Snow Load \( Ps = 57.2 \) psf

Figure 7-8 page 89
Figure 7-9 page 89

Unbalanced Snow Load: 1.5ps Ce for roof slope <= 5 degrees
1.5ps Ce for roof slope > 5 degrees and < 70 degrees
Each Building slope <=20 ft in width

Unbalanced Snow Load for \( W <= 20 = 90.0 \) psf Rafter System Only

Note: unbalanced snow loads need not be considered for slope > 70 degrees or slope < larger of 2.38 degrees and 70W + 0.5

NA = Not Applicable

Unbalanced Snow Load for All Other Roofs or Rafters > 20 ft.

Windward unbalanced load = 17.2 psf

Leeward Drift unbalanced load = 109.1 psf for 8.6 ft. from ridge

Leeward unbalanced load = 57.2 psf from 8.6 to 11.0 from ridge
# Basic Wind Load Design Criteria

**Client:** Nordic  
**Client's SN:** Solar Decathlon  
**JOB NUMBER:** 1106-033

<table>
<thead>
<tr>
<th>Roof Slope</th>
<th>3</th>
<th>H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>120</td>
<td>MPH (3 sec. Gust)</td>
</tr>
<tr>
<td>Exposure</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Mean Roof Height</td>
<td>16.0</td>
<td>ft</td>
</tr>
<tr>
<td>1st Floor Mean Wall Height</td>
<td>16.0</td>
<td>ft</td>
</tr>
<tr>
<td>Topographical Factor Kz</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Importance Factor I</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

ASCE 7-05 Simplified Design Procedure Method 1  
Enclosed Building Internal Pressure Coefficient Gopi = +/-0.18  
Positive loads act towards the surface and negative loads act away from the surface  

**MWFRS Design Pressures (Net):**

### Horizontal Roof Pressures
- End zone of Roof (B): 21.3 psf  
- Interior zone of Roof (D): 16.9 psf

### Vertical Roof Pressures
- End zone of Windward (E): 12.0 psf  
- End zone of Leeward (F): -18.9 psf  
- Interior zone of Windward (G): 10.4 psf  
- Interior zone of Leeward (H): -18.6 psf

### 1st Floor Horizontal Pressure
- End zone of Wall (A): 31.1 psf  
- Interior zone of Wall (C): 24.7 psf

### Design Load Pressures

<table>
<thead>
<tr>
<th>Component</th>
<th>Design Load (psf) af = 10</th>
<th>Design Load (psf) af = 20</th>
<th>Design Load (psf) af = 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Interior (1)</td>
<td>28.7 -31.3 psf</td>
<td>27.8 -28.8 psf</td>
<td>26.8 -27.8 psf</td>
</tr>
<tr>
<td>Roof Edge (2)</td>
<td>28.7 -36.7 psf</td>
<td>27.8 -36.1 psf</td>
<td>26.9 -32.9 psf</td>
</tr>
<tr>
<td>Roof Corner (3)</td>
<td>28.7 -36.7 psf</td>
<td>27.8 -36.1 psf</td>
<td>26.9 -32.9 psf</td>
</tr>
<tr>
<td>Overhang Edge (2)</td>
<td>-53.1 psf</td>
<td>-51.5 psf</td>
<td>-49.4 psf</td>
</tr>
<tr>
<td>Overhang Corner (3)</td>
<td>-53.1 psf</td>
<td>-51.5 psf</td>
<td>-49.4 psf</td>
</tr>
</tbody>
</table>

### 1st Floor Wall Pressures
- Wall Interior (4): 31.3 -34.0 psf  
- Wall Corner (5): 31.3 -42.0 psf

### Roof Gable Wall Pressures
- Wall Interior (4): 31.3 -34.0 psf  
- Wall Corner (5): 31.3 -42.0 psf
I-Joist used as beam-column

**Member 11-796 NI-40x**

**Loading**

- $W_{pd} = 9,000$ psf
- $W_{qr} = 14.8$ psf
- Axial load $= 2400$ lbs
- $F_r = 1200$ psi
- $F_a = 1800$ psi
- $F_e = 600$ psi
- $E = 17000000$ psi
- $S_{pd} = 281000$ psfl

**Dimensioning**

- Bending (Span Length)
  - $L = 91$ in
  - $l = 0.01$ in
  - $l_{ef} = 0.020$ in
  - $R_{p} = 0.05$ OK

- $P_{min} = 1000$ psi
- $P_{max} = 1900$ psi
- $P_{ay} = 1900$ psi
- $P_{ay} = 0$ psi
- $M_{p} = 16019.85$ in•lbs
- $M_{pl} = 45120$ in•lbs

**Shear**

- $V_{min} = 0$ lbs
- $V_{max} = 0$ lbs
- $V_{pl} = 1400$ lbs

**Deflection**

- $A_{p} = 0.056$ in
- $A_{y} = 0.000$ in
- $A_{y} = 0.000$ in

**Compression**

- $P = 1800$ lbs
- $P_{pl} = 45120$ lbs

**Tension**

- $F_{pl} = 1200$ psi
- $F_{pl} = 1200$ psi
- $F_{pl} = 1200$ psi

**Bending and Axial Compression**

- $F_{pl} = 4.52E+12$ OK
- $F_{pl} = 4.52E+12$ OK
- $F_{pl} = 4.52E+12$ OK

**Required $F_{op}$ Bearing Capacity = 473 psi**
Solar Decathlon Loading - Worst Case

Wind → 120 mph; Exposure C
Snow → 90 psf ground snow load
Roof dead → 20 psf

Rafter Exterior Bearing Wall Load
\[
(90 + 20) \left( \frac{11.33 \text{ ft}}{2} \right) = 623 \text{ psf}
\]

Wall Pressure = 31.1 psf

For a 9' - 1/2" Opening

Axial load = \[
(623 \text{ psf}) \left( \frac{9.396}{2} \right) = 3550 \text{ lbs}
\]

Bending = \[
(31.1 \text{ psf}) \left( 9.396 + 2 \right) = 177.3 \text{ psf}
\]
Truss Calculations

Job Truss Type Qty

Ply

1106-033 SOLAR DECATHLON RG1 FLAT 1

1

P.E. Robbins, Inc., Victoria, IL 61485

7.220 e Dec 29 2009 MiTek Industries, Inc.

Wed Jul 06 23:22:47 2011 Page 1 4-7-4

9-3-12 18-3-6 27-3-0 33-10-4 40-10-4

9-3-12 11-11-10 11-11-10 8-7-4 7-0-0

LOADING(psf) TCLL TCDL BCLL BCDL

90.0 25.0 0.0 20.0

SPACING Plates Increase Lumber

Increase Rep Stress Incr Code 5-5-11

1:1.5:1.5 NO IBC2009/TP2007

CSI TC BC WB (Matrix)

0.17 0.48 1.00

DEFL Vent(LL) in -0.29 -0.53 0.16

Vent(TL) (loc) 10-11

Horz(TL) 11-10-11

l/def >99 >91

Lrd 240 180 n/a

PLATES Weight: 1140 lb GRIP

BRACING

TOP CHORD Nordic 24F 3.5" x 14" TOP CHORD 2-0-0 oc purlins (6-0-0 max.), except end verticals [P] BOT CHORD Nordic 24F 3.5" x 7.5", WEBS Nordic 24F 3.5" x 3.5" except BOT CHORD Braces at joints 10 and 12

6-8: 2X4 Nordic 24F 3.5" x 7.5"

REATIONS (lb/size)

13=14988/0-7-4 (min. 0-3-8), 8=14988/0-7-4 (min. 0-3-8) Max

Up tbl=12=1529(LC 3), 8=1529(LC 3)

FORCES (lb) - Maximum Compression/Maximum Tension TOP CHORD 1-13=1150/195, 1-2=850, 2-3=16695/1682, 3-4=23606/2411, 4-5=21055/2148, 5-6=13558/1381, 6-7=94/5, 7-8=1908/319 BOT CHORD 12-13=1004/9340, 11-12=1682/16695, 10-11=2411/23606, 9-10=2148/21055, 8-9=1381/13558 WEBS 2-13=16273/1768, 3-12=8976/824, 3-11=897/8512, 5-10=92735, 6-8=18486/1888, 4-10=3142/324, 4-11=10477/1073, 2-12=1150/12472, 4-11=4049/824
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Top Chord
Description: Tension Check
Description: 
Member #: Solar Decathlon
Job: 106-033
Member Axially Loaded in Tension: yes
Load Factors
Load Duration (C_d) = 1.00
Repetitive Member Factor C_r = 1.00
Incised? no
COV_e 0.25
DEFLECTION LIMIT = L/240
SPAN LENGTH BENDING MEMBER: 108 IN
DISTANCE BETWEEN LATERAL SUPPORT ON BREADTH EDGE b (lb)= 108 IN (enter 0.001 for continuous support)
DISTANCE BETWEEN LATERAL SUPPORT ON DEPTH EDGE d (lb)= 24 IN (enter 0.001 for continuous support)
Beam Stability Factor C_s overrides: no Yes; C_s = 1.0 see note
Bearing Member 2 x 4 #2 SYP
Bearing member F_a (psi) 565

Member Properties

<table>
<thead>
<tr>
<th>F_a (psi)</th>
<th>F_c (psi)</th>
<th>F_v (psi)</th>
<th>F_w (psi)</th>
<th>F_d (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>590</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>14</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>5.84</td>
</tr>
</tbody>
</table>

(\(F_a, E, E_{min}\))\(C_t\) = 1
Wet service Factor C_w
(\(F_{cw}, F_w, F_{cw}, F_{cw}\))\(C_t\) = 1
\(F_{cw}, F_w, F_{cw}, F_{cw}\)\(C_t\) = 1
\(F_{cw}, C_t\) = 1

Bending Flexure
Area = 800.33
S_{x} = 114.33
M_{x max} = 83878.74
f_{p} = 734 psi
L_{ab} = 24
L_{ob} = 49

Bending Shear
\(V_x = 3106.62\) 154.10612
f_{o} = 95.96
f_v = 260 fb<Fv
\(V_y = 0\) 0
f_w = 250 fb<Fv

Deflection
Deflection = 0.000 OK
Deflection = 0.000 OK
Allowed = 0.45
Allowed = 0.45

Column
Axial Load (lb) = 2382
f_ = 48.6 psi
F_{c} = 1150

Combined Bending and Axial Tension
\(f_{c} = 49\ psi\)
\(f_{c}/F_{c} = 0.351978\ OK\)

Combined Bending and Axial Compression
\(F_c < F_{c1}\) OK
\(F_c < F_{c2}\) OK
\(F_ = F_{c} = 48.6\) OK

Bearing
Bearing member F_{a} (psi) 565 OK
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Top Chord
Description: Compression Check
Description:
Model #: Solar Decathlon
Job: 1106-033

Member: 24Fb 3 1/2" x 14"

Member Axially Loaded

7 Deflection Check Load: yes for O/C wind loads

Load Factors
Load Duration (C_D = 1.00)
K_u = 1.0
Incised? no
COV_E = 0.25

Deflection Limit = 0.24

Distance between Lateral Support on Breadth Edge (b) =
Distance between Lateral Support on Depth Edge (d) =
Beam Stability Factor C_M override: no

Bearing Member 2 x 4 #2 SYP
Bearing member F_u (psf) = 555

Member Properties
<table>
<thead>
<tr>
<th>F_u (psf)</th>
<th>F_t (psf)</th>
<th>F_y (psf)</th>
<th>F_0 (psf)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Pys</th>
<th>Effective b</th>
<th>F_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>14</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
</tr>
</tbody>
</table>

(F_b, E, E_wy) C_i = 1
(F_b, E, E_wy) C_i = 1
(F_b, E) C_i = 1.00
(F_b, E) C_i = 1.00
(F_b, E) C_i = 1.00

Bending Flexure

Area = 40
I_x = 800.33
S_x = 114.33
M_u_net = 8387.74
f_b = 734 psi
L_u = 24
L_u = 49.

Bending Shear

V_x = 3108.62
V_y = 0
f_w = 95.100612
F_y = 250

Deflection

Deflection = 0.000 OK
Deflection = 0.000 OK

Allowed = 0.45

Column

Axial Load (lb) = 23307
f_b = 475.7 psi
F_u = 1150

Combined Bending and Axial Tension

F_t = 478 psi
F_t = 1050 psi

Combined Bending and Axial Compression

F_u < F_u OK
F_t < F_u OK

Bearing

Bearing member F_u (psf) = 555
F_y = 475.7
### 2005 NDS Combined Bending and Axial Loading

**CLIENT:** Nordic  
**Description:** Bottom Chord  
**Description:** Tension Check  
**Description:**  

<table>
<thead>
<tr>
<th>Loading</th>
<th>Job: 1105-033</th>
<th>Member: 24Fb 3 1/2&quot; x 7 1/2&quot;</th>
<th>Column check = OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>W_bond=</td>
<td>4 ppi</td>
<td>Member Axially Loaded in Tension</td>
<td>Yes for C/G wind loads</td>
</tr>
<tr>
<td>W_destr=</td>
<td>0 ppi</td>
<td>Load Factors</td>
<td></td>
</tr>
<tr>
<td>Axial load</td>
<td>23307 lbs</td>
<td>Load Duration (C_G) = 1.15</td>
<td></td>
</tr>
</tbody>
</table>

**Conditions**  
Moisture Condition: Dry  
Temperature: T = 100  
Plies: 1  

**DEFLECTION LIMIT** = L/240 IN  
**Span Length Bending Member:** 490.25 IN  
**DISTANCE BETWEEN LATERAL SUPPORT ON BREADTH EDGE b (lb)=** 215.25 IN (enter 0.001 for continuous support)  
**DISTANCE BETWEEN LATERAL SUPPORT ON DEPTH EDGE d (lb)=** 215.25 IN (enter 0.001 for continuous support)  
**Beam Stability Factor C_u override:** no  
Yes; C_u = 1.0 see note  

**Bearing Member** 2 x 4 #2 SYP  
**Bearing member F_p (psl)** 565  

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>F_y (psi)</th>
<th>F_t (psi)</th>
<th>F_v (psi)</th>
<th>F_a (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective b</th>
<th>E (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24Fb 3 1/2&quot; x 7 1/2&quot;</td>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>7.5</td>
<td>7.5</td>
<td>0.9</td>
<td>1</td>
<td>7.5</td>
</tr>
</tbody>
</table>

\[
(F_y, E, E_{max}) C_t = 1  
(F_y, F_v, F_a, F_a) C_t = 1  
\]

\[
(F_y, E, E_{max}) C_t = 1.00  
(F_y, F_v, F_a, F_a) C_t = 1.00  
\]

**Bending Flexure**  
Area = 59.25  
I_x = 233.67  
I_y = 233.67  
M_x, max = 120172.531  
M_y, max = 0  
M_z, max = 0  
\[
\begin{align*}
F_{y,x}^* &= 3174.0  
F_{y,y}^* &= 140895677  
F_{x,x}^* &= 44390.57  
F_{y,y}^* &= 44390.57  
F_{x,y}^* &= 1.41E+08  
\end{align*}
\]

**Bending Shear**  
\[
\begin{align*}
V_y &= 980.5  
V_z &= 0  
F_{v,y} &= 0  
F_{v,z} &= 0  
\end{align*}
\]

**Deflection**  
\[
\begin{align*}
\text{Deflection}_{x,y} &= 0.000 \text{ OK}  
\text{Deflection}_{z,y} &= 0.000 \text{ OK}  
\end{align*}
\]

**Column**  
Axial Load (lb) = 23307  
\[
\begin{align*}
F_y &= 414.3 \text{ psi}  
F_{y,x}^* &= 1322.5  
L_{ab} &= 215.25  
L_{ab} &= 373.0  
L_{ad} &= 215.25  
L_{ad} &= 373.0  
\end{align*}
\]

**Combined Bending and Axial Tension**  
\[
\begin{align*}
f_t &= 414 \text{ psi}  
F_{y,x}^* &= 0.881819 \text{ OK}  
F_{y,y}^* &= 1207.5 \text{ psi}  
F_{y,z}^* &= 0.881819 \text{ OK}  
\end{align*}
\]

**Combined Bending and Axial Compression**  
\[
\begin{align*}
F_y < F_{d1} &= \text{OK}  
F_y < F_{d2} &= \text{OK}  
(f_y/F_{y,x})^2 + f_y/(F_{y,x} (1-(f_y/F_{y,x}))) + f_y/(F_{y,x} (1-(f_y/F_{y,x}))) + (f_y/F_{y,x})^2 = 0.64 \text{ OK}  
\end{align*}
\]

**Bearing**  
**Bearing member F_{y,x} (psi)** 565  
F_y = 414.3
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Bottom Chord
Description: Compression Check
Description: Member # 24Fb 3 1/2" x 7 1/2"
Member Axially Loaded in Compression.
Member Deflection Check Load: yes for C/C wind loads

Column check = OK

Load Factors
Load Duration (C_d) = 1.00
K_c = 1.0
Incised? no
COV_c = 0.25

Deflection Limit = L/240 = 240
IN
Span Length Bending Member: 215.25
IN
Distance between Lateral Support on Breadth Edge (b) = 215.25
IN (enter 0.001 for continuous support)
Distance between Lateral Support on Depth Edge (d) = 215.25
IN (enter 0.001 for continuous support)
Beam Stability Factor C_k override: no
Yes; C_k = 1.0 see note

Bearing Member 2 x 4 #2 SYP
Bearing member F_b (psl) 565

Member Properties
F_y (psl) F_t (psl) F_v (psl) F_w (psl) F_B (psl) F_D (psl) E (psl) b (in) d (in) c Plys Effective b E
24Fb 3 1/2" x 7 1/2" 2400 1050 250 550 1150 1.0E+10 7.5 7.5 0.9 1 7.5 5.84

W_0 = 2382 lbs

Deflection
Deflection_y = 0.000 OK
Deflection_y = 0.000 OK
Allowed = 0.896575

Axial Load (lb) = 2382
f_y = 42.3 psi
F_B* = 1150

Combined Bending and Axial Tension
f_t = 42 psi
F_T* = 1050 psi

Combined Bending and Axial Compression
F_C < F_d* OK
F_C < F_d OK
F_t < F_d OK

F_b = 42.3 psi
F_b* (psl) 565 OK
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Webs 1-13 3-12 4-11 5-10 6-9 7-8
Description: Compression Check

Member 24Fb 3 1/2" x 3 1/2"
Member Axially Loaded in: Compression
Load Factors

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>W&lt;sub&gt;net&lt;/sub&gt;</td>
<td>10 ppi</td>
</tr>
<tr>
<td>W&lt;sub&gt;dead&lt;/sub&gt;</td>
<td>0 ppi</td>
</tr>
<tr>
<td>Axial load</td>
<td>9368 lbs</td>
</tr>
<tr>
<td>Conditions</td>
<td>Moisture Condition: Dry Temperature T ≤ 100</td>
</tr>
<tr>
<td>COV&lt;sub&gt;ε&lt;/sub&gt;</td>
<td>0.10</td>
</tr>
</tbody>
</table>

DEFLECTION LIMIT = L/(4b) = 0.240
IN
Span Length Bending Member: 73
IN
Beam Stability Factor C<sub>L</sub> override: No
Yes, C<sub>L</sub> = 1.0 see note

Bearing Member 24Fb 3 1/2" x 14"
Bearing member F<sub>ub</sub> (psi) = 560

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F&lt;sub&gt;b&lt;/sub&gt;</td>
<td>2400</td>
</tr>
<tr>
<td>F&lt;sub&gt;r&lt;/sub&gt;</td>
<td>1050</td>
</tr>
<tr>
<td>F&lt;sub&gt;s&lt;/sub&gt;</td>
<td>250</td>
</tr>
<tr>
<td>F&lt;sub&gt;x&lt;/sub&gt;</td>
<td>560</td>
</tr>
<tr>
<td>F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>1150</td>
</tr>
<tr>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
<td>1.6E+10</td>
</tr>
<tr>
<td>b (in)</td>
<td>3.5</td>
</tr>
<tr>
<td>d (in)</td>
<td>3.5</td>
</tr>
<tr>
<td>c</td>
<td>0.9</td>
</tr>
<tr>
<td>Phys. Effective b</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Bending Flexure

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>12.25</td>
</tr>
<tr>
<td>S&lt;sub&gt;x&lt;/sub&gt;</td>
<td>7.16</td>
</tr>
<tr>
<td>M&lt;sub&gt;max&lt;/sub&gt;</td>
<td>6661.25</td>
</tr>
<tr>
<td>I&lt;sub&gt;y&lt;/sub&gt;</td>
<td>7.16</td>
</tr>
<tr>
<td>M&lt;sub&gt;max&lt;/sub&gt;</td>
<td>0</td>
</tr>
<tr>
<td>R&lt;sub&gt;x&lt;/sub&gt;</td>
<td>6.1</td>
</tr>
<tr>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
<td>2400.0</td>
</tr>
<tr>
<td>F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>2400</td>
</tr>
<tr>
<td>R&lt;sub&gt;y&lt;/sub&gt;</td>
<td>6.1</td>
</tr>
<tr>
<td>F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>2400</td>
</tr>
</tbody>
</table>

Bending Shear

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;x&lt;/sub&gt;</td>
<td>365</td>
</tr>
<tr>
<td>f&lt;sub&gt;u&lt;/sub&gt;</td>
<td>44.693878</td>
</tr>
<tr>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
<td>250</td>
</tr>
<tr>
<td>f&lt;sub&gt;v&lt;/sub&gt;</td>
<td>0</td>
</tr>
<tr>
<td>F&lt;sub&gt;v&lt;/sub&gt;</td>
<td>250</td>
</tr>
</tbody>
</table>

Deflection

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflection</td>
<td>0.000</td>
</tr>
<tr>
<td>Allowed</td>
<td>0.30416667</td>
</tr>
</tbody>
</table>

Column

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial Load (lb)</td>
<td>9368</td>
</tr>
<tr>
<td>I&lt;sub&gt;x&lt;/sub&gt;</td>
<td>764.7</td>
</tr>
<tr>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
<td>1150</td>
</tr>
<tr>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
<td>1.5673E+07</td>
</tr>
</tbody>
</table>

Combined Bending and Axial Tension

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F&lt;sub&gt;t&lt;/sub&gt;</td>
<td>765</td>
</tr>
<tr>
<td>F&lt;sub&gt;t&lt;/sub&gt;</td>
<td>1050</td>
</tr>
</tbody>
</table>

Combined Bending and Axial Compression

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F&lt;sub&gt;e&lt;/sub&gt;</td>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
</tr>
<tr>
<td>F&lt;sub&gt;e&lt;/sub&gt;</td>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
</tr>
<tr>
<td>F&lt;sub&gt;e&lt;/sub&gt;</td>
<td>F&lt;sub&gt;ub&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Bearing

<table>
<thead>
<tr>
<th>Member</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing member F&lt;sub&gt;ub&lt;/sub&gt; (psi)</td>
<td>560</td>
</tr>
<tr>
<td>F&lt;sub&gt;e&lt;/sub&gt;</td>
<td>764.7</td>
</tr>
</tbody>
</table>
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic  
Description: Web 1-13 3-12 4-11 5-10 6-9 7-8  
Description: Tension Check

Member: 24Fb 3 1/2" x 3 1/2"  
Member Axially Loaded in: Tension

Loading  
\( W_{net} = 9 \) psl  
\( W_{net} = 0 \) psl  
Axial load = 8163 lbs  
Repetitive Member Factor, \( C_{p} \) = 1.0

Conditions  
Moisture Condition = Dry
Temperature \( T \leq 100 \)  
COV, \( \xi \) = 0.10

Fêtes = 1  

DEFORMATION LIMIT = L/240 IN  
Span Length Bending Member: 73 IN

DISTANCE BETWEEN LATERAL SUPPORT ON BREADTH EDGE \( b \) (lb) = 73 IN (enter 0.001 for continuous support)
DISTANCE BETWEEN LATERAL SUPPORT ON DEPTH EDGE \( d \) (in) = 73 IN (enter 0.001 for continuous support)
Beam Stability Factor, \( C_{s} \) override: No  
Yes, \( C_{s} = 1.0 \) see note

Bearing Member 24Fb 3 1/2" x 14"  
Bearing member \( F_{pds} \) (psi) = 500

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>( F_{b} ) (psi)</th>
<th>( F_{c} ) (psi)</th>
<th>( F_{s} ) (psi)</th>
<th>( F_{c} ) (psi)</th>
<th>( F_{d} ) (psi)</th>
<th>( F_{e} ) (psi)</th>
<th>( E_{m} ) (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24Fb 3 1/2&quot; x 3 1/2&quot;</td>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
</tr>
</tbody>
</table>

\( (F_{b}, E, E_{min}) \) \( C_{b} \) = 1  
\( (F_{b}, F_{c}, F_{c}, F_{d}, F_{e}, E_{min}) \) \( C_{b} \) = 1  
\( (F_{b}, E, E_{min}) \) \( C_{b} \) = 1  

\( (F_{b}, F_{b}, F_{c}, F_{d}, F_{e}, C_{b}) \) = 1

\( (F_{b}, F_{e}, F_{e}, E_{min}) \) \( C_{e} \) = 1

\( (F_{b}, E, E_{min}) \) \( C_{e} \) = 1

Bending Flexure  
Area = 12.25  
\( I_{x} = 12.51 \)  
\( S_{x} = 7.15 \)  
\( M_{b, max} = 5995.125 \)  
\( f_{01} = 839 \) psi  
\( L_{ab} = 73 \)  
\( L_{ac} = 120 \)

\( I_{y} = 12.51 \)  
\( S_{y} = 7.15 \)  
\( M_{d, max} = 0 \)  
\( f_{02} = 0 \) psi  
\( L_{cf} = 73 \)  
\( L_{de} = 120 \)

\( R_{cb} = 6.1 \) OK  
\( F_{cb} = 2400.0 \)  
\( F_{cb} = 289034907 \)  
\( F_{cb} = 112097.9 \)  
\( C_{cb} = 1.0000 \)  
\( F_{cb} = 24 \)

\( R_{by} = 6.1 \) OK  
\( F_{by} = 2400 \)  
\( F_{by} = 2696E+08 \)  
\( F_{by} = 112097.9 \)  
\( C_{by} = 1.0000 \)  
\( F_{by} = 24 \)

Bending Shear  
\( V_{b} = 328.5 \)  
\( f_{0b} = 40.22449 \)  
\( F_{d}^{*} = 250 \)  
\( f_{0b} = 328.5 \)  
\( f_{0b} = 40.22449 \)  
\( F_{d}^{*} = 250 \)  
\( f_{0b} = 328.5 \)  
\( f_{0b} = 40.22449 \)  
\( F_{d}^{*} = 250 \)  
\( f_{0b} = 328.5 \)  
\( f_{0b} = 40.22449 \)  
\( F_{d}^{*} = 250 \)

Deflection  
Deflection, \( \Delta_{b} \) = 0.000 OK  
Deflection, \( \Delta_{d} \) = 0.000 OK  
Allowed = 0.30416667  
Allowed = 0.30416667

Column  
Axial Load (lb) = 8163  
\( f_{b} = 666.4 \) psi  
\( F_{d}^{*} = 1150 \)

\( L_{ab} = 73 \)  
\( L_{ac}/d = 20.85714 \) greater than 20.8571429 OK  
\( F_{d1} = 1.5679E+07 \)

\( L_{cd} = 73 \)  
\( L_{cd}/b = 20.85714 \)  
\( F_{d2} = 1.5679E+07 \)

\( F_{d} = 1.5679E+07 \)  
\( F_{d}/F_{d}^{*} = 13826.87 \)  
\( C_{d} = 0.99999966 \)  
\( F_{d}^{*} = 1149.99 \) OK

Combined Bending and Axial Tension  
\( f_{b} = 666 \) psi  
\( f_{b} F_{b} + f_{b} F_{b} + f_{b} F_{b} = 0.984206 \) OK

\( F_{1} = 1050 \) psi  
\( f_{b} F_{b} + f_{b} F_{2} + f_{b} F_{2} = 0.984206 \) OK

Combined Bending and Axial Compression  
\( F_{b} < F_{b} \) OK

\( F_{2} + F_{2} \) OK

\( f_{b} = \sqrt{(F_{2}/F_{b})^{2} + f_{b} (F_{2}/(F_{2} - (F_{2}/F_{2})) + f_{b} (F_{2} - (F_{2}/F_{2})) - (f_{b}/F_{b})^{2})} = 0.69 \) OK

Bearing  
Bearing member \( F_{pds} \) (psi) = 500  
\( F_{b} = 666.4 \)
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Webs 2-13
Description: Tension Check
Description: Model #: Solar Decathlon
Job #: 1196-033
Member #: 24Fb 3 1/2" x 3 1/2"
Member Axially Loaded in: Tension
Load Duration (Cp) = 1.15

Load Factors:
Franklin = 0 psi
Wdmax = 0 psi
Axial Load = 1746 lbs
Repetitive Member Factor Cpi = 1.00

Conditions:
Moisture Condition: Dry
Temperature T ≤ 100
Piles = 1

DEFLECTION LIMIT = L/240 IN
Span Length Bending Member: 92.8 IN

DISTANCE BETWEEN LATERAL SUPPORTS:
On Breadth Edge b (lb) = 92.8 IN (enter 0.001 for continuous support)
On Depth Edge d (lo) = 92.8 IN (enter 0.001 for continuous support)
Beam Stability Factor Cpi override: no

Beam Stability Factor Cpi:
Yes; Cpi = 1.0 see note

Bearing Member 24Fb 3 1/2" x 14"
Bearing member Fy (psl) = 560

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>Fy (psi)</th>
<th>Fv (psi)</th>
<th>Fv (psi)</th>
<th>Fv (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plv</th>
<th>Effective b</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>24Fb 3 1/2&quot; x 3 1/2&quot;</td>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Fy, E, E, Em, Cpi) Cpi</th>
<th>1</th>
<th>Wet service Factor Cpi</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Fy, Em, Fy, Fy, Em) Cpi</td>
<td>1</td>
<td>Cpi = 1.0</td>
</tr>
<tr>
<td>(Fy, Em, Fy, Fy, Em) Cpi</td>
<td>1</td>
<td>Cpi = 1.0</td>
</tr>
</tbody>
</table>

Bending Flexure:

Area = 12.25
Ib = 12.51
Iy = 12.51
Sx = 7.15
My, max = 0
fmin = 0 psi
Lub = 92.8
Lyd = 161


Bending Shear:

Vx = 0
Vx = 0
Vx = 0

Deflection:

Deflection = 0.000 OK
Deflection = 0.000 OK

Allowed = 0.38666667

Column:

Axial Load (lb) = 1746
Iy = 142.5 psi
Fy = 1322.5

Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi
Fy = 62.4 psi

Combined Bending and Axial Tension:

f = 143 psi
f = 1207.5 psi

Combined Bending and Axial Compression:

Fv < Fv,1 OK
Fv < Fv,2 OK
Fv < Fv,3 OK
f < f,1 OK
f < f,2 OK

Bearing:

Bearing member Fy (psl) = 560
Fy = 142.5
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Webs 2-13
Description: Compression Check
Description:
Model #: Solar Decathlon
Job: 1006-033
Member: 24Fb 3 1/2" x 3 1/2"
Member Axially Loaded in: Compression
Deflection Check Load: no for O/C wind loads
Column check = OK
Load Factors
Load Duration (C2) = 1.15
Ku = 1.0
Cp = 0.10
Incised? no

DEFLECTION LIMIT = L/240
IN
Span Length Bending Member: 92.8
DISTANCE BETWEEN LATERAL SUPPORT ON BREADTH EDGE b (lb)= 92.8
DISTANCE BETWEEN LATERAL SUPPORT ON DEPTH EDGE d (lb)= 92.8
Beam Stability Factor Cx override: no Yes; Cx = 1.0 see note

Bearing Member 24Fb 3 1/2" x 14"
Bearing member Fpy (psl) 560

Member Properties

<table>
<thead>
<tr>
<th>Fb (psi)</th>
<th>Fc (psi)</th>
<th>Fy (psi)</th>
<th>Fc (psi)</th>
<th>Fy (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective b</th>
<th>Fpy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>580</td>
<td>1150</td>
<td>1.0E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>8.29</td>
</tr>
</tbody>
</table>

W = 1

(E, Emax) Cx = 1.00

Bending Flexure

Area = 12.25
Sl = 12.51
Sx = 7.15

Mx,x = 0
fbd = 0
Lx = 92.6
Ly = 161


Bending Shear

Vx = 0
Vy = 0

Deflection

Deflection= 0.000 OK
Deflectiony= 0.000 OK
ALLOWED = 0.38666667
ALLOWED = 0.38666667

Column

Axial Load (lb) = 15891
fbd = 1297.2

Fy* = 1322.5

F = 9.6986E+06
F = 9.6986E+06

Combined Bending and Axial Tension

Ft = 1207 psi

Ft* = 1074306 OK

Combined Bending and Axial Compression

\[ \frac{F_c}{F_{ct1}} = 0.96 \]

Bearing

Fb = 1297.2
**2005 NDS Combined Bending and Axial Loading**

**CLIENT:** Nordic  
**Description:** Web2-12  
**Description:** Tension Check  
**Description:**  

**Model #:** Solar Decathlon  
**Job:** 1006-033  
**Member:** 24Fb 3 1/2" x 3 1/2"  
**Member Axially Loaded In:** Tension  
**Member check = OK**  
**Load Factors**  
**Load Duration (C_{pl}) = 1.00**  
**Repetitive Member Factor C_{r} = 1.00**  

**Conditions**  
**Moisture Condition:** Dry  
**Temperature T ≤ 100**  
**Plies = 1**  
**COV_{f} 0.25**  

**DEFLECTION LIMIT = L/400** IN  
**Span Length Bending Member:** 91.1 IN  
**Distance between lateral support on breadth edge d (lb)=** 91.1 IN (enter 0.0001 for continuous support)  
**Distance between lateral support on depth edge d (lb)=** 91.1 IN (enter 0.0001 for continuous support)  

**Beam Stability Factor C_{L} override = no** Yes; C_{L} = 1.0 see note  

**Bearing Member 24Fb 3 1/2" x 14"**  
**Bearing member F_{pb} (psi) = 560**

**Member Properties**  
<table>
<thead>
<tr>
<th>F_{b} (psi)</th>
<th>F_{t} (psi)</th>
<th>F_{v} (psi)</th>
<th>F_{c} (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective b</th>
<th>F'_{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>590</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Bending Flexure**  
**Area = 12.25**  
**I_{b} = 12.51**  
**I_{x} = 12.51**  
**M_{b,x,max} = 0**  

**F_{b} = 2400.0**  
**F_{v} = 154401433**  
**F_{c} = 64333.93**  
**C_{b} = 1.0000**  
**F'_{b} = 24.0**

**Bending Shear**  
**V_{b} = 0**  
**V_{v} = 0**  

**Deflection**  
**Deflection_{p} = 0.000 OK**  
**Deflection_{v} = 0.000 OK**  

**Column**  
**Axial Load (lb) = 12391**  
**F_{p} = 1031.1 psi**  
**F'_{p} = 1160**  
**F_{c} = 7.0917E+06**  
**F_{c}' = 7.0917E+06**  
**F_{c}' = 99998378**  
**F_{c}' = 1149.98** OK

**Combined Bending and Axial Tension**  
**F_{t} = 1031 psi**  
**F'_{t} = 1050 psi**  

**Combined Bending and Axial Compression**  

**Bearing**  
**F_{pb} (psi) = 560 OK**  
**F_{c} = 1031.1**
## 2005 NDS Combined Bending and Axial Loading

**Member:** 24Fb 3 1/2" x 3 1/2"

**Member Axially Loaded:** Compression

**Deflection Check Load:** no for C/C wind loads

**Column check:** OK

### Loading

- **W_{ext}:** 0 pli
- **W_{int}:** 0 pli
- **Axial load:** 1175 lbs

### Conditions

- **Moisture Condition:** Dry
- **Temperature:** T ≤ 100
- **Plies:** 1

### DEFLECTION LIMIT = L/240

- **IN**
- **Span Length Bending Member:** 91.1 IN
- **Distance between lateral support on breadth edge:** b (b) = 91.1 IN
- **Distance between lateral support on depth edge:** d (d) = 91.1 IN
- **Beam Stability Factor C_{u} override:** no
- **Yes; C_{u} = 1.0** see note

### Bearing Member

- **24Fb 3 1/2" x 14"**
- **Bearing member F_{b} (psi):** 560

### Member Properties

<table>
<thead>
<tr>
<th>F_b (psi)</th>
<th>F_t (psi)</th>
<th>F_s (psi)</th>
<th>F_e (psi)</th>
<th>F_p (psi)</th>
<th>F_s (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Pys</th>
<th>Effective b</th>
<th>E_b</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>5.84</td>
<td></td>
</tr>
</tbody>
</table>

### Bending Flexure

- **Area:** 12.25
- **Sx:** 7.16
- **M_{b,max} = 0**
- **f_{s1} = 0** psi
- **L_{vb} = 91.1**
- **L_{vb} = 158**
- **R_{bx} = 6.7** OK
- **F_{bx} = 2400.0**
- **F_{bx} = 154401433**
- **F_{bx}/F_{bx} = 64333.93**
- **C_{bx} = 1.0000**
- **F_{bx} = 24**

### Bending Shear

- **V_s = 0**
- **V_p = 0**
- **F_{s1} = 250** f_{vb}<F_{vb'} OK
- **F_{s1} = 250** f_{vb}<F_{vb'} OK

### Deflection

- **Deflection_{u} = 0.000 OK**
- **Deflection_{u} = 0.000 OK**

### Column

- **Axial Load (lb):** 1175
- **F_{c} = 95.9** psi
- **F_{c} = 1150**

### Combined Bending and Axial Tension

- **f_{i} = 90** psi
- **F_{i} = 1050** psi

### Combined Bending and Axial Compression

- **F_{s} < F_{c1} OK**
- **F_{s} < F_{c2} OK**
- **F_{s} < F_{c1} OK**
- **F_{s} < F_{c2} OK**
- **F_{c} = 95.0** OK

### Bearing

- **Bearing member F_{b} (psi):** 560 OK
2005 NDS Combined Bending and Axial Loading

**CLIENT:** Nordic
**Description:** Webs 3-11 4-10
**Description:** Compression Check

**Model:** Solar Decathlon
**Member:** 24Fb 3 1/2" x 3 1/2"
**Member Axially Loaded In:** Compression
**Deflection Check Load:** no for C/C wind loads
**Column check = OK**

<table>
<thead>
<tr>
<th>Load Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Duration (C) = 1.00</td>
<td></td>
</tr>
<tr>
<td>Repetitive Member Factor C = 1.00</td>
<td></td>
</tr>
<tr>
<td>Incised? no</td>
<td></td>
</tr>
<tr>
<td>COVc = 0.25</td>
<td></td>
</tr>
</tbody>
</table>

**DEFLECTION LIMIT = L/240 IN**

**Spans Length Bending Member:** 130.2 IN
**Distance Between Lateral Support on Breadth Edge (b) =** 130.2 IN (enter 0.001 for continuous support)
**Distance Between Lateral Support on Depth Edge (d) =** 130.2 IN (enter 0.001 for continuous support)

**Beam Stability Factor Cb override:** no
**Yes; Cb = 1.0 see note**

**Bearing Member 24Fb 3 1/2" x 4"**
**Bearing member Fyb (psi) = 560**

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>Fb (psi)</th>
<th>Fy (psi)</th>
<th>Fv (psi)</th>
<th>Fv (psi)</th>
<th>Fv (psi)</th>
<th>Fv (psi)</th>
<th>Fv (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective b</th>
<th>E (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24Fb 3 1/2&quot; x 3 1/2&quot;</td>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>5.44</td>
<td>8.6</td>
<td>8.6</td>
</tr>
<tr>
<td>(Fb, Fy, Fv) C1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Fy, Fv, Fy, Fy) C1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Fb, Fy, Fv) C1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Fb, Fy, Fv) C1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Bending Flexure**

<table>
<thead>
<tr>
<th>Area = 12.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>lx = 12.51</td>
</tr>
<tr>
<td>lxy = 12.51</td>
</tr>
<tr>
<td>Rx = 8.0</td>
</tr>
<tr>
<td>Ry = 8.0</td>
</tr>
</tbody>
</table>

**Bending Shear**

| Vx = 0 |
|Vy = 0 |

**Deflection**

| Deflection = 0.000 OK |
| Deflection = 0.000 OK |

**Allowed = 0.5425**

<table>
<thead>
<tr>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial Load (lb) = 3175</td>
</tr>
<tr>
<td>fy = 259.2 psi</td>
</tr>
<tr>
<td>Fy* = 1160</td>
</tr>
<tr>
<td>Lw = 130.2</td>
</tr>
<tr>
<td>Lw/d = 37.2</td>
</tr>
<tr>
<td>lex = 37.2 OK</td>
</tr>
<tr>
<td>lex/b = 37.2</td>
</tr>
<tr>
<td>Fe = 3.47E+06</td>
</tr>
<tr>
<td>Fe / Fy* = 3019.036</td>
</tr>
<tr>
<td>Cb = 0.999998877</td>
</tr>
<tr>
<td>Fy* = 1149.98 OK</td>
</tr>
</tbody>
</table>

**Combined Bending and Axial Tension**

| f_t = 295 psi |
| R_t* = 1050 psi |

**Combined Bending and Axial Compression**

| Fy < Fy* OK |
| Fy < Fy* OK |
| Fe < Fe* OK |

| \( \left( Fy \right)^2 + \frac{f_t}{Fy} \left[ 1 - \left( \frac{f_t}{Fy} \right) \right] + \frac{f_t}{Fe} \left[ 1 - \left( \frac{f_t}{Fe} \right) \right] - \left( \frac{f_t}{Fe} \right)^2 \) = 0.05 OK |

**Bearing**

| Bearing member Fyb (psi) = 560 OK |
| Fy = 259.2 |

P. E. Robbins, Inc.
1777 State Route 167
Victoria IL 61485
Tel: 309-879-3258
www.perobbins.com
### 2005 NDS Combined Bending and Axial Loading

**CLIENT:** Nordic  
**Description:** Webs 3-11 4-10  
**Description:** Tension Check  
**Description:** Model #: Solar Decathlon  
**Job:** 1106-033  
**Member:** 24FB 3 1/2" x 3 1/2"  
**Member Axially Loaded In:** Tension  
**Member Axially Loaded In:**  
**Load Factors:**  
**Load Duration (C_{ld}) = 1.00**  
**Repetitive Member Factor C_{r} = 1.00**  
**K_{l} = 1.0**  
**Incised? no**  
**COV_{f} = 0.25**  
**Column check = OK**  

**DEFORMATION LIMIT = L / 240**  
**IN**  
**Span Length Bending Member:** 130.2  
**DISTANCE BETWEEN LATERAL SUPPORT ON BREADTH EDGE b (lb) =** 130.2  
**DISTANCE BETWEEN LATERAL SUPPORT ON DEPTH EDGE d (lb) =** 130.2  
**Beam Stability Factor C_{b} override:** no  
**Yes; C_{b} = 1.0 see note**  
**Bearing Member 24FB 3 1/2" x 14"**  
**Bearing member F_{p} (psf) = 560**

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>F_{b} (psf)</th>
<th>F_{t} (psf)</th>
<th>F_{s} (psf)</th>
<th>F_{p} (psf)</th>
<th>F_{c} (psf)</th>
<th>E (psf)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective b</th>
<th>E_{p}</th>
</tr>
</thead>
<tbody>
<tr>
<td>24FB 3 1/2&quot; x 3 1/2&quot;</td>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>550</td>
<td>1150</td>
<td>1.0E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>3.6</td>
<td>5.84</td>
<td></td>
</tr>
<tr>
<td>(F_{b}, E, E_{min}) C_{t}</td>
<td>1</td>
<td>Wet service Factor C_{w}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(F_{b}, F_{t}, F_{s}, F_{p}) C_{t}</td>
<td>1</td>
<td>F_{b}</td>
<td>F_{t}</td>
<td>F_{s}</td>
<td>F_{p}</td>
<td>E and E_{min}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(E, E_{min}) C_{t}</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(F_{b}, F_{t}, F_{s}, F_{p}) C_{t}</td>
<td>1.00</td>
<td>C_{t}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(F_{b}, F_{t}, F_{s}, F_{p}) C_{t}</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bending Flexure**

| Area = 12.25 |
| bx = 12.51 (Sx = 7.15) |
| by = 12.51 (Sy = 7.15) |
| R_{bx} = 8.0 OK |
| R_{by} = 8.0 OK |

| V_{a} = 0 |
| V_{b} = 0 |

**Deflection**

| Deflection_{a} = 0.000 OK |
| Deflection_{b} = 0.000 OK |

| Allowed = 0.5425 |

**Column**

| Axial Load (lb) = 8536 |
| L_{ax} = 130.2 |
| L_{ax}/d = 37.2 |
| F_{e} = 3.47E+06 |
| F_{e}/F_{c} = 30.035 |

| Combined Bending and Axial Tension |
| f_{t} = 697 psi |
| R_{t} = 1050 psi |

| Combined Bending and Axial Compression |
| F_{c} < F_{c1} OK |
| F_{c} < F_{c2} OK |
| f_{t} < F_{t} OK |

| Bearing |
| Bearing member F_{p} (psf) = 560 OK |
## 2005 NDS Combined Bending and Axial Loading

### CLIENT: Nordic
### Description: Webs 5-9
### Description: Tension Check

**Model #: Solar Decathlon**

**Job #: 1106-033**

**Loading**
- $W_{out}$ = 0 lbs
- $W_{draft}$ = 0 lbs

**Axial load** = 1102 lbs

**Conditions**
- Moisture Condition: Dry
- Temperature: $T \leq 100$
- Piles = 1

**Member:** 24Fb 3 1/2" x 3 1/2"  
**Member Axially Loaded in:** Tension  
**Load Factors**
- Deflection Check Load: no
- Load Duration ($C_d$) = 1.00
- Incised? no
- COV$^2$ = 0.25

**Column check = OK**

**DEFORMATION LIMIT = L/240**

**Span Length Bending Member:** 110.5 in

**Distance Between Lateral Support:**
- On Breadth Edge = 110.5 in (enter 0.001 for continuous support)
- On Depth Edge = 110.5 in (enter 0.001 for continuous support)

**Beam Stability Factor ($C_v$):**
- No
- Yes: $C_v = 1.0$ see note

**Bearing Member:** 24Fb 3 1/2" x 14"  
**Bearing member $F_{up}$ (psi):** 560

### Member Properties

<table>
<thead>
<tr>
<th>$F_b$ (psi)</th>
<th>$F_{c1}$ (psi)</th>
<th>$F_{c2}$ (psi)</th>
<th>$F_{c3}$ (psi)</th>
<th>$F_{c4}$ (psi)</th>
<th>$F_e$ (psi)</th>
<th>$E$ (psi)</th>
<th>$b$ (in)</th>
<th>$d$ (in)</th>
<th>$c$</th>
<th>Plys</th>
<th>Effective $b$</th>
<th>Effective $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>240</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>5.84</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$C_t$</th>
<th>Wet service Factor $C_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Beam Stability Factor ($C_s$):**
- 1.00

**Bending Shear**

<table>
<thead>
<tr>
<th>$V_x$</th>
<th>$V_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Deflection**

<table>
<thead>
<tr>
<th>Deflection$_x$</th>
<th>0.000</th>
<th>OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflection$_y$</td>
<td>0.000</td>
<td>OK</td>
</tr>
</tbody>
</table>

**Column**

<table>
<thead>
<tr>
<th>Axial Load (lb)</th>
<th>1102</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_b$</td>
<td>90.0 psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>$F_b$ (psi)</th>
<th>$F_{c1}$ (psi)</th>
<th>$F_{c2}$ (psi)</th>
<th>$F_{c3}$ (psi)</th>
<th>$F_{c4}$ (psi)</th>
<th>$F_e$ (psi)</th>
<th>$E$ (psi)</th>
<th>$b$ (in)</th>
<th>$d$ (in)</th>
<th>$c$</th>
<th>Plys</th>
<th>Effective $b$</th>
<th>Effective $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>240</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>5.84</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bending Flexure**

<table>
<thead>
<tr>
<th>$I_{bx}$</th>
<th>$S_x$</th>
<th>$M_{b, max}$</th>
<th>$f_{x, b}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.25</td>
<td>7.16</td>
<td>0</td>
<td>0 psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$I_{by}$</th>
<th>$S_y$</th>
<th>$M_{b, max}$</th>
<th>$f_{y, b}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.25</td>
<td>7.16</td>
<td>0</td>
<td>0 psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$R_{bx}$</th>
<th>$F_{bx}$</th>
<th>2400.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{by}$</td>
<td>$F_{by}$</td>
<td>2400</td>
</tr>
</tbody>
</table>

**Deflection**

<table>
<thead>
<tr>
<th>Deflection$_x$</th>
<th>0.000</th>
<th>OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflection$_y$</td>
<td>0.000</td>
<td>OK</td>
</tr>
</tbody>
</table>

**Combined Bending and Axial Tension**

<table>
<thead>
<tr>
<th>$f_1$</th>
<th>$f_2$</th>
<th>$f_3$</th>
<th>$f_4$</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Combined Bending and Axial Compressive Stress $f_{c1}$</th>
<th>OK</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Combined Bending and Axial Compressive Stress $f_{c2}$</th>
<th>OK</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Combined Bending and Axial Compressive Stress $f_{c3}$</th>
<th>OK</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Combined Bending and Axial Compressive Stress $f_{c4}$</th>
<th>OK</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bearing member $F_{up}$ (psi)</th>
<th>560</th>
<th>OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_e$</td>
<td>90.0</td>
<td></td>
</tr>
</tbody>
</table>
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Webs 5-9
Description: Compression Check
Description:

Model #: Solar Decathlon Job: 1106-033
Member Axially Loaded in Compression

- Column check = OK

Load Factors
- Load Duration (C_D) = 1.00

Member: 24Fb 3 1/2" x 3 1/2"
- Column = OK

Moisture Condition Dry
- Conditions

Temperature T ≤ 100
- Temperature

Plies = 1
- Plies

DEFLECTION LIMIT = L/240 IN
- Deflection

Bearing Member 24Fb 3 1/2" x 14"
- Bearing Member

<table>
<thead>
<tr>
<th>Member Properties</th>
<th>F_b (psi)</th>
<th>F_c (psi)</th>
<th>F_y (psi)</th>
<th>F_z (psi)</th>
<th>F_p (psi)</th>
<th>F_y (psi)</th>
<th>F_z (psi)</th>
<th>E (psi)</th>
<th>b (in)</th>
<th>d (in)</th>
<th>c</th>
<th>Plys</th>
<th>Effective b (in)</th>
<th>Effective d (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24Fb 3 1/2&quot; x 3 1/2&quot;</td>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>590</td>
<td>1150</td>
<td>1.6E+10</td>
<td>3.5</td>
<td>3.5</td>
<td>0.9</td>
<td>1</td>
<td>3.5</td>
<td>5.84</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Bending Flexure

- Area = 12.25
- Sx = 7.15
- My = 7.15
- Mx_max = 0
- fy = 0
- fy = 0
- fy = 0
- fy = 0

Bearing Shear

- V_x = 0
- V_y = 0
- V_z = 0
- V_y = 0
- V_z = 0

Deflection

- Deflection = 0.000 OK
- Deflection = 0.000 OK

Column

- Axial Load (lb) = 10840
- l_c = 884.9 psi
- P_c = 1150

Combined Bending and Axial Tension

- f_b = 885 psi
- f_y = 1050 psi
- f_y = 1149.97 OK

Combined Bending and Axial Compression

- P_c < P_c1 OK
- P_c < P_c2 OK
- f_y < f_y1 OK
- f_y < f_y2 OK

Bearing

- Bearing member F_w (psi) = 560 OK
- F_s = 884.9
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Beams 6-8
Description: Tension Check

Model #: Solar Decathlon
Job: 1106-033

Member: 24Fb 3 1/2" x 7 1/2"
Member Axially Loaded: Yes
Loading
\[ W_{\text{net}} = 0 \, \text{psf} \]
\[ W_{\text{axl}} = 0 \, \text{psf} \]
Axial load = 1840 lbs

Load Factors
\[ K_y = 1.0 \]

Deflection Check Load: no
for C/C wind loads

Column check = OK

DEFORMATION LIMIT = L/240

Span Length Bending Member: 110.5 IN
Distance Between Lateral Support on Breadth Edge \( b \): 110.5 IN
Distance Between Lateral Support on Depth Edge \( d \): 110.5 IN

Beam Stability Factor \( C_y \) overide: no
Yes; \( C_y = 1.0 \) sea note

Bearing Member 24Fb 3 1/2" x 14"
Bearing member \( F_{b, y} \) (psi) = 560

Member Properties
\[
\begin{align*}
F_b & \text{(psi)} & F_t & \text{(psi)} & F_y & \text{(psi)} & F_s & \text{(psi)} & F_p & \text{(psi)} & F_c & \text{(psi)} & E & \text{psi} & b_1 & \text{(in)} & d_1 & \text{(in)} & c & \text{Psi} & \text{Effective b} & \text{E} \text{psi} \\
24Fb 3 1/2" x 7 1/2" & 2400 & 1050 & 250 & 560 & 1150 & 1.6E+10 & 3.5 & 7.5 & 0.9 & 1 & & 1 & & & 3.5 & 5.64 \\
\end{align*}
\]

 remar: \( (F_b, E, E_{min}) C_1 = 1 \)
Wet service Factor \( C_d \)

\[
\begin{align*}
(F_b, F_t, F_y, F_s, F_p) C_1 & = 1.00 \\
(F_b, F_t, F_y, F_s) C_1 & = 1.00 \\
(F_b, F_t) C_1 & = 1.00 \\
\end{align*}
\]

Bending Flexure

Area = 28.25
\[
\begin{align*}
I_x & = 123.05 \\
I_y & = 20.80 \\
M_{y, \text{max}} & = 0 \\
M_{x, \text{max}} & = 0 \\
F_{b, y} & = 2400.0 \\
F_{b, x} & = 56541134 \\
F_{b, x}/F_{b, y} & = 23858.81 \\
C_{b, y} & = 1.0000 \\
F_{b, y} & = 2400.0 \\
\end{align*}
\]

Bending Shear

\[
\begin{align*}
V_{b, y} & = 0 \\
V_{b, x} & = 0 \\
F_{b, y} & = 250 \quad \text{ivb<Fvb'} \quad \text{OK} \\
F_{b, x} & = 250 \quad \text{ivd<Fvd} \quad \text{OK} \\
\end{align*}
\]

Deflection

\[
\begin{align*}
\text{Deflection}_{b, y} & = 0.000 \quad \text{OK} \\
\text{Deflection}_{b, x} & = 0.000 \quad \text{OK} \\
\end{align*}
\]

Column

Axial Load (lb) = 1840
\[ f_y = 70.1 \, \text{psi} \]
\[ F_{c, y} = 1150 \]

\[
\begin{align*}
L_{\text{ub}} & = 110.5 \\
L_{\text{ub}}/d & = 14.73333 \quad \text{greater than 31.574286} \quad \text{OK} \\
L_{\text{ub}} & = 110.5 \\
L_{\text{ub}}/b & = 31.57143 \\
F_{c, y} & = 4.82E+08 \\
F_{c, y}/F_{c, x} & = 4191.462 \\
C_s & = 0.99997614 \\
F_{c, y} & = 1149.97 \quad \text{OK} \\
\end{align*}
\]

Combined Bending and Axial Tension

\[
\begin{align*}
\tau' & = 0.066757 \quad \text{OK} \\
\end{align*}
\]

Combined Bending and Axial Compression

\[
\begin{align*}
F_{b, y} & < F_{c, y} \quad \text{OK} \\
F_{b, x} & < F_{c, x} \quad \text{OK} \\
F_{b, x}/F_{b, y} & = 0.066757 \quad \text{OK} \\
\end{align*}
\]

Bearing

Bearin member \( F_{b, y} \) (psi) = 560
\[ F_{b, y} = 70.1 \quad \text{OK} \]
2005 NDS Combined Bending and Axial Loading

CLIENT: Nordic
Description: Webs 6-8
Description: Compression Check
Description: Model E: Solar Decathlon
Job: 1108-033

Member: 24Fb 3 1/2" x 7 1/2"
Member Axially Loaded in: Compression
Load Factors
.7 Deflection Check Load: no for C/C wind loads
Column check = OK

Axial load = 17897 lbs
Repetitive Member Factor C_r = 1.00

K_s = 1.0
Incised? no
COV_E = 0.25

Moisture Condition: Dry
Temperature T = 100
Plies = 1

DEFLECTION LIMIT = L/240
Span Length Bending Member: 110.5
IN

DISTANCE BETWEEN LATERAL SUPPORT ON BREADTH EDGE b (lb) =
110.5 IN (enter 0.001 for continuous support)
DISTANCE BETWEEN LATERAL SUPPORT ON DEPTH EDGE d (lb) =
110.5 IN (enter 0.001 for continuous support)
Beam Stability Factor C_s over/d: yes; C_s = 1.0 see note

Bearing Member 24Fb 3 1/2" x 14"
Bearing member F_(tp) (psf) = 560

Member Properties

<table>
<thead>
<tr>
<th>F_b (psl)</th>
<th>F_t (psl)</th>
<th>F_s (psl)</th>
<th>F_w (psl)</th>
<th>F_r (psl)</th>
<th>F_e (psl)</th>
<th>F_p</th>
<th>F_s</th>
<th>E and F_min</th>
</tr>
</thead>
<tbody>
<tr>
<td>2400</td>
<td>1050</td>
<td>250</td>
<td>560</td>
<td>1150</td>
<td>1.0E+10</td>
<td>3.5</td>
<td>7.5</td>
<td>0.9</td>
</tr>
</tbody>
</table>

F_b = (F_p, E, F_min) C_t
F_t = F_s = F_v
F_w = F_p
F_e = E and F_min

(Wet service Factor C_d)


Beam Bending

Area = 26.25
I_x = 123.05
I_y = 26.90
M_x,max = 14.7333
f_b = 0 psf
f_d = 0 psf
L_ab = 110.5
L_db = 202

R_x = 11.1
R_y = 3.6
F_x,y = 2400.0
F_x,y = 5.56E+08
C_x,y = 23558.81
C_x,y = 1.0000

Bending Shear

V_x = 0
V_y = 0
V_x = 0
V_y = 0
F_x,y = 250
F_x,y = 250
f_v = f_v
 OK

Deflection

Deflection_x = 0.000 OK
Deflection_y = 0.000 OK

Allowed = 0.46041667

Column
Axial Load (lb) = 17897
F_b = 881.8 psf
F_x = 1150
L_ab = 110.5
L_db = greater than 31.5714286
OK
F_x,y = 2.2133E+07

F_x = 4.92E+06
F_x,y = 4.92E+06
C_y = 0.99697614
F_y = 1419.46

Combined Bending and Axial Tension
f_t = 682 psf
F_x,y = 0.649324 OK
F_x,y = 0.649324 OK

Combined Bending and Axial Compression
F_b = F_x,y OK
F_x,y = F_x,y
F_x,y = F_x,y
F_x,y = F_x,y
F_x,y = F_x,y

Bearing
Bearing member F_(tp) (psf) = 560
F_b = 881.8
## Detailed Water Budget

<table>
<thead>
<tr>
<th>Function</th>
<th>Events</th>
<th>Gallons per Event</th>
<th>Water Used (Gallons)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water Draws</td>
<td>16</td>
<td>20</td>
<td>320</td>
<td>15 gallon requirement plus 5 gals extra for “warm up”, if necessary, to reach 110 F</td>
</tr>
<tr>
<td>Water Vaporization</td>
<td>5</td>
<td>0.75</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>3 gallons per use from Manufacturer's Specifications</td>
</tr>
<tr>
<td>Laundry Washer</td>
<td>8</td>
<td>11</td>
<td>88</td>
<td>11 gallons per use from Manufacturer's Specifications</td>
</tr>
<tr>
<td>Hot Water Storage Tanks</td>
<td>1</td>
<td>135</td>
<td>135</td>
<td>80 gallon Solar Thermal Tank, 50 gallon Backup Tank, and Circulation line</td>
</tr>
<tr>
<td>Initial System Fill</td>
<td>1</td>
<td>45</td>
<td>45</td>
<td>Initial water system bleed and pipe fill</td>
</tr>
<tr>
<td>Irrigation</td>
<td>15</td>
<td>5</td>
<td>75</td>
<td>5 gallons per day for 15 days, for flowers</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>N/A</td>
<td>N/A</td>
<td>500</td>
<td>Sprinkler system discharge</td>
</tr>
<tr>
<td>Testing</td>
<td>N/A</td>
<td>N/A</td>
<td>100</td>
<td>Testing of domestic hot water system prior to start</td>
</tr>
<tr>
<td>Safety Factor</td>
<td>N/A</td>
<td>N/A</td>
<td>193</td>
<td>15% of total water use</td>
</tr>
<tr>
<td>Water Required</td>
<td></td>
<td></td>
<td>1479</td>
<td>Total water used over Decathlon Competition</td>
</tr>
</tbody>
</table>
Summary of Unlisted Electrical Components

We have no unlisted electrical components. All electrical components carry an approved testing agency’s listing per section 6-7 of the SD2011 Building Code.
Summary of Reconfigurable Features

Storage Wall

The storage walls are effortlessly slid into the hallway expanding the dining and living rooms to provide more flexibility for the family. They are offset from each other, allowing them to be in the open position simultaneously or one at a time. The walls are connected to a track along a truss, which carries a portion of the load. There are also casters along the bottom of the wall, which run along a minimal steel track in the floor and carry the majority of the load. The storage walls are engineered to slide along the track safely and effortlessly.

For the public tours, the house will be configured in its primary layout, however, we will demonstrate the movable components to the jurors during their guided tour. The west storage wall will be moved to expand the dining room for the dinner party and allow the table and chairs to be reconfigured to comfortably seat eight. For movie night the east storage wall will be moved to the open position allowing the living room furniture to be reconfigured.

REF: DRAWING: A-603 MOVABLE COMPONENT DIAGRAM

Operable External Blinds

The windows on the south, east and west facades of the 4Dhome are all shaded by exterior horizontal blinds. These products are all commercially available and produced by Hella. The blinds are operated by electronic controls from the interior of the house allowing the user to control the tilt angle and total window coverage. They can be used to mitigate both solar heat gain and daylight.

The blinds will be used in the competition to supplement the passive cooling strategy for the 4dhome. During peak cooling load hours, the blinds will be used to reduce the solar heat gain coefficient of the respective glazing they are covering. The blinds will be retracted as necessary to optimize passive cooling throughout the day.

At night the blinds will be fully retracted to allow views to the interior from outside. During juried walkthroughs the full spectrum of configurations will be demonstrated.
Interconnection Application Form

Team Massachusetts, Lot 401

### PV Systems

<table>
<thead>
<tr>
<th>Module Manufacturer</th>
<th>Short Description of Array</th>
<th>DC Rating of Array</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUNPOWER</td>
<td>Twenty-eight E-19/240 modules; arranged in two arrays, each array having two strings of seven panels each.</td>
<td>6720 W [28 panels rated 240 W]</td>
</tr>
</tbody>
</table>

Total DC power of all arrays is \(6.7\) kW (in tenths)

### INVERTERS

<table>
<thead>
<tr>
<th>Inverter Manufacturer</th>
<th>Model Number</th>
<th>Voltage</th>
<th>Rating (kVA or KW)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLECTRIA</td>
<td>PVI 4000</td>
<td>240 VAC</td>
<td>4.0 KW</td>
<td>2</td>
</tr>
</tbody>
</table>

Total AC power of all inverters is \(8\) kW (in whole numbers)
<table>
<thead>
<tr>
<th>Tag</th>
<th>Components</th>
<th>No.</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PV Module</td>
<td>28</td>
<td>Sunpower</td>
<td>E19 / 240</td>
<td>4 Strings of 7 Modules Per String</td>
</tr>
<tr>
<td>2</td>
<td>Combiner Box</td>
<td>2</td>
<td>Wiley Electronics</td>
<td>ACE-2P</td>
<td>NEMA 3R Enclosure</td>
</tr>
<tr>
<td>3</td>
<td>DC Disconnect</td>
<td>2</td>
<td>Square D</td>
<td>HU362RB</td>
<td>3-Pole Unfused, 60A, 600VDC, NEMA 3R Enclosure, 200kA Max Short Circuit Rating</td>
</tr>
<tr>
<td>4</td>
<td>DC/AC Inverter</td>
<td>2</td>
<td>Solectria</td>
<td>PVI 4000</td>
<td>Not Capable of Back-Feeding Currents, NEMA 4/IP 65 Enclosure</td>
</tr>
<tr>
<td>5</td>
<td>Aux Load Center</td>
<td>1</td>
<td>Square D</td>
<td>QO612L100RB</td>
<td>100A Main Lug Load Center, Outdoor Rated, 1Ø 120/240VAC 3W, 12 Circuits 6 Spaces, 10 KA Max Short Circuit Rating</td>
</tr>
<tr>
<td>6</td>
<td>Meter</td>
<td>1</td>
<td>GE</td>
<td>I-210+C</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Main Load Center</td>
<td>1</td>
<td>Square D</td>
<td>HOM1632L200TC</td>
<td>240V, 200A, 1 Phase, 16 Sp, 10 KA Max Short Circuit Rating</td>
</tr>
<tr>
<td>8</td>
<td>Meter</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>Organizer Supplied Meter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description or Conductor Type</th>
<th>Conductor Gauge</th>
<th>#/Color of Conductors</th>
<th>Conduit Type</th>
<th>Conduit Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USE-2</td>
<td>10 AWG</td>
<td>4/Black, 4/Black W/White Terminal Markings</td>
<td>Free Air</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>EQUIP. GROUNDING CONDUCTOR (EGC)</td>
<td>10 AWG</td>
<td>1/Bare CU</td>
<td>Free Air</td>
<td>N/A</td>
</tr>
<tr>
<td>2 &amp; 3</td>
<td>THWN-2</td>
<td>10 AWG</td>
<td>1/Black, 1/White Per Conduit</td>
<td>2/EMT</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td></td>
<td>INSULATED EGC</td>
<td>10 AWG</td>
<td>1/Green Per Conduit</td>
<td></td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>4</td>
<td>THWN-2</td>
<td>10 AWG</td>
<td>2/Red, 2/Black, 2/White Per Conduit</td>
<td>2/EMT</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td></td>
<td>INSULATED EGC</td>
<td>10 AWG</td>
<td>1/Green Per Conduit</td>
<td></td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>5</td>
<td>THWN-2</td>
<td>4 AWG</td>
<td>1/Black, 1/Red, 1/White</td>
<td>EMT</td>
<td>1.5&quot;</td>
</tr>
<tr>
<td></td>
<td>INSULATED EGC</td>
<td>10 AWG</td>
<td>1 Bare CU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>GROUNDING ELECTRODE CONDUCTOR (GEC)</td>
<td>4 AWG</td>
<td>1 Bare CU</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>THWN-2</td>
<td>2/0 AWG</td>
<td>2/Black, 1/White</td>
<td>1/EMT</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>
### LOAD CALCULATIONS

<table>
<thead>
<tr>
<th>REFERENCES</th>
<th>LOAD</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>220.82 (B) (1)</td>
<td>GENERAL LIGHTING LOAD (3 VA/SQ FT*945 SQ FT)</td>
<td>2835</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (2)</td>
<td>TWO 20 AMP SMALL APPLIANCE CIRCUIT (2X1500)</td>
<td>3000</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (2)</td>
<td>LAUNDRY CIRCUIT</td>
<td>1500</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>REFRIGERATOR</td>
<td>1800</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>COOK TOP</td>
<td>7700</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>COOKTOP HOOD</td>
<td>240</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>DISHWASHER</td>
<td>1800</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>MICROWAVE</td>
<td>1800</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>HRV</td>
<td>96</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>AIR SOURCE HOT WATER HEATER</td>
<td>1440</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>50 GAL HOT WATER TANK</td>
<td>6000</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>DEHUMIDIFIER</td>
<td>624</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>WATER SUPPLY PUMP</td>
<td>1500</td>
<td>VA</td>
</tr>
<tr>
<td>220.82 (B) (3)</td>
<td>DRYER</td>
<td>5000</td>
<td>VA</td>
</tr>
</tbody>
</table>

**TOTAL, GENERAL LOAD:**

- **FIRST 10KVA AT 100%**
  - 10000 VA
- **REMAINDER AT 40% (0.4*25335)**
  - 10134 VA

**SUBTOTAL GENERAL LOAD**

- 20134 VA

**220.82 (C) (2) MR. SLIM HEAT PUMP (AIR CONDITIONING)**

- **TOTAL:**
  - 21634 VA

**CALCULATED LOAD FOR SERVICE:** (TOTAL/240V)

- 90 A

**DECATHLON GRID SERVICE & HOUSE LOAD CENTER MAIN BREAKER**

- 150 A

**TOTAL AMPACITY FOR PV INVERTER CIRCUITS (2*25)**

- 50 A

**TOTAL AMPACITY OF CIRCUITS SUPPLYING POWER TO LOAD CENTER**

- 200 A

**MAIN LOAD CENTER RATING**

- 200 A

**690.64 (B) (2) ALLOWABLE AMPACITY FOR CIRCUITS SUPPLYING POWER (1.2*200)**

- 240 A

*Therefore, Decathlon Grid Service supplies enough current to meet load requirement (90< 150A), and total of input circuits is less than 120% of load center capacity (150+50 < 240)*
### NEUTRAL LOAD CALCULATIONS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENERAL LIGHTING LOAD (3VA/ft²)</td>
<td>2835</td>
<td>VA</td>
</tr>
<tr>
<td>20 AMP SMALL BRANCH CIRCUIT (2X1500)</td>
<td>3000</td>
<td>VA</td>
</tr>
<tr>
<td>Sub Total</td>
<td>5835</td>
<td>VA</td>
</tr>
<tr>
<td>3000 VA @ 100%</td>
<td>3000</td>
<td>VA</td>
</tr>
<tr>
<td>5835VA - 3000VA = 2835 @ 35%</td>
<td>992.3</td>
<td>VA</td>
</tr>
<tr>
<td>Sub Total</td>
<td>3992</td>
<td>VA</td>
</tr>
<tr>
<td>Microwave and cooktop 9740 VA X 70% for neutral load</td>
<td>6818</td>
<td>VA</td>
</tr>
<tr>
<td>Clothes washer dryer 5000 VA X 70%</td>
<td>3500</td>
<td>VA</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1800</td>
<td>VA</td>
</tr>
<tr>
<td>Sub total</td>
<td>12118</td>
<td>VA</td>
</tr>
<tr>
<td>Total Load</td>
<td>16110</td>
<td>VA</td>
</tr>
<tr>
<td>Calculated for neutral = 16110 / 240V</td>
<td>67.13</td>
<td>A</td>
</tr>
</tbody>
</table>
Plan view of the lot showing the house, decks, ramps, tour paths and the service point
Elevation view showing the terminal box (contains the service point), meter and other service equipment

1: DC Disconnect Switches
2: Inverters
3: Conduit Trough
4: Aux Load Center
5: PV Meter
6: Organizer Meter
1. **INTRODUCTION** ........................................................................................................................................... 90

2. **ENERGY EFFICIENT DESIGN** .......................................................................................................................... 90
   2.1. *PHPP as Design Tool* .................................................................................................................................. 90
   2.2. *Thermal Bridge Analysis and PHPP* ............................................................................................................ 92
   2.3. *PHPP Results for Boston* ............................................................................................................................ 93
   2.4. *PHPP Results for Washington DC* .............................................................................................................. 93

3. **HVAC SYSTEM** ............................................................................................................................................. 93
   3.1. *Heating & Cooling* ..................................................................................................................................... 93
   3.2. *Dehumidification* ...................................................................................................................................... 93
   3.3. *Ventilation* ............................................................................................................................................... 94
   3.4. *Indoor Air Quality* ................................................................................................................................... 94

4. **SOLAR THERMAL SYSTEM** ........................................................................................................................... 94
   4.1. *Sizing the System* ....................................................................................................................................... 95
   4.2. *The SunDrum Collector* .............................................................................................................................. 97

5. **SOLAR ELECTRIC SYSTEM** ............................................................................................................................. 98
   5.1. *The Modules* .............................................................................................................................................. 98
   5.2. *The Array* ............................................................................................................................................... 98
   5.3. *Optimal Tilt Angle* ................................................................................................................................... 98
   5.4. *Electrical Load* ........................................................................................................................................... 99

6. **DYNAMIC MODEL IN SIMULINK** ................................................................................................................ 100
   6.1. *Description* ............................................................................................................................................... 100
   6.2. *Modeling Philosophy* ............................................................................................................................... 100
   6.3. *Modeling the Building Envelope* ................................................................................................................ 101
   6.4. *Modeling Moisture and CO₂* .................................................................................................................... 101
   6.5. *Modeling DHW* ......................................................................................................................................... 102
   6.7. *Modeling HVAC* ..................................................................................................................................... 102
   6.8. *Inputs* ....................................................................................................................................................... 102
   6.9. *Initial conditions* .................................................................................................................................... 106

7. **DYNAMIC MODEL RESULTS** ....................................................................................................................... 106

8. **4DHome ENERGY MONITORING** ................................................................................................................ 109
8.1. Philosophy ............................................................................................................................................... 109
8.2. Real Time Energy Monitoring .................................................................................................................. 109
8.3. Energy Usage Analysis ............................................................................................................................. 110

9. CONCLUSION ............................................................................................................................................. 111
1. INTRODUCTION

The results of the Solar Decathlon are not only a showcase of cutting edge homes designed by students, the homes are the embodiment of the ideas of the future where sustainability will help save nations from their dependence on fossil fuels and the earth from climate change. One emerging idea is Passive House, which aims in the design of a home that uses 90% less energy than a conventional home. Passive house standards were formulated at the first Earth Summit in 1992 and aim for a specific energy use equal to or less than 4.75 kBtu/ft\(^2\)/yr. This value is regarded as the most amount of energy humanity can afford to spend in each new and retrofitted home in order to maintain and save our climate.

Team Massachusetts has decided to design to Passive House standards. The design methodology leads to a final product where highly insulated walls, superior air tightness, and passive solar and internal gains allow a home to be ultra-efficient. Only after an efficient building envelope is designed, are the photovoltaics then implemented to mitigate electrical loads.

The adoption of Passive House principles has informed the 4Dhome’s building envelope to the highest degree; including window placements, wall constructions, and the mitigation of thermal bridging. The Passive House Planning Package (PHPP) has given Team Massachusetts the ability to make quick changes to the envelope design and to see the subsequent effects on an annual steady state energy balance.

To further investigate the dynamic behavior of the mechanical systems, the 4Dhome has been simulated using Matlab’s Simulink, a fully customizable graphical user interface. The dynamic model was successful in simulating the solar decathlon events, something that could not have been simulated using the PHPP. The results showed the mechanical systems in place will satisfy the 4Dhome’s needs during climate extremes and most importantly, the rigors of the Solar Decathlon Competition. The results of the PHPP analysis, the HVAC design, the active and passive systems, and the results from dynamic model are explained in the subsequent sections.

2. ENERGY EFFICIENT DESIGN

2.1. PHPP as Design Tool

The basis for all design considerations began with output from the PHPP. The results from the PHPP model are culminated together on a verification page, so as changes are made to the whole house model, the verification page can be reviewed to see whether a design change improved the overall energy balance. Figure 2.1 is a screen shot of the verification page for the 4Dhome.

Most parameters on the verification page are based on the treated floor area (TFA). In brief, the TFA is all area inside the home not including area underneath the footprint of the walls. The TFA also considers rooms with limited use like mechanical rooms to contribute only 60% of their floor area to the TFA total. The heating load and the cooling load are useful to size the mechanical systems for environmental extremes. The specific space heating and specific space cooling energy demands inform how much energy will be required to heat and cool each space on an annual basis.
The building envelope, the skin of the 4Dhome, is a very important membrane that stops heat exchange between interior and exterior environments. PHPP allows for the construction of different wall, ceiling, and floor types and then for quick implementation into the steady state model. Figure 2.2 shows an example of a wall with an 11.875” TIJ wall stud, 24” on center aside a 2.5” utility chase.

### Figure 2.1: Screen Shot of PHPP Verification

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Building Assembly Description</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gypsum Board</td>
<td>0.910</td>
</tr>
<tr>
<td>2</td>
<td>Air Space</td>
<td>0.089</td>
</tr>
<tr>
<td>3</td>
<td>Fiberglass Sprayed</td>
<td>0.002</td>
</tr>
<tr>
<td>4</td>
<td>Polyurethane Foam</td>
<td>0.590</td>
</tr>
<tr>
<td>5</td>
<td>Composite Wood</td>
<td>0.770</td>
</tr>
</tbody>
</table>

### Figure 2.2: Screen Shot of Wall Element R-Value Calculation

After the walls are modeled, the windows can be assigned to each wall with their own specific orientation, size, solar heat gain coefficients, thermal properties, and overhangs. A way PHPP informed us in glazing application was to help determine the proper amount of glazing area required on the southern façade. The current glazing area is significantly higher than the conceptual design glazing area. The area of the windows needed to be increased so the sun could passively heat the home in the winter time. The PHPP also verified that the addition of more windows would mean a larger heat loss coefficient for the entire home, thus increasing the heating and cooling demand throughout the year. Using the verification page and the windows worksheet in tandem, the window area could be optimized. This trial and error method was not only the method for weighing the energy costs of different windows and their sizes, but also helped in the design of window overhangs, wall R-values, ventilation schemes, and thermal bridges.

After the entire building envelope is constructed in the PHPP, including walls, windows, doors, and thermal bridges, the heat loss of different components of the building envelope can be interpreted. Figure 2.3 shows the percentage of heat.
loss transported through each building element. Notice the flux through the thermal bridges is negative; this means with respect to the original PHPP inputs, the thermal bridge analysis increased the accuracy of the model by eliminating redundancies in the heat loss calculations when they were made with respect to exterior dimensions.

<table>
<thead>
<tr>
<th>Group #</th>
<th>Area Group</th>
<th>Area</th>
<th>Unit</th>
<th>Average R-Value [(hr·ft²·F)/BTU]</th>
<th>H-Value: U x A [BTU/ hr·F]</th>
<th>Fraction of Transmission Heat Losses</th>
<th>Average R-Value [(hr·ft²·F)/BTU]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Treated Floor Area</td>
<td>638.6</td>
<td>ft²</td>
<td>4.3</td>
<td>6.2</td>
<td>6%</td>
<td>4.3</td>
</tr>
<tr>
<td>2</td>
<td>North Windows</td>
<td>26.7</td>
<td>ft²</td>
<td>5.6</td>
<td>8.3</td>
<td>8%</td>
<td>5.6</td>
</tr>
<tr>
<td>3</td>
<td>East Windows</td>
<td>46.3</td>
<td>ft²</td>
<td>5.7</td>
<td>33.0</td>
<td>31%</td>
<td>5.7</td>
</tr>
<tr>
<td>4</td>
<td>South Windows</td>
<td>192.4</td>
<td>ft²</td>
<td>5.2</td>
<td>7.7</td>
<td>7%</td>
<td>5.2</td>
</tr>
<tr>
<td>5</td>
<td>West Windows</td>
<td>39.8</td>
<td>ft²</td>
<td>5.6</td>
<td>19.6</td>
<td>18%</td>
<td>56.8</td>
</tr>
<tr>
<td>6</td>
<td>Exterior Wall - Ambient</td>
<td>1110.1</td>
<td>ft²</td>
<td>60.8</td>
<td>34.2</td>
<td>31%</td>
<td>56.8</td>
</tr>
<tr>
<td>7</td>
<td>Roof/Ceiling - Ambient</td>
<td>2077.2</td>
<td>ft²</td>
<td>34.2</td>
<td>-1.0</td>
<td>-1%</td>
<td>34.2</td>
</tr>
<tr>
<td>Total Thermal Bridges Ambient</td>
<td>277.8</td>
<td>ft²</td>
<td>32.2</td>
<td>108.6</td>
<td>100%</td>
<td>32.159</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.3: Screen Shot of Summary of Heat Loss through Each Building Element**

### 2.2. Thermal Bridge Analysis and PHPP

Since PHPP models the building envelope with respect to exterior dimensions, there is some redundancy and sometimes a conservative heat loss calculation at any façade intersection. THERM by Lawrence Berkeley National Laboratory was used to model thermal bridges and to calculate their UA-Value for implementation into the PHPP model. For example, Figure 2.4 shows the peak of the home during a design and development stage as it was modeled through PHPP.

First, exterior dimensions are input into the PHPP, notice Figure 2.4, block 1, there is overlap between each element; this is what PHPP first assumes because of its one dimensional data input. To further show this, the elements are split up in block 2. The red lines indicate the overlapping boundaries of the separate entities. If PHPP were to calculate the UA of the building envelope with these overlapping entities, in cases where a thermal bridge free connection was designed, would yield a conservative heat loss calculation. Using THERM, the entities are combined into one by modeling the actual construction of the roof peak. The new heat loss coefficient for the thermal bridge determined in THERM is entered in place of the overlapping entities in PHPP, resulting in a more accurate heat loss model. Using THERM method ensures a precise building heat loss coefficient, like those needed for Passive House standards.

**Figure 2.4: Eliminating Heat Loss Calculation Redundancies in PHPP with Thermal Bridge Calculations**
2.3. PHPP Results for Boston

Great results from the PHPP near the Boston location were one of the main priorities because this is where the home will eventually reside. As the verification page was shown previously, the home meets PHPP standards in Boston, pending the blower door test which will determine the final air tightness of the home. The design heating load is 5495 BTU/hr and the design cooling load is just under one third of a ton, or 3820 BTU/hr. To put the heating use into perspective for the 4Dhome, it would take an 85% efficient furnace only 18 gallons of #2 fuel oil to heat the 4Dhome for one year!

Out of the total heat required for the home, the passive solar heating and internal gains will account for 83% of the total required heat. Window overhangs, window reveals, and shading reduction factors were designed for the Boston location in order to bring the specific cooling demand within acceptable levels.

2.4. PHPP Results for Washington DC

There is not much the PHPP can reveal about the competition in Washington for the short time the 4Dhome is there, but it can shed some light onto the difference of climate in Washington. For example, the design heating load is reduced to 1329 BTU/hr and design cooling load is reduced to 3386 BTU/hr. Although the design cooling load is reduced compared to Boston, the total annual cooling demand is increased to 7.73 kBTU/ft²/yr. This indicates Boston is prone to higher climatic extremes than Washington, but Washington is a warmer location throughout the year. If the home was placed in Washington year round, 92% of the annual required heating energy would be satisfied by solar and internal gains alone. The dynamic simulation yielded the best results as to how the 4Dhome will perform in the Washington DC climate during the rigors of the competition.

3. HVAC SYSTEM

The mechanical systems have been designed to be highly efficient and to recover heat, to work seamlessly within the HVAC system as a whole while maintaining autonomy, and to provide comfort and convenience in an affordable and reliable design that will function for decades to come. Off-the-shelf components have been used which are accessible to the consumer, coupling them together in an innovative and yet simple and efficient configuration.

3.1. Heating & Cooling

The 4Dhome is heated and cooled with a highly efficient ducted heat pump. Meeting Passive House criteria has permitted the use of a small 9,000 BTU Mitsubishi unit, which is ducted to the main living space and each bedroom. In this split heat pump, a refrigerant is pumped between an outdoor and indoor unit; this fluid can absorb heat from interior air and transfer it outside (which cools the home), or can absorb heat from the outside air and transfer it inside (which heats the home). Unlike conventional electric heaters that use electricity to create heat inside the house, a heat pump uses electricity simply to transfer heat, making it much more efficient.

In addition, unlike conventional heat pumps, this unit is driven by an inverter which adjusts the compressor speed, allowing a varied output based on demand to save energy when possible. The heat pump used in the 4Dhome home transfers 2.9 times more heat energy than electricity it consumes, making it nearly 3 times more efficient than a conventional electric resistance heater.

3.2. Dehumidification

A dehumidifier is needed during hot summer months in Boston, and the Simulink energy model confirms the need for dehumidification in Washington DC in September. The 4Dhome has a 65 pint Honeywell dehumidifier ducted into the HVAC system. The dehumidifier has a dedicated return from the main living space in the hallway, and feeds into the existing main supply duct for the heat pump. With an energy factor of 2.11, this unit is one of the most efficient
residential dehumidifiers available. Because it is installed in the attic space and equipped with a drain line, the homeowner doesn’t have to empty out the condensate from a tray, or trip over a large plug-in unit sitting in the middle of a room.

### 3.3. Ventilation

A Passive House is much more airtight than the conventional home, and so mechanical ventilation is very important. The 4D Home employs a heat recovery ventilator (HRV), which ventilates stale interior air through a heat exchanger, using it to pre-heat or pre-cool the incoming fresh air. The Nu-Air HRV unit in the 4D Home is Energy Star rated and captures up to 85% of the energy from the exhausted air. It requires small 5” penetrations in the roof for the fresh air intake and exhaust, and feeds into the main supply duct to the house.

### 3.4. Indoor Air Quality

Smoke and airborne debris from cooking contribute to poor air quality in the home. In addition to ventilation, a ductless range hood with separate filtering stages for grease, odors, and smoke was chosen to filter cooking fumes before they enter the conditioned space. This allows the occupants of the home to enjoy the benefits of cooking with a range hood without creating an additional penetration in the envelope. Since the hood does not vent to the outside, there is no cost associated with conditioning the make-up air, resulting in significant energy savings when there is a large temperature difference between the outside and conditioned space.

Heating and cooling loads have been minimized by meeting Passive House criteria, which has allowed the use of small and few mechanical components. It is still crucial, however, to design the HVAC system to be highly efficient to minimize electrical consumption and remain net-zero, without adding costly PV panels to our array. The mechanical components must operate under the extreme climate conditions of the area, and work with the other HVAC equipment efficiently, to ensure comfort for the homeowner throughout all seasons.

### 4. SOLAR THERMAL SYSTEM

Capturing energy from the sun and converting it to electricity via photovoltaic panels is a very clean way to generate electrical energy. However, PV panels are currently not that efficient in converting the sun’s energy, most having efficiencies between 10-20% (ours are 19.3% efficient). A much more efficient means of capturing solar energy is through the use of solar thermal collectors, which capture the heat from the sunlight and transfer it to a fluid, which in turn can be used for any number of applications, including heating domestic hot water or space conditioning. Thermal collectors have efficiencies of 50% or higher, thus are anywhere from 3-5 times more efficient at capturing solar energy than PV panels. In previous Solar Decathlon events, several teams heated their hot water with efficient heat pumps and skipped a solar thermal system altogether. Team Massachusetts decided early on that solar thermal system technology, as a vital part of the greater solar energy industry, was too vital not to use on the 4Dhome.

For the 4Dhome, with its Passive House inspired design and super-efficient heat pump, we decided to use solar thermal for our domestic hot water (DHW). Though we could have used it for both heating and cooling the air, we decided the benefits did not outweigh the extra complication and cost.

In brief, this system uses solar thermal collectors and a heat exchanger in closed loop to pre-heat water in an 80 gallon “solar tank”. The water in the 80 gallon tank then serves as preheated inlet water for the 50 gallon “backup” tank. If needed, the water is further heated to the set temperature of 125°F by a modern, efficient electric heat pump that is mounted on top of the 50 gallon tank. An electric element in the 50 gallon tank serves as a backup heating source. See a schematic of this system in Figure 4.1.
4.1. Sizing the System

The first step in sizing any DHW system is to determine the load on the system. How much hot water will the home's residents use during a typical day? What is the possible maximum load that the system may face? "Load" can be thought of as the gallons used per day at the hot water set point temperature. Two loads had to be considered; one for just the decathlon contests, and one for the home's permanent location here in Massachusetts. For the decathlon, the load is based off the hot water draws and the dishwasher runs (Team Massachusetts plans to use cold water for clothes washing). The contest hot water load is in Table 4.1.

![Figure 4.1: Schematic of DHW](image)

<table>
<thead>
<tr>
<th>Day</th>
<th>Hot Water Draws</th>
<th>Gallons</th>
<th>Dishwasher Runs</th>
<th>Gallons</th>
<th>Total Gallons/Day</th>
<th>Liters</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
<td>30</td>
<td>1</td>
<td>2.9</td>
<td>32.9</td>
<td>124.4</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>113.4</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>30</td>
<td>1</td>
<td>2.9</td>
<td>32.9</td>
<td>124.4</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>113.4</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>56.7</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>45</td>
<td>1</td>
<td>2.9</td>
<td>47.9</td>
<td>181.1</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>30</td>
<td>1</td>
<td>2.9</td>
<td>32.9</td>
<td>124.4</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>30</td>
<td>1</td>
<td>2.9</td>
<td>32.9</td>
<td>124.4</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>240</td>
<td>5</td>
<td>14.5</td>
<td>254.5</td>
<td>962.0</td>
</tr>
</tbody>
</table>

**Table 4.1: Hot Water Contest Loads per Day for the 2011 Decathlon**

For the annual load after the home is rebuilt in Boston, the industry standard of 20 gallons per person per day, or 60 gallons per day for the three person household was used (an independent analysis resulted in a 57 gal/day load for the 4Dhome). 60 gallons per day is nearly double the average requirement for the decathlon. Therefore, our initial question was should the solar thermal system be sized to meet the higher load in Boston or the lower load for the competition. Other factors to be considered included system cost; that back-up water heater was a very efficient electric heat pump.
which itself would consume little energy; and finally, the weather conditions for the decathlon (DC in September) were much more favorable for solar hot water heating than the conditions the system would be exposed to in Boston through an entire year. The team turned to two modeling methods to help with this decision—using the publically available Retscreen and an analytical method carried out by using MathCAD. A screen shot of the analysis from Retscreen showing the use of Boston annual data, 120°F water temp, and a demand of 60 gal/day is shown in Figure 4.2.

![Figure 4.2: Screen Shot of Retscreen Modeling Software used to Calculate the Solar Fraction](image)

The second method allowed the team to take an analytical approach to the problem. Several important calculations were achieved using MathCAD, including:

- Determining the available solar energy (the monthly average (for Boston) or daily (for the decathlon) irradiation on a tilted surface
- Converting the load from gallons per day into energy required per day, calculating the energy lost through the storage tank walls, and then combining these two to determine the total energy load (per day for the decathlon, per month for Boston)
- Using the "f-chart" method where a series of equations are used to determine the solar fraction, using the same parameters for the SunDrum panels as were used in Retscreen

Table 4.2 includes the results from 9 runs in MathCAD, using the same scenarios used in Retscreen. Both models yield similar results. To reach a relatively high solar fraction in Boston (73% average), a system using eight SunDrum panels is required. However, for the much smaller load and more favorable conditions of the decathlon, only six panels would provide 94% of our DHW load. In result, the 4Dhome will be using six panels during the competition, whereby the solar thermal system should be able to supply nearly the entire contest load. The final owner of the home could always add two additional SunDrum panels for a relatively low cost during the rebuild, if they desired a higher solar fraction for their home.

*Table 4.2: Comparison of Results between Retscreen and Analytical Method*
4.2. The SunDrum Collector

Finally, the SunDrum Panels were chosen over traditional flat plat or evacuated tube collectors for their innovative hybrid technology. Unlike other solar thermal collectors which are mounted separately from a PV system, SunDrum’s panels are very thin and mount directly behind the surface of the PV modules. As a PV panel’s temperature increases from exposure to sunlight, the temperature difference between the panel and the cooler liquid flowing in planar flow inside the SunDrum panel (water for the competition, a glycol solution to prevent freezing once rebuilt in Massachusetts) causes heat to transfer from the panel to the liquid. Thus, part of the sun’s energy that would ordinarily have been wasted is captured by the hybrid panel, and used to heat DHW. A secondary effect is that the PV panel’s temperature is lowered during this process, and therefore its efficiency is increased slightly compared to an un-paired panel. Figure 4.3 shows a SunDrum panel mounted in a PV panel. The relative thinness of the panel is evident.

<table>
<thead>
<tr>
<th>Simulation Number</th>
<th>Climate Data Location</th>
<th>Duration</th>
<th>Hot Water Temperature (°F)</th>
<th>Load (gal/day)</th>
<th># of SunDrum Panels</th>
<th>Retscreen</th>
<th>Analytical</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DC</td>
<td>9 days</td>
<td>120</td>
<td>31.8</td>
<td>4</td>
<td>68%</td>
<td>82%</td>
<td>75%</td>
</tr>
<tr>
<td>2</td>
<td>DC</td>
<td>9 days</td>
<td>120</td>
<td>31.8</td>
<td>6</td>
<td>100%</td>
<td>92%</td>
<td>96%</td>
</tr>
<tr>
<td>3</td>
<td>DC</td>
<td>9 days</td>
<td>130</td>
<td>31.8</td>
<td>4</td>
<td>59%</td>
<td>75%</td>
<td>67%</td>
</tr>
<tr>
<td>4</td>
<td>DC</td>
<td>9 days</td>
<td>130</td>
<td>31.8</td>
<td>6</td>
<td>100%</td>
<td>87%</td>
<td>94%</td>
</tr>
<tr>
<td>5</td>
<td>Boston</td>
<td>year</td>
<td>120</td>
<td>60</td>
<td>4</td>
<td>29%</td>
<td>44%</td>
<td>37%</td>
</tr>
<tr>
<td>6</td>
<td>Boston</td>
<td>year</td>
<td>120</td>
<td>60</td>
<td>6</td>
<td>58%</td>
<td>59%</td>
<td>59%</td>
</tr>
<tr>
<td>7</td>
<td>Boston</td>
<td>year</td>
<td>130</td>
<td>60</td>
<td>4</td>
<td>23%</td>
<td>38%</td>
<td>31%</td>
</tr>
<tr>
<td>8</td>
<td>Boston</td>
<td>year</td>
<td>130</td>
<td>60</td>
<td>6</td>
<td>47%</td>
<td>51%</td>
<td>49%</td>
</tr>
<tr>
<td>9</td>
<td>Boston</td>
<td>year</td>
<td>130</td>
<td>60</td>
<td>8</td>
<td>82%</td>
<td>63%</td>
<td>73%</td>
</tr>
</tbody>
</table>

*Figure 4.3: SunDrum Panel Installed in its Mated PV panel*

Each panel is made of two thin sheets of sandwiched metal, a thin sheet of insulation, and a frame. In this system, there aren't cylindrical pipes underneath the PV that carry the water; it instead flows between two thin sheets of metal. These sheets have perforations that direct this planar flow along a serpentine path. The hybrid panels will have inlet and outlet pipes (PEX tubing) feeding into and from the bottom (connected to other panels in series). The inlet and outlet ports are located at the top and bottom corners. Using hybrid panels frees up more roof space for additional PV panels (if required), and captures more energy per square foot of installed panel.
5. SOLAR ELECTRIC SYSTEM

5.1. The Modules
The decision to use SunPower monocrystalline modules was based on several factors; the extremely high efficiency and competitive temperature rating of the panel, and the company’s locality. The SunPower E19/240 panels are 19.3% efficient, and have a temperature rating of over 90% (ratio of the rated power at PTC, to the rated power at STC). A module’s rating at PTC is a more accurate reflection of the real life performance of the panel than is the STC. The high efficiency of this panel is largely attributed to the use of monocrystalline material, and the all-back contact design. Because our trellis design imposes size constraints for the PV array, it is necessary to use a highly efficient panel with a large power output per area, to ensure the entire electrical load of the home is met with the particular array area available.

5.2. The Array
The photovoltaic system is sized to meet the entire annual electrical load of the 4Dhome when in Boston, Massachusetts. The main array is comprised of twenty-eight SunPower E19/240 panels, having a total DC rating of 6664 W. Because of the size of the array necessary, and the temperature conditions of Massachusetts, proper string sizing requires us to have two arrays, each having two strings of seven panels. Each array connects to a Solectria PVI 4000 string inverter. This configuration allows the user to determine if the PV system is working correctly; each array should produce an equal amount of power, so a malfunction in one array will be easily detectable. All twenty-eight panels are mounted on a south-facing trellis; the PV panels act as an overhang and provide summer shading. The trellis sits above the roof and allows for natural convective cooling of the panels.

5.3. Optimal Tilt Angle
Using an analytical method and TMY3 data, it was found the optimal PV array tilt angle for a non-shaded site in Boston, Massachusetts is 36.5 degrees. This is nearly 6 degrees less than the latitude of 42.4 degrees. Figure 5.1 shows changing the tilt angle from the optimal slope will result in a loss of electricity produced over the 30 year lifetime of the array; the farther away the array is installed from the optimal tilt angle, the losses become more significant. In the design of the 4Dhome’s roof and trellis, the optimal tilt angle was considered. Weighing aesthetics and minimal predicted losses in performance, the angle of the roof and trellis is 33 degrees. An array at 33 degrees receives 99.9% the incident energy of an array at the optimal angle.
5.4. Electrical Load

The total electrical energy use of the 4Dhome is a sum of the appliance, lighting, domestic hot water, and HVAC loads. The power usage and operation schedule of the appliances, lighting, DHW, and the air heat pump are known but the electricity demand of the HVAC system required a more detailed analysis. A dynamic model constructed in Matlab’s Simulink will aid in calculating the electrical energy use of all HVAC equipment for both Boston and the competition in Washington DC. The characteristics of the annual electrical load are in Figure 5.2 for Boston.

The predicted annual energy usage of the 4Dhome in Boston, Massachusetts is 6900 kWh. The expected annual energy production of the PV system is over 130% of this load, as predicted by PVWatts. The “extra” energy will ensure that the home will be net-zero even if the eventual owners add more loads, and will also help the home achieve success during the Decathlon Energy Balance event.
6. DYNAMIC MODEL IN SIMULINK

6.1. Description
Simulink is a mathematical modeling environment within Matlab with a block-diagram graphical user interface used to simulate dynamic systems. Simulink contains a vast library of predefined and customizable functions, or “blocks”, and offers tight integration with the rest of the Matlab environment. Simulink was the preferred modeling environment because of its robustness and accessibility, which allowed accurate and fully customizable simulations of the 4Dhome’s energy systems during a Solar Decathlon competition period.

The primary goals of the Simulink modeling effort were to verify initial HVAC equipment sizing calculations and develop a tool for simulating various energy related design considerations in competition scenarios.

6.2. Modeling Philosophy
The transport of energy in any home is incredibly complex. Many simplifications must be made to simulate the energy performance of a home in a practical fashion. For the purposes of this model, many energy interactions did not need to be considered. The energy systems that were simulated were building envelope, moisture and carbon dioxide concentration inside the home, PV, DHW, solar thermal, and HVAC systems. Figure 6.1 shows a flow chart of these various systems and their interactions.

Since the competition schedule is known, it was possible to build an input load schedule. These loads represent thermal, moisture and CO₂ concentration gains to the living space of the house that are then used as inputs for the model.

TMY data was used for all ambient conditions. Because of the statistical nature of TMY data it was important to use a wide range of data to establish meaningful results. Competition performance was simulated using various TMY data sets to gain insight into the typical performance variations.

Figure 5.2: Annual Electrical Load for the 4Dhome in Boston

![Annual Electrical Loads]

- Heat Pump: 38%
- DHW: 23%
- Lighting: 8%
- Appliances: 13%
- Dehumidifier: 18%
- Lighting: 8%
- Appliances: 13%
- Dehumidifier: 18%
6.3. Modeling the Building Envelope

Equations describing the flow of energy in the home and DHW system were cast into state space representations for ease of modeling. The equations (1st order, ODEs) describe the change in state (temperature) in a particular “thermal zone” with respect to time, as a function of the other states and inputs. The state space formulation provides a convenient scheme for representing coupled systems, implementing controlled and uncontrolled inputs, and computing relevant outputs. Certain inputs (such as a variable mass flow rates) result in mildly non-linear systems. This was dealt with by recasting the state space equations within the simulation for changes in such inputs, as they were infrequent. With initial conditions and environmental inputs, the temperature of each thermal zone can be determined through time integration of the state space equations. The home is represented by six coupled nodes and is shown in Figure 6.2 in the form of a thermal network model. The house model uses ambient temperature and heat gains to the mechanical room and living space as inputs, and then outputs the temperature at each node over the simulation period.

<table>
<thead>
<tr>
<th>Node</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air in the Mechanical Room</td>
</tr>
<tr>
<td>2</td>
<td>Air in the Living Space</td>
</tr>
<tr>
<td>3</td>
<td>Thermal Mass in Mechanical Room</td>
</tr>
<tr>
<td>4</td>
<td>Thermal Mass in Living Space</td>
</tr>
<tr>
<td>5</td>
<td>Thermal Mass in Exterior Wall/Floor/Ceiling of Mechanical Room</td>
</tr>
<tr>
<td>6</td>
<td>Thermal Mass of Exterior Wall/Floor/Ceiling of Living Space</td>
</tr>
</tbody>
</table>

6.4. Modeling Moisture and CO₂

Simplified moisture and CO₂ concentration models were used. Air infiltration and HRV ventilation provide mechanisms for moisture and CO₂ exchange through the building envelope. Moisture is also produced within the house from occupants, appliances and equipment. Saturation pressure data was embedded in the model to compute relative humidity. The only source of CO₂ production in the house is the occupants. The CO₂ concentration in the home is a good indicator of the overall air quality and is used to control the operation of the HRV.
6.5. Modeling DHW

The tank temperatures in the DHW system were simulated with a state space model. The tanks are exposed to the air in the mechanical room, causing them to lose heat to the home. The DHW model outputs the temperatures of the tanks, the heat given to the mechanical room from the tanks, and the heat removed from the air by the heat pump.

6.6. Modeling Solar

A modified Hottel-Whillier model was used to model the SunDrum hybrid solar-thermal panels, which extends the conventional thermal analysis of flat plate solar water collector to include a coupled PV panel. This extended model by Florshuetz allows the use of the usual parameters of the conventional Hottel-Whillier model, such as the collector heat removal factor and heat loss factor and modify them with factors that describe the PV reference efficiency and the decrease in PV efficiency with temperature.

Therefore, the Hottel-Whillier equations can be used for useful thermal output, simply by replacing the parameters with the modified parameters for a hybrid system. Then the useful electrical output of the PV panels that are coupled with SunDrum’s hybrid panels can be found by subtracting the useful thermal energy and the overall thermal loss of the system from the total solar energy collected by the surface. The electrical energy produced by the remaining 22 PV panels that are not coupled with hybrid collectors was then simply summed and de-rated according to the system efficiency.

6.7. Modeling HVAC

Heat Pump – The output of the mini-split heat pump is modeled with a tuned PID controller, designed to simulate the unit in cooling mode. The system rise time, settling time, and overshoot were calibrated within Simulink with a built in PID tuner. The set point temperature for the heat pump controller is 23°C.

HRV – The HRV is modeled in its nominal mode of operation and is controlled by a CO₂ sensor located in the living space. The HRV set point is 300ppm higher than the ambient concentration. The HRV facilitates the exchange of air between the home and the environment. When the HRV switches on, the CO₂ concentration in the home falls towards the ambient concentration. The HRV turns off when the concentration in the home is within 10% of the ambient concentration.

Dehumidifier – The electric dehumidifier is modeled in its nominal mode of operation and is controlled by a relative humidity (RH) sensor located in the living space. The dehumidifier operates independently and is not coupled to any other HVAC equipment. The dehumidifier turns on when the RH in the living space reaches 60% and off when it reaches 40%.

6.8. Inputs

The competition schedule was used to tabulate the following sets of scheduled inputs for the model at 15 minute intervals:

Electrical Draws - Includes electrical draws from appliances and lighting, [W]
Heat Gains - Includes heat gains associated with scheduled electrical usage and occupants, [W]
Moisture Gains - Includes moisture gains associated with occupant perspiration, appliances (cooktop and dishwasher), and shower use, [kg/hr]
CO₂ - Includes CO₂ gains from scheduled number of occupants at a “low” activity level, [g/hr]
DHW Draw - Includes DHW draws from the shower and dishwasher, [L/hr]
Doors - Includes schedule of door states [open, closed] used to determine natural air exchange rate with the environment.

TMY data (hourly intervals) - TMY3 data was used to for atmospheric conditions. Information on temperature, humidity, and irradiation were pre-processed for our needs and used as inputs to the model. Because of the random nature of the data and relatively short duration of the competition, the house model was simulated with several different TMY3 data sets, from various locations and time frames surrounding the competition site and duration.

The following Figures, 6.3 through 6.8, show various inputs to this dynamic model, both TMY data and scheduled inputs.

![Figure 6.3: Use of TMY Temperature Data Surrounding Competition Period](image)

![Figure 6.4: Use of TMY Relative Humidity Data Surrounding Competition Period](image)
Figure 6.4: Use of TMY Relative Humidity Data Surrounding Competition Period

Figure 6.5: A Predicted Schedule of Incident Irradiation

Figure 6.6: A Predicted Schedule of Internal Heat Gains during Competition Period
Figure 6.7: A Predicted Schedule of Electric Demand during Competition Period

Figure 6.8: A Predicted Schedule of Intermittent Hot Water Draws during Competition Period
6.9. Initial conditions

The model’s initial conditions were simply set to be within their controlled ranges. This was preferred to simulating pre-competition days for ease of modeling and post processing. Both approaches showed negligible differences in predicted performance.

**House** - All house zone temperatures are initially set to 23°C.

**DHW** – The backup tank is initially set to 55°C.

**CO₂** – The initial CO₂ concentration in the house is the average ambient concentration of about 550 ppm (by mass).

**RH** – The initial relative humidity inside the home is about 55%.

7. DYNAMIC MODEL RESULTS

For the purposes of this section, a “typical” sample simulation was used to generate data and figures to be analyzed in detail. The time frame corresponding to September 13rd through 21st from the Reagan Intl TMY3 data was used because it allowed us to use a more conservative estimation of irradiance.

The results show the temperature and relative humidity in the living space remaining within the comfort zone (between 22.2 and 24.4°C and below 60% RH) outside of touring hours. The air temperature in the mechanical room is very sensitive to the operation of the air-to-water heat pump. This will reduce the cooling load over the competition period, but it will be recommended to install ducting for the unit to increase the home’s performance during the winter months in its final location. The thermal mass in the home and exterior walls, floor, and ceiling, helps stabilize the air temperatures, especially during times with large temperature swings. The model also shows the HRV is able to handle the CO₂ removal load through ventilation, ensuring fresh air for the occupants.

![Home Air Temperatures](image_url)

*Figure 7.1: Interior Air Temperatures of the Mechanical Room and Living Space over the Sample Simulation.*
Figure 7.2: Relative Humidity in the living space.

The DHW tank temperature results shows the backup tank being maintained at acceptable levels during the competition draws. This simulation predicted that the solar-thermal system produces about 60% of the domestic hot water load over the simulated competition period. Although this system was sized to meet 80 to 90% of the DHW load over the course of a year, the competition DHW draws do not represent the hot water use of a typical family. When the draws are dispersed over day, this percentage is much higher.

Figure 7.3: DHW Tank Temperatures During Competition.
Figure 7.4: Net Thermal Energy Includes Useful Heat from Solar Thermal System and Heat Losses to Mechanical Room.

The simulation results show the 4Dhome performing better than net-zero over the competition period, while meeting comfort zone and fresh air requirements. Over the various time frames simulated, a range of ± 15kWh on this metric is expected.

Figure 7.5: Electrical energy production rate from PV and PVT systems.
The most influential parameters on the model performance seem to be the local irradiance, swinging temperatures and high humidity. These results show the culmination of many energy conscious design decisions. Efficient appliance and equipment selection significantly reduced the electrical load compared to a conventional house (approximately 80% reduction compared to similarly-sized conventional home). Net-zero is not an easy metric to achieve under the competition loads and comfort zone requirements, but with careful planning and a conservative modeling approach we believe we have designed an affordable home-energy system with exceptional performance.

8. 4DHome ENERGY MONITORING

8.1. Philosophy
The modern lifestyle of a working couple with a young child may not allow time for actively monitoring the energy usage of the 4Dhome, unless the activity of doing so is easy, interesting and accessible. The only time typical households are able to evaluate their energy consumption is when they receive their utility bill. With only a monthly bill to review, the detail required to pinpoint energy overuse is not present. The energy monitoring system of the 4Dhome makes understanding energy use easy by explaining energy in forms familiar to the average homeowner. It also actively monitors specific circuits and appliances in the home, giving the home owners a much more detailed picture than from a utility bill.

8.2. Real Time Energy Monitoring
The power consumption at the individual circuit level is measured and logged into the energy monitoring system at one second intervals. This data is then averaged to one minute intervals and transmitted over the internet to an offsite server. The power consumption data is then accessible in real time with any device with a browser (computer, laptop, smart phone, etc.). This interface is called the dashboard and an example of this real time monitoring is in Figure 8.1.
8.3. Energy Usage Analysis

The easy accessibility of this system will allow the 4Dhome owners to observe their consumption habits and create lifestyle adjustments to save energy, whether it is on a daily, weekly, or monthly basis. Figure 8.2 shows an example screen shot of the electricity consumption timeline by day (graph on the left) and by the minute (graph on the right). The system is precise enough so that it is possible to see energy spikes from appliances as small as clock radios and compact fluorescent lights.
The dashboard makes understanding energy use easy, interesting and accessible all the time. The daily, weekly and monthly average home energy consumption is always displayed in parameters that are intuitive and easily understood. The instantaneous energy consumption display can alert the family via text or email if there is unexpected usage and gives a sense of magnitude of appliance and circuit (room) energy consumption. Additionally, as shown in Figure 8.3, this system translates energy use into dollars, thereby aiding the family’s understanding of how they can save money through better energy management. Thus, we believe the dashboard will serve as an active promoter to decrease energy consumption by effectively informing the 4Dhome’s inhabitants of their energy use.

9. CONCLUSION

Team Massachusetts has designed an efficient solar powered home optimized for both its permanent home in Boston and the Solar Decathlon competition site. Through steady state modeling with the Passive House Planning Package, independent analysis using Retscreen, PVWatts, and various analytical methods including performing an in depth dynamic simulation, Team Massachusetts is confident the 4Dhome can be net-zero at both sites. The energy analyses have enabled considerations that will allow the 4Dhome to be both competitive and prepared for its final resting place. Construction Specifications
Division 00 - Procurement and Contracting Requirements

Division 01 - General Requirements
01 10 00 Summary
01 54 00 Construction Aids

Division 02 – Existing Conditions
02 05 19.13 Geotextiles for Existing Conditions

Division 03 – Concrete

Division 04 – Masonry

Division 05 – Metals
05 14 13 Architecturally Exposed Structural Aluminum Framing
05 50 00 Metal Fabrications

Division 06 – Wood, Plastics, and Composites
06 05 23 Wood, Plastic and Composite Fastenings
06 10 00 Rough Carpentry
06 16 00 Sheathing
06 20 00 Finish Carpentry
06 41 16 Architectural Woodwork
06 46 00 Wood Trim

Division 07 – Thermal and Moisture Protection
07 21 00 Thermal Insulation
07 41 13 Metal Roof Panels
07 46 46 Mineral Fiber Cement Siding
07 61 13 Corrugated Sheet Metal Roofing
07 71 23 Manufactured Gutters and Downspouts
07 91 00 Preformed Joint Seals

Division 08 – Openings
08 14 00 Wood Doors and Frames
08 52 00 Wood Windows
08 61 00 Roof Windows
Division 09 – Finishes
09 29 00 Gypsum Board
09 30 33 Stone Tiling
09 64 29 Wood Strip and Plank Flooring
09 91 23 Interior Painting

Division 10 – Specialties
10 06 10 Schedules for Information Specialties
10 06 20 Interior Specialties
10 22 26.43 Operable Partitions
10 44 16 Fire Extinguisher
10 71 13.13 Exterior Shutters

Division 11 – Equipment
11 31 00 Residential Appliances

Division 12 – Furnishings
12 36 00 Countertops
12 42 00 Table Accessories
12 43 00 Portable Lamps
12 44 00 Bath Furnishings
12 45 00 Bedroom Furnishings
12 46 00 Furnishing Accessories
12 48 00 Rugs and Mats
12 58 00 Residential Furniture
12 58 29 Beds
12 58 36 Nightstands

Division 13 – Special Construction

Division 14 – Conveying Equipment

Division 21 – Fire Suppression
21 13 13 Wet-Pipe Sprinkler System
Division 22 – Plumbing
22 05 00 Common Work Results for Plumbing
22 11 16 Domestic Water Piping
22 11 19 Domestic Water Piping Specialties
22 12 19 Facility Potable Water Storage Tanks
22 13 16 Sanitary Waste Piping and Vent Piping
22 13 53 Facility Septic Tanks
22 33 30.16 Residential, Storage Electric Domestic Water Heaters
22 33 30.26 Residential, Collector-to-Tank, Heat Exchanger Coil, Solar Electric Domestic Water Heaters

Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC)
23 31 13.16 Round and Flat-Oval Spiral Ducts
23 33 13 Back Draft Dampers
23 37 13 Diffusers, Registers and Grilles
23 40 00 Super Ultra-Low Penetration Filtration
23 72 00 Air to Air Recovery Equipment
23 81 26 Split System Air Conditioner
23 84 16 Dehumidifiers

Division 25 – Integrated Automation

Division 26 – Electrical
26 05 19 Low-Voltage Electrical Power Conductors and Cables
26 05 33 Raceway and Boxes for Electrical Systems
26 24 16 Panelboards
26 27 13 Electricity Metering
26 28 16 Enclosed Switches and Circuit Breakers
26 31 00 Photovoltaic Collector System
26 51 00 Interior Lighting
26 56 00 Exterior Lighting

Division 27 – Communications
27 21 00 Data Communication Network Equipment
27 21 33 Data Communication Wireless Access Points
27 22 26 Data Communications Laptop

Division 28 – Electronic Safety and Security
Divisions 31 – Earthwork
31 05 00 Soils for Earthwork

Division 32 – Exterior Improvements
32 90 00 Planting

Division 33 – Utilities

Division 34 – Transportation

Division 35 – Waterway and Marine Construction

Division 40 – Process Integration

Division 41 – Material Processing and Handling Equipment

Division 42 – Process, Heating, Cooling, and Drying Equipment

Division 43 – Process Gas and Liquid Handling, Purification, and Storage Equipment

Division 44 – Pollution Control Equipment

Division 45 – Industry-Specific Manufacturing Equipment

Division 48 – Electrical Power Generation
48 19 16 Electrical Power Generation Inverters
DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01 10 00
SUMMARY

PART 1 – GENERAL

1.01 PROJECT INFORMATION
   A. Project: Team Massachusetts 4D Home entry, 2011 US Solar Decathlon
      1. Location: National Mall, Washington, DC
   B. Architect: Team Massachusetts - Massachusetts College of Art and Design
   C. Engineer: Team Massachusetts - University of Massachusetts, Lowell
   D. Work Consists of: Design, construction, transportation and assembly of a 1000 sq.ft. house

1.02 INTENT
   A. Drawings and specifications are intended to provide the basis for the proper completion of the Project
      suitable for the intended use of the Owner.
   B. Items not expressly set forth but which are reasonably implied or necessary for the proper
      performance of this work shall be included.

1.03 CUTTING AND PATCHING
   A. Provide cutting and patching work to properly complete the Project
   B. Do not remove or alter structural components without written approval
   C. Cut with tools appropriate for materials to be cut
   D. Patch with materials and methods to produce patch which is not visible from a distance of three feet
   E. Do not cut and patch in manner that would result in a failure of the work to perform as intended, decrease
      fire performance, decrease acoustical performance, decrease energy performance, decrease operational life,
      or decrease safety factors
1.04 PROJECT MEETINGS

A. Arrange for a preconstruction conference prior to start of construction. Meeting shall be attended by Owner, Architect, Engineer, Construction Manager, Contractor, Health and Safety Officer and major subcontractors

B. Arrange for progress meetings once a month during construction, prior to application for payment. Record minutes and distribute promptly.

1.05 SUBMITTALS

A. Submit a project schedule and update at least monthly. Submit for approval all submittals listed in individual sections with the following number of copies: Shop Drawings, reviewed and annotated by the Contractor, 3 copies; product data, 3 copies; samples, 3 sets plus range samples where applicable; test reports, 3 copies; warranties, 3 copies; other submittals, 3 copies

B. Include details of construction and adjacent construction in shop drawings. Clearly indicate any deviations from requirements of the contract documents. Fabricate materials from approved shop drawings only.

1.06 QUALITY ASSURANCE

A. Comply with applicable codes, regulations, ordinances and requirements of authorities having jurisdiction, including accessibility guidelines where applicable. Submit copies of inspection reports, notices and similar documents to Construction Manager

B. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years unless otherwise approved by Architect or Engineer

C. Use experienced installers. Furnish evidence of experience if requested.

D. Deliver, handle, and store materials in strict accordance with manufacturer’s instructions.

E. Use of any supplier or subcontractor is subject to Owners approval.

F. Engage and pay for testing agencies as required. Refer to individual sections for additional requirements.

1.08 TEMPORARY FACILITIES

A. Provide temporary facilities and connections as required for the proper completion of the project.
B. Provide and maintain temporary utility services

C. Owner will pay for temporary utility service. Do not waste.

D. Provide temporary protection for adjacent areas to prevent contamination by construction dust and debris.

E. Provide temporary barricades as necessary to ensure protection of the public.

F. Provide suitable waste disposal units and empty regularly. Do not permit accumulation of trash and waste materials.

G. Maintain egress within and around construction areas.

H. Maintain fire alarm systems in operation during construction

I. Provide fire extinguishers in work areas during construction.

J. Provide temporary protection for adjacent construction. Promptly repair any damage at no additional cost to the Owner.

1.09 PRODUCTS AND SUBSTITUTIONS

A. Provide products and materials specified. Request Architects selection of colors and accessories in sufficient time to avoid delaying progress of work.

B. Submit requests for substitutions shall be in writing, including reasons. Submit sufficient information for Architect or Engineer to evaluate proposed substitution.

C. Remove and replace work which does not conform to the contract documents at no additional expense to the Owner.

1.10 INSTALLATION

A. Inspect substrates and report any unsatisfactory conditions in writing.

B. Do not proceed until unsatisfactory conditions have been corrected.

C. Take field measurements prior to fabrication where practical. Form to required shapes and sizes with true edges, lines and angles. Provide inserts and templates as needed for work of other trades.

D. Install materials in exact accordance with manufacturer’s instruction and approved submittals.
E. Install materials in proper relation with adjacent construction and with proper appearance.

F. Restore units damaged during installation. Replace units which cannot be restored at no additional expense to the Owner.

G. Refer to additional installation requirements and tolerances specified under individual specification sections.

1.11 CLOSEOUT

A. Prepare punchlist for remaining work for review by the Architect, Project Manager or Construction Manager

B. Complete punchlist items promptly at no additional expense to the Owner.

C. Submit accurate record documents of building and site.

D. Submit operating manuals, maintenance manuals, and warranty information

E. Obtain and submit copies of occupancy permits.

F. Train Owner in use of building systems

G. Remove temporary facilities and provide final cleaning and touch up.

H. Restore portions of building, site improvements, landscaping and other items damaged by construction operations to the satisfaction of the Architect, Project Manager or Construction Manager at no additional expense to the Owner

PART 2 – PRODUCTS

PART 3 – EXECUTION

END OF SECTION 01 10 00
SECTION 01 54 00
CONSTRUCTION AIDS

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Temporary Generator
   B. Temporary Crane
   C. Temporary Scaffolding
   D. Temporary Barricades

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
   A. NPS noise regulation 36CFR2.12, NCCCO

1.04 SUBMITTALS
   A. Generator: Proof of compliance with NPS 36CFR2.12
   B. Crane: Proof of operator NCCCO certification

PART 2 – PRODUCTS

2.01 GENERATOR
   A. Honda EU6500iSA
      1. hondapowerequipment.generator spec
   B. Plastic Tray
      1. Liquid Volume Capacity Greater Than Liquid Contents in Generator
2. Compliance with All Codes Regarding Spill Containment

2.02 CRANE

A. 100 Ton Hydraulic Crane

1. Operator provided by crane owner

2. Set crew: Mod-Set, Inc., 29 Trufant Lane, Topsham, ME 04086, 207-725-0959

2.03 SCAFFOLDING

A. BAKER STYLE SCAFFOLDING

1. Adjustable 6 foot to 12 foot

2.04 TEMPORARY BARRICADES

A. Cones

B. Yellow Caution Tape

C. Signal Flags

PART 3 – EXECUTION

3.01 Install provided temporary protection to prevent damage to turf grass surfaces

END OF SECTION 01 54 00
PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Filter Fabric for Temporary Foundations

1.02 RELATED SECTIONS
   05 50 00 Metal Fabrications
   31 05 00 Soils for Earthwork

1.03 REFERENCE STANDARDS
   A. ASTM D 5261, D 4632, D 4533, D 4833, D 3786, D 4491, and D 4751

1.04 SUBMITTALS

PART 2 - PRODUCTS

2.01 GEOTEXTILES
   A. US Construction Fabrics: Geotextile SKAPS W200
      1. Material: Woven polypropylene
      2. Roll Dimensions (W x L) – ft: 12.5 x 432 / 17.5 x 309
      3. Square Yards per Roll: 600

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Geotextile fabric must be placed on ground before sand is used for leveling footings
B. Geotextile fabric must be wrapped around leveling sand the top must be closed by placing footing Foamglas and steel plate material on top to ensure sand will not erode from underneath footings due to wind or rain

END OF SECTION 02 05 19.13
PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Photovoltaic mounting system
      1. Structural aluminum
      2. Stainless steel hardware

1.02 RELATED SECTIONS
   A. Section 26 31 00 - Photovoltaic Collector System

1.03 REFERENCE STANDARDS
   A. ANSI/AF&PA NDS-2005, UL 467

1.04 SUBMITTALS
   A. Product datasheets from manufacturer

1.05 QUALITY ASSURANCE
   A. Manufacturer Qualifications: Company specializes in manufacturing the products specified in this section with minimum 10 years’ experience.

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. IronRidge

2.02 COMPONENTS
   A. XRS Rail
      1. Extruded, anodized 6105-T5 aluminum, clear.
2. 16’ long sections and 7’ sections cut to size.

B. Mounting Accessories

1. Aluminum, mill
   a. Internal rail splice – Joins two rails
   b. Adjustable L-foot – Attaches rails to wooden trellis frame
   c. Center clamp – Type F, 2.5”, clamps inside edges of PV panels to rails
   d. End clamp – Type F, 1.81”, clamps outer edges of PV panels to rails

2. Stainless steel hardware
   a. Self-drilling, self tapping screw (10-16 x ½”) – Fastens rails and splice; Eight per splice.
   b. Hex cap bolt (3/8-16 x 1”) – One per L-foot.
   c. Flange nut (3/8”-16) – One per L-foot bolt.
   d. Hex cap bolt (1/4-20 x 2.50”) – One per center clamp
   e. Flange nut (1/4-20) – One per center clamp, one per end clamp
   f. Hex cap bolt (1/4-20 x 1.81”) – One per end clamp

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Tools and instructions required for assembly; IronRidge installation manual
   1. Wrenches – open-end, box-end, or socket drive with sockets to support the following size hex heads:
      a. 3/8”, used for ¼ cap-end screws, ¼ bolts
      b. ¼”, used for 3/8 cap-end screws, 3/8 bolts
   2. Torque values for dry bolts
      a. Required torque of 84 in-lbs for bolt size of ¼-20
      b. Required torque of 144 in-lbs for bolt size of 5/16-18
      c. Required torque of 180 in-lbs for bolt size of 3/8-16

END OF SECTION 05 14 13
SECTION 05 50 00
METAL FABRICATIONS

PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Steel plate for temporary footings

1.02 RELATED REQUIREMENTS
   A. 31 05 00 Soils for Earthwork
   B. 02 05 19.13 Geotextiles for Existing Conditions

1.03 REFERENCE STANDARDS
   A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

PART 2 - PRODUCTS

2.01 METAL FABRICATIONS
   A. General: Shear and punch metals cleanly and accurately. Remove burrs and ease exposed edges.
   B. Dimensions
      1. 2 foot x 2 foot x 1/2 inch – Quantity: 18
      2. 2 foot 6 inch x 2 foot 6 inch x 1/2 inch – Quantity: 6
      3. 2 foot x 2 foot 4 inches x 1/2 inch - Quantity: 1

2.03 STEEL AND IRON FINISHES
   A. Prepare uncoated ferrous metal surfaces to comply with SSPC-SP 3, “Power Tool Cleaning,” and paint with a fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79.
   B. Shop Priming: Prepare surfaces according to SSPC-SP 2, “Hand Tool Cleaning”; or SSPC-SP 3, “Power Tool Cleaning.” Shop prime steel to a dry film thickness of at least 0.038 mm. Do not prime surfaces to be embedded in concrete or mortar or to be field welded.
C. Apply bituminous paint to concealed surfaces of units set into concrete.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Perform cutting, drilling, and fitting required for installing miscellaneous metal fabrications. Set metal fabrication accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack.

B. Fit exposed connections accurately together to form hairline joints.

END OF SECTION 05 50 00
DIVISION 06 – WOODS, PLASTICS AND COMPOSITES

SECTION 06 05 23

WOOD, PLASTIC AND COMPOSITE FASTENINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Metal Plates
   B. Metal Connectors
   C. Bolts, Washers and Nuts
   D. Threaded Rod

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
   A. ICC-ES ESR-2105 / ESR-2523 / ESR-2604 / ESR-2523

PART 2 – PRODUCTS

2.01 METAL PLATES
   A. Simpson Strong-Tie: Architectural products group, The Specialty Collection
      1. Custom Fabricated Truss Plates
      2. Custom Fabricated Trellis Plates
      3. Finish: Factory Primed Grey, Field Painted

2.02 METAL CONNECTORS
A. Manufacturer: Simpson Strong-Tie

1. DTT2Z - Module Connectors, Quantity: 56
2. HL37 - Trellis Angle Connectors, Quantity: 36
3. LUS28 - Deck Joist Hanger, Quantity: 25
4. LUS26 - Deck Joist Hanger, Quantity: 240
5. ABA44Z - Deck Post Base, Quantity: 36
6. IUS 3 1/2 inch x 11 7/8 inch - Floor Joist, Quantity: 138
7. A34 Angle - Hall Ceiling Connection, Quantity: 20
8. HL53 - House Footings L Bracket, Quantity: 40
9. CMST - Coil Strap
10. U24 - Ceiling Joist Hanger, Quantity: 17

B. Metal Fabrication

1. L Bracket, East Trellis Column: 3 1/2 inch x 3 1/2 inch x 1/4 inch, Qty: 4
2. L Bracket, East Trellis Column: 3 1/2 inch x 4 3/4 inch x 1/4 inch, Qty: 4

2.03 BOLTS, WASHERS AND NUTS

A. Manufacturer: Simpson Strong-Tie

1. Lag Bolt
   a. 6 inch x 1/4 inch - Decks and Ramps, Quantity: 102
   b. 4 inch x 1/4 inch - Decks and Ramps, Quantity: 42
   c. 8 inch x 1/2 inch - Decks and Ramps, Quantity: 42
   d. 4 inch x  3/4 inch - Truss, Quantity: 200
   e. 10 inch x 3/4 inch - Truss, Quantity: 26
   f. 4 inch x 1/2 inch - Trellis, Quantity: 328

2. Eye Bolt
a. 6 inch x 1/2 inch - Trellis, Quantity: 36

2.04 THREADED ROD

A. 11 1/2 inch - Module Connectors
B. 15 inch - Module Connectors

PART 3 – EXECUTION

3.01 EXECUTION

A. Steel washers, flat to be used where bolt head or hex nut in direct contact with wood

END OF SECTION 06 05 23
SECTION 06 10 00
ROUGH CARPENTRY

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Engineered Wood Products
   B. Dimensional Lumber

1.02 RELATED REQUIREMENTS
   A. Reinforcing and Framing Schedules S-601
   B. Column and Beam Schedules S-602

1.03 REFERENCE STANDARDS
   A. Dimensional lumber: AWPA C24; ALSC Board of Review; IRC 2009
   B. Engineered lumber: ICC ES ESR-1387, HUD MR 925; ICC ES ESR-1153
   C. Fasteners: CABO NER-272; CABO NER-272; ASTM A 563; ASTM A 563;
      ASTM A 153/A153M; ASTM A 307, Grade A

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER

2.02 ENGINEERED WOOD PRODUCTS
   A. Nordic Joist
      1. Floor Joists: Nordic NI80, 11 7/8 inches
      2. Plates and Studs: Nordic NI40x, 11 7/8 inches

Published 11/23/2010
U.S. D.O.E. Solar Decathlon 2011
3. Rafters: Nordic NI40x, 14 inches

4. Nordic Joist Data Sheets

B. Nordic Lam

1. Columns: 1 3/4 inch x 9 1/2 inch

2. Columns at Module Marriage Line: 4 inch x 8 inch

3. Roof and Deck Beams: 3 1/2 inch x 11 7/8 inch

4. Beam and Header Data Sheets

5. Column Data Sheets

C. Nordic EnviroWall

1. Module Mating Line Keyway: 2 inch x 4 inch

2. Module Mating Line Keyway: 2 inch x 6 inch

3. Envirowall Data Sheets

2.02 DIMENSIONAL LUMBER

A. S4S

B. Spruce, Pine, Fir

C. 2 inch x 4 inch

D. 2 inch x 6 inch

2.03 FASTENERS

A. Power Drive Fasteners

B. Steel bolts, hex nuts and flat washers

PART 3 – EXECUTION

3.01 INSTALLATION

A. Locate nailers, blocking and similar supports to comply with requirements for attaching other Construction.

B. Securely attach rough carpentry to substrates
C. Provide preservative-treated materials for all exterior rough carpentry unless otherwise indicated.

D. Where rough carpentry is exposed to weather, in ground contact, or in areas of high relative humidity, provide fasteners with hot-dip zinc coating or of type 304 stainless steel.

E. Steel washers, flat to be used where bolt head or hex nut in direct contact with wood

F. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent

END OF SECTION 06 10 00
SECTION 06 16 00
SHEATHING

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Combination Wall Sheathing, Water-resistive Barrier and Air Barrier
   B. Combination Roof Sheathing and Roof Underlayment
   C. Self-Adhering Flexible Flashing
   D. Subflooring Material
   E. Interior Sheathing

1.02 RELATED REQUIREMENTS
   A. 09 60 00 Flooring
   B. 10 22 26.43 Operable Partitions

1.03 REFERENCE STANDARDS
   A. US DOC PS-2, 2009 IRC, CABO NER-272

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER
2.02 EXTERIOR SHEATHING

A. Exterior Wall Sheathing

1. ZIP System, 1/2 inch Oriented Strand Board Wall Sheathing with Integral Water-Resistive Barrier, Exposure I Sheathing.

2. Dimensions: 1/2 inch, 4 foot x 8 foot panels

B. Roof Sheathing

1. ZIP System, 5/8 inch Oriented Strand Board Roof Sheathing with Integral Water-Resistive Barrier, Exposure I, Structural I Sheathing

2. Dimensions: 5/8 inch, 4 foot x 8 foot panels

3. Edge: Tongue and Groove

C. Self-Adhering Flexible Flashing

1. ZIP System Self-Adhering Tape: Pressure Sensitive, Self-Adhering, Cold-Applied, Proprietary Seam Tape Consisting of Polyolefin Film with Acrylic Adhesive

2. 3 1/2 inch flashing tape

3. 6 inch flashing tape

2.03 SUBFLOORING

A. Underlayment

1. Advantech (AT-Series) Engineered Flooring Panels

2. Not less than 23/32 inch x 4 feet x 8 feet, 24 oc

3. Edge Detail: Tongue and Groove

2.04 INTERIOR SHEATHING

A. Walls

1. Oriented-Strand-Board Sheathing

2. Dimensions: 5/8 inch, 4 foot x 8 foot panels

3. Performance Standard: DOC PS2 and ICC-ES ESR-1785
B. Ceiling

1. Oriented-Strand-Board Sheathing

2. Dimensions: 5/8 inch, 4 foot x 8 foot panels

3. Performance Standard: DOC PS2 and ICC-ES ESR-1785

PART 3 – EXECUTION

3.01 INSTALLATION

A. Securely attach to substrates

B. All Subflooring, Wall and Roof Sheathing to be glued and nailed to wood framing.

C. Furnish tape gun for Zip System flashing tapes

END OF SECTION 06 16 00
SECTION 06 20 00
Finish Carpentry

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Lumber
   B. Interior Trim
   C. Exterior Trim
   D. Fasteners

1.02 RELATED REQUIREMENTS
   A. 06 10 00 Rough Carpentry
   B. 06 41 16 Architectural Woodwork

1.03 REFERENCE STANDARDS
   A. DOC PS 20, American Lumber Standards Committee Board and Review

1.04 SUBMITTALS
   A. Certification Requirements

PART 2 – PRODUCTS

2.01 LUMBER
   A. Dimensional lumber: S4S Spruce, Pine or Fir

2.02 INTERIOR STANDING AND RUNNING TRIM
   A. Trim: Kiln dried, #1 clear pine
2.02 EXTERIOR STANDING AND RUNNING TRIM
   A. Trim: Kiln dried, #1 Clear Western Red Cedar

2.03 FASTENERS
   A. Hardware: Stainless-steel, hot-dip galvanized or aluminum.
   B. Glue: Aliphatic-resin, polyurethane or resorcinol wood glue recommended by the manufacturer.

PART 3 – EXECUTION

3.01 INSTALLATION
   A. Install standing and running trim with minimum number of joints practical, using full length pieces from maximum lengths of lumber available. Stagger joints in adjacent and related trim. Cope at returns and miter at corners.
   B. Use waterproof glue for exterior applications.

END OF SECTION 06 20 0
PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Door and Window Casings
   B. Base Board

1.02 RELATED REQUIREMENTS
   A. 06 20 00 Finish Carpentry
   B. 06 41 16 Architectural Woodwork

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 DOOR AND WINDOW TRIM
   A. Finish Grade Plywood
   B. 10 inch x 3/4 inch nominal
   C. Finish: Natural satin finish, water based acrylic

2.02 BASE BOARD
   A. Clear Pine or Poplar
   B. 1 inch x 6 inch nominal, square profile
   C. Finish: Painted same color as walls
SECTION 06 82 00
GLASS-FIBER REINFORCED PLASTIC

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Temporary Footing Materials

1.02 RELATED REQUIREMENTS

A. 05 50 00 Metal Fabrications

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Pittsburgh Corning US, www.foamglas.us/foamglas specs

2.02 TEMPORARY FOOTINGS

A. Foamglas Flat Block– 18 inch x 24 inch x 3 inch thick

PART 3- EXECUTION (Not Used)

END OF SECTION 06 82 00
DIVISION 7 – THERMAL AND MOISTURE PROTECTION

SECTION 07 21 00
THERMAL INSULATION

PART 1 – GENERAL

1.01 SECTION INCLUDES
A. Sprayed Insulation
B. Blown Fiberglass Insulation

1.02 RELATED REQUIREMENTS
A. 06 10 00 Rough Carpentry
B. 06 16 00 Sheathing

1.03 REFERENCE STANDARDS
A. ICC-ES; IBC/IRC; ASTM E 84; ASTM E 96; ASTM E 283; ASTM C 518; ASTM C 687; ASTM C 177; ASTM C 764 Type I; ASTM C 1338; ASTM D 1621; ASTM D 1622; ASTM D 1623; ASTM D 2126; ASTM D 2842; ASTM E 136

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER
A. CertainTeed Corp., Insulation Group: 750 E. Swedesford Rd. P. O. Box 860; Valley Forge, PA 19482-0860; Toll Free Tel: 800-233-8990, www.certainteed.com

2.02 SPRAYED INSULATION
A. CertaSpray Polyurethane Closed Cell Foam

U.S. D.O.E. Solar Decathlon 2011
B. Roof, Floor and Walls: 3,000 square feet at a depth of 4 inches

2.02 BLOWN FIBERGLASS INSULATION

A. Optima Blown Fiberglass Insulation

B. Roof: 1,250 square feet at a depth of 10 inches

C. Floor and Walls: 1,850 square feet at a depth of 8 inches

PART 3 – EXECUTION

A. Confirm completion of work in writing for all trades requiring access to interior of wall before application.

3.01 INSTALLATION

END OF SECTION 07 21 0
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Standing Seam Corrugated Metal Roof Panels

B. Trim

1.02 RELATED REQUIREMENTS

A. 06 16 00 SHEATHING

1.03 REFERENCE STANDARDS

A. UL 263 Fire Resistance Rating; UL 2218 Class 4 Impact Resistance; UL 790 Class A Fire Resistance Rating; ASTM E-283 Air Infiltration Approved; ASTM E-331 Water Penetration Approved CEGS-07416 US Army Corps of Engineers Rated-ASTM E-1592; UL 580 Class 90 Wind Uplift; ASTM 2112-07 5.13; ASTM D 226

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 STEEL ROOFING PANELS

A. Manufacturer: Drexel Metals, Inc., 204 Railroad Dr., Ivyland, PA 18974, drexmet.com

B. Galvanized steel sheet metal roofing panels, 24” width, 26 gage.
   1. Exposed seam
   2. 1/2 inch rib height

2.02 TRIM

A. Eave Drip Edge

B. Rake Drip Edge
C. Ridge Cap

PART 3 – EXECUTION

END OF SECTION 07 41 13
SECTION 07 46 46
MINERAL FIBER CEMENT SIDING

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Mineral fiber cement siding

1.02 RELATED REQUIREMENTS
   A. 06 16 00 SHEATHING

1.03 REFERENCE STANDARDS
   A. ASTM C 920; ASTM C 1185; ASTM C 1186; ASTM E 72; ASTM E 84; ASTM E 96; ASTM E 136; ASTM E 228; ASTM G 26

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. CertainTeed Corporation, Siding Products Group, P.O. Box 860, Valley Forge, Pennsylvania 19482. (800) 233-8990, www.certainteed.com

2.02 FIBER CEMENT SIDING
   A. CertainTeed ColorMax Prefinished Smooth Lap
   B. Size: 8 1/4 inch x 12 foot

PART 3 – EXECUTION

END OF SECTION 07 46 46
SECTION 07 71 23
MANUFACTURED GUTTERS AND DOWNSPOUTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Gutters
B. Downspouts

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 GUTTERS

A. Aluminum Gutters
   1. 4 inch
   2. Style: Box Gutter, Square
   3. Aluminum Gutter Hangers

2.02 DOWNSPOUTS

A. Aluminum Downspout
   1. 3 inch
   2. Aluminum Strapping

PART 3 – EXECUTION (Not Used)

END OF SECTION 07 71 23
SECTION 07 91 00
PREFORMED JOINT SEALS

1.01 SECTION INCLUDES

   A. Module Joint Seals
   B. Window Joint Seals

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

   A. CE EN 14909, ASTM E2112

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER

   A. Tremco - Illbruck

2.02 Joint Seal

   A. Illbruck 2112 Insulation Tape
   B. willseal product info

PART 3 – EXECUTION

END OF SECTION 07 91 00
DIVISION 8 - OPENINGS

SECTION 08 14 00
WOOD DOORS AND FRAMES

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Pocket Doors
   B. Prefinished Wood Doors
   C. Door Hardware

1.02 RELATED REQUIREMENTS
   A. 08 06 10 Door Schedule

1.03 REFERENCE STANDARDS
   A. Passive House Certification
   B. Glazing: IRC 308.6

1.04 SUBMITTALS
   A. Passive House Certification
   B. Schematic Drawings

PART 2 – PRODUCTS

2.01 POCKET DOORS

   A. Johnson Hardware, www.johnsonhardware.com
      1. 2060 Pocket Door Frame
         2. Frame compatible with 2 inch x 6 inch interior wall

U.S. D.O.E. Solar Decathlon 2011

Published 11/23/2010
2.02 EXTERIOR DOORS

A. Front Door, South elevation

1. Model: Makrowin 88G2
2. Passive House Certified
3. Finish: Mahogany

A. Patio Door, West elevation

1. Model: Makrowin 88G2
2. Passive House Certified
3. Finish: Mahogany

2.02 DOOR GLAZING

A. Triple Glazed Low E Insulated with Warm-Edge Spacer System – Swisspacer V, Ug-value of 0.105, SHGC of 0.5 and VT of 0.71

2.03 Hardware: Secustic Melbourne F9-2

A. Aluminum Steel Matte textured

PART 3 – EXECUTION

END OF SECTION 08 14 00
SECTION 08 52 00
WOOD WINDOWS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Manufactured Windows
B. Window Hardware

1.02 RELATED REQUIREMENTS

A. 08 06 50 Window Schedule

1.03 REFERENCE STANDARDS

A. Passive House Certification, IRC 308.6

1.04 SUBMITTALS

A. Passive House Certification

PART 2 – PRODUCTS

2.01 MANUFACTURER


2.02 WINDOW

A. Profile: Makrowin 88G2
B. Glazing: Triple Glazed Low E Insulated with Warm-Edge Spacer System – Swisspacer V, Ug value of 0.105, SHGC of 0.5 and VT of 0.71
2.03  Hardware: Secustic Melbourne F9-2

A. Aluminum Steel Matte textured

B. Fully perimeter locking with 2 security closures and safety lock

PART 3 – EXECUTION (Not Used)

END OF SECTION 08 52 00
SECTION 08 61 00
ROOF WINDOWS

PART 1 – GENERAL

1.01  SECTION INCLUDES

A. Skylight

1.02  RELATED REQUIREMENTS

A. 08 06 60 Skylight Schedule

1.03  REFERENCE STANDARDS

A. IRC 308.6

1.04  SUBMITTALS

PART 2 – PRODUCTS

2.01  MANUFACTURER


2.02  SKYLIGHT

A. Model: WDF Design R8 – Top Hinged

B. Frame: Wood Profile

C. Glazing: 9A 3 Pane, Tempered, Ug 0.08, Uw 0.14, SHGC 30%, VT 45%

PART 3 – EXECUTION

END OF SECTION 08 61 00
DIVISION 9 – FINISHES

SECTION 09 29 00

GYPSUM BOARD

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Gypsum Board Wall Panels
B. Mold and Mildew Resistant Gypsum
C. Gypsum Board Ceiling Panels

1.02 RELATED REQUIREMENTS

A. 09 06 20 Schedule for Gypsum

1.03 REFERENCE STANDARDS

A. ASTM C 473; ASTM C 475; ASTM C 514; ASTM C 665; ASTM C 840; ASTM C 954; ASTM C 1002; ASTM C 1047; ASTM C 1396; ASTM C 1629; ASTM D 3273; GA-214; GA-216; GA-231; GA-238 Federal Specification SS-L-30D Type III (Grade X); GREENGUARD Children & Schools Certified

1.05 SUBMITTALS

1.06 QUALITY ASSURANCE

A. Provide Products Manufactured in North America Only

PART 2 – PRODUCTS

2.01 MANUFACTURER
2.02 GYPSUM BOARD WALL PANELS

A. REGULAR GYPSUM BOARD: Gypsum core panel solid set core enclosed in paper. Complying with ASTM C1396.

1. ProRoc® Regular, manufactured by CertainTeed Gypsum, Inc.
2. Thickness: 1/2 inch
3. Width: 48 inches
4. Length: 8 feet

B. MOISTURE AND MOLD RESISTANT GYPSUM BOARD: Moisture and Mold Resistant Gypsum Board: Gypsum core panel with enhanced core formulated for resistance to moisture and mold; surfaced with moisture/mold resistant paper on front, back, and long edges. Complying with ASTM C1396

1. ProRoc® Moisture and Mold Resistant With M2TECH™ Gypsum Board by CertainTeed Gypsum, Inc.
2. Thickness: 1/2 inch
3. Width: 48 inches
4. Length: 8 feet

2.03 GYPSUM BOARD CEILING PANELS

A. REGULAR GYPSUM CEILING BOARD: Gypsum Core panel with enhanced sag resistant core. Complying with ASTM C 1396.

1. ProRoc® Interior Ceiling, manufactured by CertainTeed Gypsum, Inc.
2. Thickness: 1/2 inch
3. Width: 48 inches
4. Length: 8 feet

PART 3 – EXECUTION (Not Used)

END OF SECTION 09 29 00
SECTION 09 30 33
CERAMIC TILING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Concrete Tile
B. Grout
C. Tile Backing Board

1.02 RELATED REQUIREMENTS

A. 09 06 30 Schedule for Tiling

1.03 REFERENCE STANDARDS

B. Grout: ANSI A118.7, ANSI A108.10
C. Tile Backing Board: ANSI A118.9, UL
   1. Bonding Material: ANSI A118.4, ANSI A118.11

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 CONCRETE TILE

A. 6 inch x 6 inch

2.02 GROUT
A. Color to match tile color

2.03 TILE BACKING BOARD

A. WonderBoard 1/2 inch
B. 36 inch x 60 inch x 1/2 inch
C. FlexBond Crack Prevention Mortar

PART 3 – EXECUTION (Not Used)

END OF SECTION 09 30 33
SECTION 09 64 29
WOOD STRIP AND PLANK FLOORING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Pre-finished, tongue and groove wood flooring

1.02 RELATED REQUIREMENTS

A. 06 16 00 Sheathing

1.03 REFERENCE STANDARDS

A. NOFMA grading rules for species, grade, and cut.

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 SOLID-WOOD STRIP FLOORING

A. Maple

B. Tongue and grooved

C. 3/4 inch

D. 3-1/4 inch

E. Random Lengths 9 to 84 inch

F. Pre-Finished

PART 3 – EXECUTION
3.01 Installation

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

B. Solid-wood, Strip flooring: nail down on or above grade

END OF SECTION 09 64 29
SECTION 09 91 23
INTERIOR PAINTING

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Interior Paint

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
   A. Conformance Standards: AIM; CARB; LADCO; OTC; SCQAMD; Low VOC; MPI

1.04 SUBMITTALS
   A. Color Sample

PART 2 – PRODUCTS

2.01 LATEX PAINT
   A. Benjamin Moore, EcoSpec Interior Latex Flat 219
   B. Color: Pure White
   C. Low VOC, low odor

PART 3 – EXECUTION

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

D. General surface preparation indicated by manufacturer.

1. Gypsum Wallboard: Nails or screws should be countersunk, and they along with any indentations should be mudded flush with the surface, sanded smooth and cleaned to remove any dust, then prime with a high quality latex primer prior to painting the substrate.

2. Wood: Unpainted wood or wood in poor condition should be sanded smooth, wiped clean, then primed. Any knots or resinous areas must be primed before painting. Countersink all nails, putty flush with surface, then prime with a high quality latex primer.

E. Provide materials that are compatible with one another and with substrates

3.02 APPLICATION

A. Comply with recommendations in MPI’s “MPI Architectural Painting Specification Manual” applicable to substrates indicated.

B. Paint exposed surfaces, unless otherwise indicated.

1. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces.

2. Paint surfaces behind permanently fixed equipment or furniture with prime coat only.

3. Paint the backside of access panels.

4. Do not paint prefinished items, items with an integral finish, operating parts, and labels unless otherwise indicated.

C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, or other surface imperfections. Cut in sharp lines and color breaks.

D. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
3.03 CLEANING

A. Washing Instructions: Wait at least 14 days after painting before cleaning the surface with a non-abrasive mild cleaner.

B. Clean up: Wipe up spills immediately with damp cloth or sponge. Wash brushes, rollers and other painting tools with soap and water immediately after use.

END OF SECTION 09 91 23
DIVISION 10 - SPECIALTIES

SECTION 10 06 10
SCHEDULES FOR INFORMATION SPECIALTIES

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Exterior Signage
   B. Interior Signage

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 - PRODUCTS

2.01 TBD

PART 3 - EXECUTION

3.01 TBD

END OF SECTION 10 06 10
SECTION 10 06 20
INTERIOR SPECIALTIES

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Towel Racks
   B. Soap Dishes
   C. Shower Curtain
   D. Toilet Paper holder

1.02 RELATED REQUIREMENTS
   A. 09 30 13 Ceramic Tiling

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 TOWEL BAR
   A. IKEA Grundtal: Rail
      1. Stainless Steel Rail, 20 7/8", model 900.113.96, cost $6.99, quantity 1

2.02 SOAP DISHES
   A. Ceramic Tile Soap Dishes
   B. Product Description: Glazed Ceramic Soap Dish Tiles for the bathroom

Published 11/23/2010
2.03  SHOWER CURTAIN

A. Water Resistant Shower Curtain and Shower Rod

B. Product Description: Water resistant fabric/plastic shower curtain, curtain rod, curtain rings, and mounting hardware.

2.04  TOILET ROLL HOLDER

A. IKEA Grundtal

   1. Toilet Paper Roll Holder, Stainless Steel, model 200.478.98, cost $4.99, quantity 1
   2. Wall mounted, wood

PART 3 – EXECUTION

END OF SECTION 10 06 20
SECTION 10 22 26.43
OPERABLE PARTITIONS

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Hardware for moveable walls
   B. Plywood

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
   A. CARB Phase 2

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 OVERHEAD TRACK
   A. 2610F Wall Mount Door Hardware
      1. Part #: 2610F
      2. Johnson Hardware: http://johnsonhardware.com track

2.02 WHEELS
   A. Hamilton Caster
      1. XC70D Duralast Wheel ; 6inch x 3 inch ; 3/4 BB
      2. Model : W-630-DB70-3/4
2.03 PLYWOOD

A. Finish Grade

B. Birch

C. Formaldehyde free

PART 3 – EXECUTION

END OF SECTION 10 22 26.43
PART 1 – GENERAL

1.01 SECTION INCLUDES
A. Fire Extinguisher

1.02 RELATED REQUIREMENTS
A. 21 13 13 Wet Pipe Sprinkler System

1.03 REFERENCE STANDARDS
A. Mets NFPA requirements, UL rated 2-A:10-B:C, UL listed

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 KIDDE model FX210R
A. Type 2A-10BC
B. Part # 21002770
B. http://www.kidde.com fire extinguisher

PART 3 – EXECUTION

END OF SECTION 10 44 16
SECTION 10 71 13.13
EXTERIOR SHUTTERS

PART 1 – GENERAL

1.01  SECTION INCLUDES
   A. Exterior Shutters, Motorized

1.02  RELATED REQUIREMENTS

1.03  REFERENCE STANDARDS

1.04  SUBMITTALS

PART 2 – PRODUCTS

2.01  EXTERIOR SHUTTERS, MOTORIZED
   A. Manufacturer: HELLA
   B. Model: AR 63 ZM
   C. http://www.hella.info outdoor blinds

PART 3 – EXECUTION

END OF SECTION 10 71 13.13
SECTION 11 31 00
RESIDENTIAL APPLIANCES

PART 1 – GENERAL

1.01 SECTION INCLUDES
A. Kitchen appliances.
B. Laundry appliances.
C. Entertainment equipment.

1.02 RELATED REQUIREMENTS
A. Division 22 – Plumbing Piping: Plumbing connections for appliances
B. Division 26 – Equipment Wiring: Electrical connections for appliances

1.03 REFERENCE STANDARDS
A. UL – Underwriters Laboratories Inc.; ENERGY STAR

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 KITCHEN APPLIANCES
A. Refrigerator/Freezer combination
   1. Manufacturer & Model: Whirlpool GB9FHDXWS
   2. Type: bottom freezer
3. Size: 18.5 cubic feet

4. Specifications: To view this product’s technical data, CLICK HERE.

B. Dishwasher

1. Manufacturer & Model: Fisher & Paykel DD24SCX6
2. Type: compact, single drawer
3. Specifications: To view this product’s technical data, CLICK HERE.

C. Cooktop

1. Manufacturer & Model: BOSCH NETS054UC 500 Series
2. Type: built-in
3. Size: 4-burner
4. Specifications: To view this product’s technical data, CLICK HERE.

D. Microwave-Convection Oven combination

1. Manufacturer & Model: GE Monogram Built-In Oven ZSC1201NSS
2. Type: built-in
3. Size: 1.6 CU FT
4. Specifications: To view this product’s technical data, CLICK HERE.

E. Range Hood

1. Manufacturer & Model: BROAN 413004
2. Specifications: To view this product’s technical data, CLICK HERE.

2.02 LAUNDRY APPLIANCES

A. Clothes Washer/Dryer combination

1. Manufacturer & Model: LG WM3455HW
2. Type: compact
3. Size: 2.7 cubic feet
4. Specifications: To view this product’s technical data, CLICK HERE.
203 ENTERTAINMENT EQUIPMENT

A. Television

1. Manufacturer & Model: Panasonic TC-L42D2
2. Type: LED
3. Size: 42 inches
4. Energy: Power Rating 0.105 kW
5. Specifications: To view this product’s technical data, CLICK HERE.

B. Home Theater

1. Manufacturer & Model: Sony BDV-E770W
2. Type: Includes blu-ray player, audio-video receiver & speakers
3. Energy: Power Rating 0.12 kW
4. Specifications: To view this product’s technical data, CLICK HERE.

PART 3 – EXECUTION

END OF SECTION 11 31 00
DIVISION 12 - FURNISHING

SECTION 12 30 00

CASEWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Kitchen Cabinets
   B. Bathroom Cabinets

1.02 RELATED REQUIREMENTS
   A. 12 36 13 Countertops

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. IKEA

2.02 KITCHEN CABINETS
   A. IKEA Akurum: Frame: White; Front: Abstrakt High Gloss White
      1. Upper Cabinet, model 298.695.04, cost $84.00, quantity 2
      2. Base Cabinet, 2+2 Drawers, model 098.692.70, cost $270.96, quantity 1
      3. Base Cabinet, 2 Drawers / 2 Doors, model 398.693.44, cost $223.98, quantity 3
4. Base Cabinet, Sink, model 998.692.61, cost $119.00, quantity 1
5. Base Cabinet, Drawer / Door, model 998.693.22, cost $124.99, quantity 1
6. Drawer Base Cabinet, 3 Drawer, model 098.692.89, cost $175.97, quantity 1
7. www.ikea.com akurum cabinets

2.03  BATHROOM CABINETS

A. IKEA Freden

1. Mirror Cabinet, model 801.411.81, cost $99.99, quantity 1
2. Sink Cabinet, model 298.627.34, cost $279.00, quantity 1
3. www.ikea.com freden cabinets

PART 3 – EXECUTION (Not Used)

END OF SECTION 12 30 00
SECTION 12 36 00
COUNTERTOPS

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Quartz Composite Countertop

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. Caesarstone, 6840 Hayvenhurst Ave. Suite 100, Van Nuys, CA 91406 (877)978-2789, caesarstoneus.com

2.02 COUNTERTOP
   A. Color: Concrete 2003
   B. Edge: Radius
   C. Thickness: 3/4 inch

PART 3 – EXECUTION

3.02 INSTALLATION

END OF SECTION 12 36 00

Published 11/23/2010
U.S. D.O.E. Solar Decathlon 2011
SECTION 12 58 00
RESIDENTIAL FURNITURE

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Custom Fabricated Residential Furniture
   1. Desktop Work Space
   2. Dining Table and chairs
   3. Residential Chairs
   4. Coffee Table
   5. Side Tables
   6. Storage Bench Seating
   7. Couches and Loveseats

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 RESIDENTIAL FURNITURE

A. Desktop Workspace: Desktop is a collapsible work surface that can easily be folded up and relocated. Desktop consists primarily of wood and metal.

B. Dining Table: The dining table is designed to seat up to 10 guests, contain storage for house wares and be reconfigured to accommodate various dining arrangements. The table is comprised primarily of wood and metal.
C. Multi-use Chairs: These chairs are intended to service the dining room table, both desktop workspaces, and casual seating throughout the house. The primary materials used will be wood and metal.

D. Coffee Table: The coffee table will be made up of wood and metal, and will incorporate a storage element.

E. Side Tables: The side tables will be flexible furniture pieces that can be used either as night side tables or end tables for living room seating. The tables will be fabricated out of wood and metal.

F. Storage Bench Seating: The bench seating will be reconfigurable to accommodate various dining arrangements, and will incorporate a storage component. The bench seating will consist of wood and metal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The installation of all furniture will be in accordance with the architectural drawings provided by team Massachusetts.

B. The installation of all furniture will take place after the 4D house is assembled and the interior finishes are complete.

END OF SECTION 12 58 00
SECTION 12 58 29
BEDS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Bed – Master Bedroom

B. Bed – Child Bedroom

1.02 RELATED REQUIREMENTS

A. 12 45 00 Bedroom Furnishings

1.03 REFERENCE STANDARDS

1.04 SUBmittals

PART 2 – PRODUCTS

2.01 Master Bed

2.02 Child Bed

PART 3 – EXECUTION (Not Used)

END OF SECTION 12 58 29
SECTION 12 58 36
NIGHTSTANDS

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Nightstands – Master Bedroom
   B. Nightstands – Child Bedroom

1.02 RELATED REQUIREMENTS
   A. 12 43 00 Portable Lamps

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 Master Bedroom Nightstands

2.02 Child Bedroom Nightstands

PART 3 – EXECUTION (Not Used)

END OF SECTION 12 58 36
DIVISION 21 – FIRE SUPPRESSION

SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 – GENERAL

1.01 SECTION INCLUDES
A. Tubing
B. Rings
C. Supports
D. Tees
E. Valves
F. Finishes
G. Sprinkler Assemblies
H. Cabinet
I. Adapters
J. Tools

1.02 RELATED REQUIREMENTS
A. 10 44 16 Fire Extinguishers

1.03 REFERENCE STANDARDS
A. UPC, IPC, NSPC, NPC
B. B137.5, ASTM F1960
C. ANSI/NSF 14/61, ICC ESR 1099, IAPMO 3558

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 PIPING AND FITTINGS
A. Manufacturer: Uponor Inc., 5925 148th Street West, Apple Valley, MN 55124 www.uponor-usa.com

B. AquaPEX Tubing, White
   1. 1/2 inch, Quantity: 100 foot
2. 3/4 inch, Quantity: 10 foot
3. 1 inch, Quantity: 200 foot

C. ProPEX Rings
1. Ring with Stop -1/2 inch, Quantity: 8
2. Ring with Stop - 3/4 inch, Quantity: 2
3. Ring - 1 inch, Quantity: 28

D. Supports
1. Tube Talon
   a. 1/2 inch, Quantity: 100
   b. 5/8 inch, Quantity: 100
   c. 3/4 inch, Quantity: 100
   d. 1 inch, Quantity: 100
2. PEX Wall Support Bracket
   a. 1/2 inch, Quantity: 3
   b. 3/4 inch, Quantity: 3
3. Plastic Bend Support - 1/2 inch, Quantity: 4

E. Tees
1. ProPEX LF Brass Tee
   a. 1inch PEX x 1 inch PEX x 1 inch PEX, Quantity: 1
   b. 1 inch PEX x 3/4 inch PEX x 1 inch PEX, Quantity: 1
   c. 1 inch PEX x 1 inch PEX x 1/2 inch PEX, Quantity: 1
2. EP Multi-port Tee
   a. 3/4 inch EP Branch Opposing Multi-port Tee- 3 Outlets, Quantity: 1

F. Valves
1. ProPEX EP Angle Stop Valve for 1/2 inch PEX, Quantity: 3
2. UL/FM Ball Valve Full Port 1 inch, Quantity: 1
G. Finishes
1. Concealed Flat Cover Plate - White, Quantity: 10
2. ProPEX LF Copper Tub Ell - 1/2 inch PEX x 1/2 inch Copper (3 inch x 4 inch), Quantity: 1
3. ProPEX Escutcheon for 1/2 inch PEX (11/16 inch O.D.) White, Quantity: 3

H. Sprinkler Assembly
1. RFC43 (165oF) Flat Concealed Sprinkler, Quantity: 10 inch

I. Cabinet
1. Sprinkler Cabinet without Sprinkler Heads, Quantity: 1

J. Adapters
1. ProPEX LF Brass Sweat Adapter -1 inch PEX x 1 inch Copper, Quantity: 1
2. Fire Sprinkler Adapter Push-On Nut, Quantity: 25
3. Fire Sprinkler Adapter Mounting Bracket
   a. 3/4 inch, Quantity: 10
   b. 1 inch, Quantity: 10
4. ProPEX LF Brass Fire Sprinkler Adapter Tee - 1 inch PEX x 1 inch PEX x 1/2 inch FNPT, Quantity: 10

K. Tools
1. In-Line Flow Test Kit, Quantity: 1
2. Concealed Sprinkler Wrench for RFC43 Heads, Flat, Quantity: 1
3. Cover Plate, Quantity: 1

PART 3 – EXECUTION (Not Used)

END OF SECTION 21 13 13
DIVISION 22 – PLUMBING

SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

PART 1 – GENERAL

1.01 SECTION INCLUDES:
A. Piping
B. Miscellaneous

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
A. NSF Standard 61 Drinking Water System Components - Health Effects

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 PIPING
A. Copper; Type L
B. Cross-linked Polyethylene (PEX)
C. PVC

2.02 GROUT

PART 3 – EXECUTION

3.01 GENERAL PIPING INSTALLATION
A. Install piping free of sags and bends.
B. Install Fittings for changes in direction and branch connections.

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

END OF SECTION 22 05 00
SECTION 22 11 16
DOMESTIC WATER PIPING

PART 1 – GENERAL

1.01 SECTION INCLUDES:
   A. Piping
   B. Fittings
   C. Joining Materials

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
   A. NSF-61 - health requirements
   B. ASTM F876 - dimensions and
   C. ASTM F877- ability to withstand pressure and temperature
   D. SDR 9 - Standard Dimension Ratio

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 PIPING AND FITTINGS
   A. Hard Copper Tubing: Type L
      1. Joining Material: lead-free flux
   B. Soft Copper Tubing: Type L
      1. Joining Material: lead-free flux
   C. Wirsbo PEX Tubing and Fittings

PART 3 – EXECUTION

3.01 PREPARATION
   A. Make sure that the pipe is clean and clear of debris.

3.02 INSTALLATION
   A. Install domestic water piping without pitch for horizontal piping and plumb for vertical piping.
3.03 INSPECTING
   A. Inspect all pipe as follows:
      1. Fill domestic water. Check components to determine that they are not air bound and that piping is full of water.
      2. Test for leaks and defects in new piping and parts of existing piping that have been altered extended, or repaired.

END OF SECTION 22 11 16
SECTION 22 11 19
DOMESTIC WATER PIPING SPECIALTIES

PART 1 – GENERAL

1.01 SECTION INCLUDES:
   A. Specialty Items

1.02 RELATED REQUIREMENTS
   A. 22 11 16 Domestic Water Piping

1.03 REFERENCE STANDARDS
   A. ASSE 1015
   B. AWWA C510
   C. ASTM F877
   D. ASTM F1960
   E. ANSI B18.18
   F. NSF 61-8

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 MANUFACTURED UNITS
   A. Reduced-Pressure Backflow Preventers
   B. Laundry Outlet Boxes
   C. Stop-and-Waste Drain Valves

PART 3 – EXECUTION

3.01 INSTALLATION
   A. Install backflow preventer at main water-supply connection.
   B. Install Cloths Washer Box To wall and connect pipes as specified by Manufacturer.
   C. Install Stop-and-Waste Drain Valves as specified by Manufacturer.

END OF SECTION 22 11 19
SECTION 22 12 19
FACILITY POTABLE WATER STORAGE TANKS

PART 1 – GENERAL

1.01 SECTION INCLUDES:
   A. Water Tanks
   B. Fresh Water Transfer Pump
   C. Pressure Regulating Tank

1.02 RELATED REQUIREMENTS
   A. 22 33 30.16 Residential, Storage Electric Domestic Water Heaters
   B. 22 33 30.26 Residential, Collector-to-Tank, Solar-Electric Domestic Water Heater

1.03 REFERENCE STANDARDS
   A. PPI 63101-016H
   B. XR3 FDA/NSF-61
   C. C-UL

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 DOMESTIC WATER STORAGE TANK
   A. Manufacturer: Aire Industrial, Model#: 951-015002
   B. Size: 1500 Gallon Fresh Water Bladder Tank, Dimensions 9' (W) x 13' (L) x 18" (H)
   C. One 4 inch PVC Fill Fitting/Scotty Cap and one 1-1/2" PVC Flange Fitting with PVC Ball Valve
   D. Bladder Tanks are manufactured using XR3 FDA/NSF-61 approved materials, which are specifically engineered for the storage of consumable fluids
   E. To view this product’s technical data, CLICK HERE

2.02 FRESH WATER TRANSFER PUMP
   A. Manufacturer: Craftsman model Professional 3/4 hp Hydro-Glass® Shallow Well Jet Pump
   B. Description: Used to provide a constant pressure to domestic water lines
   C. Motor: 3/4 Hp, Capacitor Start, Dual voltage 115 or 230

Published 11/23/2010
U.S. D.O.E. Solar Decathlon 2011
D. Tap Size: Discharge Two 1 inch, Suction 1-1/4 inches  
E. Pressure Rating: 40/60 PSI  
F. To view this product’s technical data, CLICK HERE

2.03 PRESSURIZATION TANK  
A. Manufacturer: Amtrol, Model WX-202P  
B. Description: Holds pressure in tank to reduce the amount of times the pump is needed. When pressure is dropped below a certain rating the pump will recharge the tank.  
C. Size: 20 Gallon 32-1/8” (H) x 15-3/8 (D)  
D. Pressure Rating: Pre-charge 38 PSI, Working Pressure 125 PSI  
E. Inlet/Outlet: 1” NPTF Stainless Steel  
F. To view this product’s technical data, CLICK HERE  

PART 3 – EXECUTION  
A. There must be an accessible area around openings for filling and emptying the tank of no less than 12 inches

END OF SECTION 22 12 19
SECTION 22 13 16
SANITARY WASTE PIPING AND VENT PIPING

PART 1 – GENERAL

1.01 SECTION INCLUDES:
   A. Piping
   B. Fittings
   C. Joining Material

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
   A. ASTM D 1784 - Rigid Vinyl Compounds
   B. ASTM D 1785 - PVC Plastic Pipe, Schedule 40
   C. ASTM D 2466 - PVC Plastic Fittings, Schedule 40
   D. ASTM D 2564 - Solvent Cements for PVC Pipe and Fittings
   E. NSF Standard 14- Plastic Piping Components and Related Materials
   F. NSF Standard 61 - Drinking Water System Components - Health Effects

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 PIPING
   A. Polyvinyl Chloride (PVC)
   B. Polyvinyl Chloride Fittings
      1. 1. Coupler
      2. 90 degrees
      3. 45 degrees
      4. Tee

2.03 Joining Materials
   A. Primer
   B. Cement

PART 3 – EXECUTION
3.01 PREPARATION
A. Prepare pipe by reaming burrs.
B. Remove scale dirt on inside and outside of pipe.
C. Prepare piping fittings.

3.02 INSTALLATION
A. Cut pipe to desired length.
B. Support pipe with hangers every 5 feet
C. Add Primer and Cement to pipe and fitting then press together holding for several seconds till cement has cured.

END OF SECTION 22 13 16
SECTION 22 13 53
FACILITY SEPTIC TANKS

PART 1 – GENERAL

1.01 SECTION INCLUDES:
  A. Water Tank

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
  A. ASTM D 751

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 GRAY WATER STORAGE TANK
  A. Manufacturer: Aire Industrial, Model#: 951-010001
  B. Size: 1000 Gallon Fresh Water Bladder Tank, Dimensions 9’ (W) x 12’ (L) x 16” (H)
  C. One 4 inch PVC Fill Fitting/Scotty Cap and one 1-1/2” PVC Flange Fitting with PVC Ball Valve
  D. Bladder Tanks are manufactured using rugged 22 oz. reinforced PVC fabrics, which are specifically engineered for the storage of gray water
  E. To view this product’s technical data, CLICK HERE

PART 3 – EXECUTION
  A. There must be an accessible area around openings for filling and emptying the tank of no less than 12 inches

END OF SECTION 22 13 53
PART 1 – GENERAL

1.01 SECTION INCLUDES:

A.  50 Gallon Back-Up DHW Storage Tank

B.  Heat Pump used to augment solar thermal system

1.02 RELATED REQUIREMENTS

A.  22 33 30.26 Residential, Collector-to-Tank, Heat-Exchanger-Coil, Solar-Electric Domestic Water Heaters

B.  22 11 23 Domestic Water Pumps

C.  22 05 00 Common Work Results for Plumbing

1.03 REFERENCE STANDARDS

A.  ANSI STANDARD 61 DRINKING WATER SYSTEM COMPONENTS

1.04 SUBMITTALS

A.  DHW system schematic

B.  Mechanical room layout drawing

PART 2 – PRODUCTS

2.01 BACK-UP HOT WATER STORAGE TANK

A.  Manufacturer:  State Water Heaters

B.  Description:  This 50-gallon tank (designated the back-up hot water tank) stores the DHW at the desired set point of 120 degrees F.  Its cold water inlet is connected to the 80-gallon solar hot water tank, and its hot water outlet is connected to the hot water piping for the home.  This tank’s water is heated primarily by the Green Star heat pump mounted on top of it, but also has a built-in electric element to augment the heat pump.

Published 11/23/2010

U.S. D.O.E. Solar Decathlon 2011
C. Equipment:
   1. State Water Heaters model ES6 50 DOCS
      a. Weight: 155
      b. Warranty: 10 years
      c. Substitutions: any 50 gallon electric hot water tank.
      d. To view this product’s technical data, CLICK HERE

2.02 HOT WATER HEAT PUMP
A. Manufacturer: USI Green Energy
B. Description: This heat pump operates by transferring heat from the surrounding air to the water stored in the tank on which it is attached. This technology is a relatively new application to an old idea, and is more than twice as efficient as traditional electric water heaters. A copper coil is inserted into the tank, through which the heat transfer fluid circulates. The heat pump should be able to keep the water at the desired set point for most loads. At high loads, the back-up electric element build into the tank will activate and augment the heat pump.
C. Equipment
   1. Green Star Model WH 270
      a. Weight: 48 lbs
      b. Warranty: 1 year labor, 6 year parts
      c. Substitutions: a 50-gallon hot water tank with a built-in electric heat pump could replace this heat pump along with the 50-gallon tank on which it sits.
      d. To view this product’s spec sheet, CLICK HERE.

PART 3 – EXECUTION

END OF SECTION 22 33 30.16
PART 1 – GENERAL

1.01 SECTION INCLUDES:
   A. SunDrum Hybrid Solar Collector System
   B. Solar-heated hot water tank storage tank

1.02 RELATED REQUIREMENTS
   A. 22 33 30.16 Residential, Storage Electric Domestic Water Heaters
   B. 22 11 23 Domestic Water Pumps
   C. 22 05 00 Common Work Results for Plumbing

1.03 REFERENCE STANDARDS
   A. ANSI Standard 61 Drinking Water System Components
   B. Solar Rating & Certification Corporation (SRCC) Standards

1.04 SUBMITTALS
   A. Solar hot water system schematic

PART 2 – PRODUCTS

2.01 SOLAR THERMAL SYSTEM
   A. Manufacturers
      1. Solar thermal panels: SunDrum Solar
      2. Controller: Steca Elektronik GmbH
      3. Expansion tank: Amtrol, Inc.
      4. Circulator pump: Grundfos
   B. Description: The closed-loop system used is the SDM300-6-B, consisting of two strings of three panels connected in parallel. This is a hybrid system that not only provides heat to the DHW system, but also helps cool the PV array. Each of the six panels is mounted directly underneath a PV panel, and hence will not be visible. While the sun is shining, heat from the PV panels is transferred to the fluid flowing through the...
SunDrum panels. This fluid is pumped to the 80 Gallon solar water tank, where it flows through a heat exchanger coil inside the tank. The heat is transferred to the water in the tank, and thus the fluid leaving the coil is cooler than the fluid exiting from the collectors. This cooler fluid then circulates back to the collectors and the process repeats. There is a temperature sensor in one of the collectors, and another in the water tank. A preprogrammed controller is connected to these two sensors. It activates a circulator pump when it detects a collector temperature 16° F higher than tank temperature and will shut the pump off when collector temperature drops to within 8° F higher than tank temperature. The heat transfer fluid is distilled water.

C. Equipment

1. Six (6) SunDrum SDM100 solar thermal collector panels.
   b. Operating temperature range: -40° C to +90° C
   c. Warranty: 10 years
   d. Substitutions: none. All components listed make up one complete system and are all provided by SunDrum Solar, LLC, per MOU with Team Massachusetts.

2. Six (6) SDM100 Connection Kits
   a. Each kit includes 2-3/8 inch barbs, 2 plugs, 2 stainless steel hose clamps, 5 feet of industrial hose, and 5 feet of UV resistant insulation.

3. One (1) HK-2 Header Kit
   a. x inch diameter copper piping
   b. Air expansion valve

4. Controller
   a. Steca Solar TR0301U
   b. For this product’s data sheet, CLICK HERE.

5. Pump Station: pump and check valve
   a. Grundfos Alpha pump
   b. For this product’s data sheet, CLICK HERE.

6. Expansion tank
   a. Amtrol Extrol Rx-15
   b. For this product’s data sheet, CLICK HERE.

7. Five Gallons of Distilled Water

2.02 SOLAR HOT WATER TANK

A. Manufacturer: Heat Transfer Products, Inc.

B. Description: This is a Heat Transfer Contender SSC-80SE 80 Gallon Water Tank that includes a built-in heat exchanger coil used for a solar thermal system. The water in this tank serves two purposes: as a “heat sink” to absorb heat from the solar thermal system; and as “pre-heat” tank for the “cold” water entering the back-up, 50 gallon hot water tank (see section 22 33 30.26). This tank will not be connected to power so that the electrical heating...
element in this tank will never turn on. The solar thermal system controller will control the water temperature in this tank.

C. Equipment
1. Manufacturer: Heat Transfer Products, Inc.
3. For this product’s data sheet, CLICK HERE.

2.03 DISTILLED WATER - 5 gallons

PART 3 – EXECUTION

3.01 INSTALLATION

A. Special Techniques


A. Interface with Other Work

1. The solar thermal panel installation must be coordinated with the installation of the PV system, since the panels are mounted directly into six PV panels. Exact location of the six chosen PV panels in the PV array must be confirmed, so that SunDrum solar panels are placed correctly.

3.02 SYSTEMS START-UP

A. This closed loop solar thermal system must be charged differently than most solar thermal systems. Follow steps in SunDrum Solar SDM300 Series Installation Manual starting under the heading “System Startup and Shutdown”.

END OF SECTION 22 33 30.26
DIVISION 23 – HEATING, VENTILATING AND AIR-CONDITIONING

23 31 13.16
ROUND AND FLAT-OVAL SPIRAL DUCTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Metal ductwork
B. Duct fittings

1.02 RELATED SECTIONS

A. Section 23 33 13 – Back Draft Dampers
B. Section 23 37 13 – Diffusers, Registers, and Grilles
C. Section 23 72 00 – Air to Air Energy Recovery Equipment
D. Section 23 81 26 – Split System Air Conditioner

1.03 REFERENCE STANDARDS

A. National Fire Protection Association (NFPA) 90A, Standard for the Installation of Air Conditioning and Ventilating Systems
B. American Society for Testing and Materials (ASTM) A653, Standard specifications for Steel Sheet, Zinc-coated (Galvanized) or Zinc-Iron Alloy Coated (Galva-nealed) by the hot-dip process.
C. Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA) – HVAC Duct Construction Standards (DCS) – Metal and Flexible

1.04 SUBMITTALS

A. Construction Drawings, Ductwork
B. Product datasheets from manufacturer

1.05 QUALITY ASSURANCE

A. Qualifications
   1. Company specializing in manufacturing the type of products used here should have a minimum of three years of documented experience.
PART 2 – PRODUCTS

2.01 MANUFACTURERS
A. Fantech
B. The Duct Shop

2.02 MATERIALS
A. Ductwork
   1. Rigid ducts are hot dipped galvanized steel, ASTM A653/A653M FS type B, with G60/Z180 coating.
   2. 5”, 8”, and 10” circular ductwork is used.
   3. Minimal amounts of flexible round insulated ductwork will be used.

B. Duct fittings
   1. Saddle taps on round – The Duct Store
      a. 6” saddletap to fit on 10” round; for supply run off to secondary bedroom.
      b. 6” saddletap to fit on 8” round; for fresh air supply run off to HRV.
      c. 26 gauge galvanized steel
   2. Reducer – Fantech
      a. Fantech CKR Series (Model CKR 54); 5” to 4”
      b. Use to reduce 5” HRV return to 4” for bathroom return
      c. Length in line: 3 ¾”
   3. Reducer – The Duct Shop
      a. (2) 10” to 6”; reduce 10” main line to 6” bedroom registers
      b. (2) 6” to 5”; (1) expand 5” HRV supply collar to 6” to use the 6” saddletap on the 8” fresh air supply duct, and (1) expand 5” HRV exhaust collar to 6” to then expand to 8”, for the combined 8” exhaust duct.
      c. (1) 6” to 8”; expand 6” HRV exhaust section to 8” for 8” combined exhaust.
      d. 26 gauge galvanized steel
   4. Elbows – The Duct Shop
a. 45 degree adjustable elbow; 8”, 5”, 4”
b. 90 degree adjustable elbow, 10”, 8”, 5”, 4”
c. 26 gauge galvanized steel

5. Wye adapters – The Duct Shop

a. 10 x 10 x 8”; used to connect dehumidifier supply to main 10” supply.
b. 10 x 10 x 10”; to split heat pump supply.
c. 8 x 8 x 8”; used to branch the dehumidifier exhaust into the combined exhaust.
d. 26 gauge galvanized steel

C. Exterior Vents, weather hoods – Fantech

1. Roof cap (Model RC 8), 8”, with damper flap closure, duct connection and screened exhaust opening.
   a. Total height from bottom of collar to top of bend: 11 ¾”
2. Supply outdoor weather hood (Model FML 8, UPC # 24118), 8”, single unit

D. Duct accessories – Fantech

1. Stabilizing mounting clamps (5”, 8”, 10”) – two inch wide galvanized steel bands lined with neoprene
2. Inlet guards (8”) – Wire ring, zinc chromate plated steel. Used at fresh air intake.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Special instructions
   1. Minimize flexible ductwork.
   2. A rectangular to round transition is required to connect the Mr. Slim unit.
   3. Use fittings that minimize head loss.
   4. Maintain access to volume dampers and backflow dampers for airflow tuning and maintenance.

END OF SECTION 23 31 13.16
SECTION 23 33 13
BACK DRAFT DAMPERS

PART 1 – GENERAL

1.01 SECTION INCLUDES
A. Back draft dampers
B. Volume dampers

1.02 RELATED SECTIONS
A. Section 23 31 13.16 – Round and Flat-Oval Spiral Ducts

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS
A. Construction Drawings, Ductwork

1.05 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializes in manufacturing the products specified in this section with minimum 10 years’ experience.

1.05 SYSTEM DESCRIPTION
A. Back draft dampers are used where backflow could occur.

B. Supplies from air-to-air heat pump, HRV, and dehumidifier are combined to form a single supply duct. Returns from house and from bathroom combine before entering the HRV. A single fresh air and single exhaust house penetration serve both the dehumidifier and HRV. Back draft dampers are needed in the house supply and exhaust lines, mainly where duct runs join together.

C. Not included in this section are back draft dampers installed at the diffuser/register collar. See Section 23 37 13 – Diffusers, Registers, and Grilles.

D. Volume dampers are used to control the airflow to/from equipment and the house.

E. Volume dampers are needed in the return line to the house to the dehumidifier, in the supply from the house to the dehumidifier, and at the combined supply to the house and to each bedroom.
PART 2 – PRODUCTS

2.01 MANUFACTURERS
   A. Fantech

2.02 MATERIALS
   A. Back draft damper
      1. RSK back draft dampers, models RSK 8 and RSK 10 (UPC # 69080 and 69100)
      2. 8” diameter and 3 1/8” wide, 10” diameter and 3” wide
      3. Galvanized Steel Collar and Lightweight Aluminum Damper Blades
      4. Spring loaded for positive closure
   B. Volume damper
      1. Iris Damper, models IR 6, IR 8, and IR10 (UPC # 63060, 63080, 63100)
      2. 6” diameter and 2” wide, 8” diameter and 2 ¼” wide, 10” diameter and 2 3/4” wide
      3. Include calibrated airflow measuring device.

PART3 – EXECUTION

3.01 INSTALLATION
   A. Install back draft dampers in locations to eliminate backflow.
   B. Install volume dampers in locations where air tuning is required.
   C. Follow manufacturer’s instructions for ductwork installation, and follow measures for maximizing efficiency.

END OF SECTION 23 33 13
SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Diffusers
   B. Registers
   C. Dampers installed at diffuser collar

1.02 RELATED SECTIONS
   A. Section 23 31 13.16 – Round and Flat-Oval Spiral Ducts

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS
   A. Product datasheet from manufacturer.

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. Fantech
   B. Hart and Cooley

2.02 PRODUCTS
   A. Supply and exhaust grilles
      1. Fantech DG Series exhaust grille (Model DG 4, UPC # 67940)
         a. Low profile, fixed circular plastic.
         b. Used in bathroom ceiling; return from bathroom to HRV.
         c. For use with 4” duct; duct connections are 1/8” smaller than duct size.
d. Matching diameter galvanized mounting collar with nailing strip is included.

  e. Total length: 3 ¾”, grille outer diameter: 4 7/8”

2. Hart and Cooley CBPS/CBPR T-bar curved-blade perforated supply/return diffuser, steel
   a. Used at each 6” diameter bedroom supply, at the 8” dehumidifier hallway return, and at the 10” combined hallway supply.
   b. Dimension: 23-¾” x 23-¾”
   c. Perforated steel face, white finish
   d. Available in 6”, 8”, 10”, 12”, 14”, and 16” diameter necks.
   e. 2” high collar permits easy flex connections
   f. Individually adjusted pattern deflectors can be field-adjusted for 1, 2, 3-way air patterns.

3. Hart and Cooley T-bar accessories
   a. 5400 Series Collar Ring; 2” high collar permits easy flex connections.
   b. 3800 Series adjustable damper; for use with 5400 series collar.

PART 3 – EXECUTION

3.01 INSTALLATION
   A. Follow manufacturer’s instructions for installation

END OF SECTION 23 37 13
SECTION 23 40 00
SUPER ULTRA-LOW PENETRATION FILTRATION

PART1 – GENERAL

1.01 SECTION INCLUDES
A. Super Ultra-Low Penetration Air-filters

1.02 RELATED SECTIONS
A. Section 23 37 13 – Diffusers, registers, and grilles

1.03 SUBMITTALS
A. Product datasheet from manufacturer.

PART2 – PRODUCTS

2.1 MANUFACTURERS
A. Flanders Corporation

2.2 Materials
A. Flanders Precisionaire 2 inch LEED MERV 13 Filters
B. Actual filter face size for 12 inch x 24 inch and 24 inch x 24 inch filters is 5/8 inch under on height and width
   Actual face size on all other sizes is 1/2 inch under on height and width
C. Actual filter depth is 1/4 inch under for these nominal 2 inch deep filters

PART3 – EXECUTION (Not Used)

END SECTION 23 40 00
SECTION 23 72 00
AIR TO AIR ENERGY RECOVERY EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Ventilation Equipment

1.02 RELATED SECTIONS
   A. Section 23 31 13.16 - Round and Flat-oval Spiral Ducts

1.03 REFERENCE STANDARDS
   A. HVI, CSA C22.2

1.04 SUBMITTALS
   A. Product datasheet from manufacturer

1.05 QUALITY ASSURANCE
   A. Manufacturer Qualifications: Company specializes in manufacturing the products specified in this section with minimum 10 years’ experience.


PART 2 – PRODUCTS

2.01 MANUFACTURERS
   A. Nu-Air Ventilation Inc.

2.02 COMPONENTS
   A. Heat Recovery Ventilator (HRV), Model ES100

   B. Housing/Core
      1. Painted 0.032 Aluminum casing with a white enamel finish
      2. Cabinet insulation is 1-inch polyurethane

U.S. D.O.E. Solar Decathlon 2011
Published 11/23/2010
3. Core is a cross-flow heat exchanger

C. Characteristics

1. Defrosting system for outdoor conditions below -5 degrees Celsius.
2. Polyester Air Filters: MERV rating of 9
3. Expanded Polystyrene Insulation
4. 24 V circuit protection with self resetting fuse

D. Specifications

1. Airflow: 104-129 CFM at 0.4 in wg
2. Electrical: 120V/1 /60 Hz, 0.7 A, 84 W

E. To view this product’s technical data, CLICK HERE.

PART 3 – EXECUTION

3.01 PREPARATION

A. Clean surfaces thoroughly prior to installation. Remove all debris and confirm structural support for connections and supporting elements.

B. Verify all clearances and requirements as specified by manufacturer.

3.02 INSTALLATION

A. Follow manufacturer’s instructions for handling and installation, and follow measures for maximizing efficiency in the duct layout.

B. Install units with adequate spacing to access heat recovery coils and filters for maintenance.

C. To view this product’s technical data, CLICK HERE.

END OF SECTION 23 72 00
PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Indoor and outdoor units of split-ducted air-conditioning system
   B. Refrigerant piping
   C. Controls
   D. Fan

1.02 RELATED SECTIONS
   A. Section 23 31 13.16 - Round and Flat-oval Spiral Ducts

1.03 REFERENCE STANDARDS
   A. Comply with ASHRAE 15, EPA, AHRI, UL, ETL and ISO Standards

1.04 SUBMITTALS
   A. Product datasheet from manufacturer

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. Mitsubishi Electric

2.02 COMPONENTS
   A. Mr. Slim Concealed Duct Mini Split Heat Pump System
      1. Includes (1) SEZKD09NA4 Indoor unit and (1) SUZKA09NA Outdoor condensing unit
      2. External finish: Galvanized-steel sheets
      3. Built-in drain mechanism for condensate removal
      4. Polypropylene Honeycomb Air filter included with indoor unit
5. Cooling capacity: 8100 BTU, Cooling capacity range: 3,800 – 10,900 BTU
6. Heating capacity: 10,900 BTU, Heating capacity range: 4,800 – 14,100 BTU
7. Total Input: 670 W Cooling and 1,020 W heating
8. Power Supply: 1-phase, 60 Hz, 208/230V
10. Weight: 42 lb (indoor unit), 66 lb (outdoor unit)
11. Dimensions [W x D x H]: 31-1/8” x 27-9/16” x 7-7/8” (Indoor unit), 31-1/2” x 11-1/4” x 21-5/8” (outdoor unit).

B. Refrigerant
   1. R410A refrigerant
   2. Piping: Insulated Copper tubing size at gas side 3/8 inch and liquid side 1/4 inch

C. Controls
   1. PAR-21 MAA wired remote controller included
   2. Indoor unit powered from outdoor unit using A-Control
   3. Automatic fan speed control
   4. Auto restart following a power outage

D. Fan
   1. Two Sirocco Fans
   2. Direct-driven DC Brushless Motor
   3. Motor Output: 96W

E. To view these products technical data, CLICK HERE.

PART 3 – EXECUTION

3.01 PREPARATION
   A. Clean surfaces thoroughly prior to installation
   B. Mount the indoor unit into a ceiling strong enough to withstand the weight of the unit

3.02 INSTALLATION
   A. Perform the installation securely referring to the product installation manual.
B. Be sure to install the unit level

C. Use an exclusive circuit as accordance to NFPA 90B.

D. To view this product’s technical data, CLICK HERE.

END OF SECTION 23 81 26
SECTION 23 84 16  
DEHUMIDIFIER

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Dehumidifier

1.02 RELATED SECTIONS
   A. Section 23 31 13.16 – Round and Flat-oval Spiral Ducts

1.03 REFERENCE STANDARDS
   A. ETL listed, UL 474

1.04 SYSTEM DESCRIPTION
   A. Ducted, with dedicated return to main supply.

1.05 SUBMITTALS
   A. Product datasheet from manufacturer.

PART 2 – PRODUCTS

2.01 MANUFACTURER
   A. Honeywell International Inc.

2.02 COMPONENTS
   A. Honeywell TrueDRY DR65 ventilating dehumidification system
      1. Energy performance: 2.22 liters (4.7 pints) per kilowatt hour.
      2. Dimensions (L x W x H) / weight: 28.5” x 12” x 12” / 55 lbs (length includes duct collars)
      3. Electrical: 120V AC, 60HZ, 5.2 Amps
      4. Blower: 160 CFM @ 0.0 inches WG
      5. Capacity at 60% RH: 21 pints/day (60 F), 42 pints/day (70 F), 65 pints/day (80 F)
      6. Drain connection: ¼” threaded female NPT, with attached ¾” threaded male NPT.

Published 11/23/2010 
U.S. D.O.E. Solar Decathlon 2011
7. Refrigerant: R-410A
8. Filter: standard MERV-11, 1” (D) x 9” (H) x 11” (W)
9. Duct connections: 8” duct collars for inlet and outlet, ABS plastic
10. For this product’s data sheet, CLICK HERE.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation must conform to NEC, ANSI/NFPA 70 and National Fuel Gas Code ANSI Z223.1

B. Install in accordance with manufacturer’s instructions.

C. Use backdraft damper immediately before connection of dehumidifier outlet to main supply.

C. Allow for adequate clearances for servicing and proper operation.

END OF SECTION 23 84 16
DIVISION 26 - ELECTRICAL

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

PART 1 – GENERAL

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

1.02 RELATED SECTIONS
   A. Section 26 05 33 – Raceway and Boxes for Electrical Systems

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

1.05 QUALITY ASSURANCE
   A. Conform to requirements of NFPA 70.
   B. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with a minimum of 10 years experience.
   C. Products: Furnish products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 – PRODUCTS

2.01 MANUFACTURERS
   A. Southwire
   B. General Cable

U.S. D.O.E. Solar Decathlon 2011
2.02 MATERIALS

A. Southwire CU-USE wire
   1. Type USE-2 copper conductor
   2. Insulation voltage rating: 600V
   3. Cross-linked polyethylene insulation

B. Southwire Simpull THWN-2 wire
   1. Type THWN-2 copper conductor
   2. Insulation voltage rating: 600V
   3. Thermoplastic insulation/SIM nylon sheath

C. Southwire bare copper wire

D. Southwire Romex wire

E. General Cable, Carol Brand 18-3 thermostat wire
   1. 150V
   2. Type CL2

F. Belden RG6/U cable
   1. Quad shielded
   2. Coaxial

D. Wiring Connectors
   1. In accordance with UL and NEC.
   2. Branch Circuits 10 AWG and smaller:
      a. Connectors shall be solderless, screw-on, pressure cable type, 600 volt, 105 degrees C, with integral insulation; approved for copper and aluminum conductors, and reusable.
      b. Integral Insulator: Must have skirt to completely cover stripped wires.
      c. Comply with manufacturer’s listing/labeling as to the number, size, and combination of conductors that may be joined.
3. Feeder Circuits: Connectors shall be indent, hex screw, or bolt-clamp type. Material shall be highly conductive and corrosion resistant.

2.03 WIRING REQUIREMENTS

A. See “Conductor and Conduit Schedule” on page E-602 (Three-line diagram) of Construction Documents for required wire gauges/colors.

B. Concealed Dry Interior Locations: Use only building wire in raceway, nonmetallic-sheathed cable, armored cable, or metal clad cable.

C. Exposed Dry Interior Locations: Typically, use only building wire in raceway.
   1. At equipment rooms use building wire in raceway, nonmetallic-sheathed cable, armored cable, or metal clad cable.

D. Wet or Damp Interior Locations: Use only building wire in raceway, direct burial cable, armored cable with jacket, or metal clad cable.

E. Exterior Locations: Use only building wire in raceway, direct burial cable, service-entrance cable, armored cable with jacket, or metal clad cable.

F. Underground Installations: Use only building wire in raceway, direct burial cable, or service-entrance cable.

G. Use solid conductor for feeders and branch circuits 10 AWG and smaller.

H. Use stranded conductors for control circuits.

I. Use minimum of 12 AWG conductors for power and lighting circuits.

J. Use minimum of 16 AWG conductors for control circuits.

K. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 25 meters (75 feet).

L. Use 10 AWG conductors for 20 ampere, 240 volt branch circuits longer than 60 meters (200 feet).

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that any mechanical work likely to damage wire and cable has been completed.

B. Verify that raceway installation is completed and supported.

3.02 PREPARATION

A. Swab raceway before installing wire.
B. Clean conductor surfaces before installing lugs and connectors.

3.03 INSTALLATION

A. Install wire and cable securely and neatly, as in NECA 1.

B. Route wire and cable as required to meet project conditions.

1. Wire and cable routing indicated is approximate unless dimensioned.

C. Pull all conductors into raceway at same time.

D. Protect exposed cable from damage.

E. Neatly train and lace wiring inside boxes, equipment, and panelboards.

F. Trench and backfill for direct burial cable installation. Install warning tape along entire length of direct burial cable, within 75 millimeters (3 inches) of grade.

END OF SECTION 26 05 19
SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY
   A. Ground rod kit
   B. Washer Electrical Equipment Bond (WEEB) hardware

1.02 RELATED SECTIONS
   A. Section 05 14 13 – Architecturally-exposed structural aluminum

1.03 REFERENCE STANDARDS
   A. UL 467, CSA C22.2#41 2007

1.04 SUBMITTALS
   A. Product datasheet from manufacturer

PART 2 – PRODUCTS

2.01 MANUFACTURERS
   A. Wiley Electronics LLC

2.02 MATERIALS
   A. Copper Bonded Grounding Rod 5/8 inch x 8/ feet
   B. Bronze Clamps
   C. Conductor
   D. Ground Rod Connector
   E. Drive Sleeve
   F. WEEB-DMC Compression Clip
   G. WEEBL-6.7 Grounding Lug
   H. WEEB Bonding Jumper-6.7
PART 3 – EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. WEEBs are single use only.

C. WEEB clip and lug assembly: Tighten fasteners to 10 ft-lb / 13.5 N-m using general purpose anti-seize compound on threads.

D. WEEB lug assembly: Lay in equipment grounding conductor and tighten bolt to 7 ft-lb / 10 N-m.

E. WEEB bonding jumper assembly: Torque to 10 ft-lb / 13.5 N-m using general purpose anti-seize compound on threads.

END OF SECTION 26 05 26
PART 1 – GENERAL

1.01 SUMMARY
   A. RACEWAY
   B. CONDUITS

1.02 RELATED SECTIONS
   A. 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

1.03 REFERENCE STANDARDS
   A. UL 797 – Electrical Metallic Tubing.
   B. UL 514B Conduit, Tubing and Cable Fittings.
   C. UL 6 – Electrical Rigid Metal Conduit – Steel
   D. ANSI C80.1 – Electrical Rigid Steel Conduit
   E. ANSI C80.3 – Steel Electrical Metallic Tubing.
   F. ANSI B1.20.1 – Pipe Threads, General Purpose.
   G. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 2003.

1.04 SUBMITTALS

1.05 QUALITY ASSURANCE
   A. Conform to requirements of NFPA 70
   B. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with a minimum of 10 years experience.
   C. Products: Furnish products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Allied Electrical Group
B. JM Eagle

2.02 MATERIALS

A. Allied Kwik-Fit EMT (Electrical Metallic Tubing) for indoors, 1-1/4 inch Trade Size
   1. Nominal outside diameter: 1.510 inch
   2. Nominal wall thickness: 0.065 inch
   3. Approximate weight per 100 Feet: 101 pounds
   4. Bundle: 840 feet, approx. 720 pounds
   5. To view this product’s technical data, CLICK HERE

B. Allied Rigid Steel Conduit, hot-dip galvanized steel, exterior, 1-1/2 inch Trade Size
   1. Nominal outside diameter: 1.900 inch
   2. Nominal wall thickness: 0.138 inch
   3. Approximate weight per 100 Feet: 263 pounds
   4. Bundle: 800 feet
   5. Allied RIGID is recognized as an equipment grounding conductor by NEC Article 250.
   6. To view this product’s technical data, CLICK HERE

C. JM Eagle Electrical Conduit
   1. PVC/non-metallic
   2. ANSI/UL 651 conforming
   3. NEMA TC-2 conforming
   4. To view this product’s technical data, CLICK HERE

PART 3 – EXECUTION (Not Used)

END OF SECTION 26 05 33
PART 1 – GENERAL

1.01 SUMMARY

A. CIRCUIT BREAKERS

B. LOAD CENTERS

1.02 SUBMITTALS

A. Construction Drawings: Wiring diagram

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Schneider Electric

2.02 PRODUCTS

A. Homeline Load Center HOM1632L200TC, single phase, indoor main lugs, ground bar included.
   1. 32 branch circuits
   2. 200 Amp Mains Rating
   3. To view this product’s technical data, CLICK HERE

B. QO Load Center QO612L100RB, single phase, outdoor main lugs, ground bar sold separately
   1. 12 branch circuits
   2. 100 Amp Mains Rating
   3. To view this product’s technical data, CLICK HERE

PART 3 – EXECUTION (Not Used)

END OF SECTION 26 24 16
PART 1 – GENERAL

1.01 SUMMARY

A. Wall Receptacles

B. Switches

1.02 RELATED SECTIONS

A. 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

1.03 REFERENCE STANDARDS

A. UL 2003

B. UL 943

C. UL 1472

D. CSA C22.2 184.1

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Hubbell

B. Leviton

2.02 MATERIALS

A. Hubbell Tamper-Proof Receptacle RRD15SWTR

1. 15A/125V

2. Self-Grounding

3. To view this product’s technical data, CLICK HERE

B. Hubbell Tamper-Proof Receptacle DR20WHITR

1. 20A/125V
2. 3-Wire Grounding

3. To view this product’s technical data, CLICK HERE

C. Leviton Single-Pole Switch 5601-2W

1. 15A/120V

2. To view this product’s technical data, CLICK HERE

D. Leviton 3-Way Switch 5603-2W

1. 15A/120V

2. To view this product’s technical data, CLICK HERE

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

END OF SECTION 26 27 00
PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

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

PART 2 - PRODUCTS

2.01 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

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

2.02 MANUFACTURERS

A. Landis & Gyr

B. General Electric

2.03 MATERIALS

A. Landis & Gyr Meter Socket UAT-4

1. Single phase, 200A

2. OH/UG Service feeder location

3. Standard 4-jaw, ringless

4. NEMA 3R, rainproof enclosure

5. To view this product’s technical data, CLICK HERE

B. GE Singlephase Meter I-210+c

1. ANSI C12.1, C12.10, C12.20, C37.90.1 conforming

2. To view this product’s technical data, CLICK HERE

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

END OF SECTION 26 27 13
PART 1 – GENERAL

1.01 SUMMARY

A. NONFUSIBLE SWITCHES

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

A. UL98, Standard for Safety, Enclosed and Dead Front Switches. UL Listed under File E2875, or E154828.

B. NEMA Standards Publication KS1, Enclosed Switches.

C. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 V maximum); National Electric Manufacturers Association; 2001 (R2006).


1.04 SUBMITTALS

A. Construction Documents: Electrical wiring diagram.

1.05 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.

C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Schneider Electric

2.02 COMPONENTS

A. Square D DC Disconnect Switch, model HU362RB, 3-pole, unfused.
1. Product Data
   a. Current Rating: 60 Amp
   b. Voltage Rating: 600 Volt DC
   c. Weight: 6 pounds
   d. Dimensions: (H D W): 17.5 inch x 10.5 inch x 7.25 inch
   e. To view this product’s technical data, CLICK HERE

PART 3 - EXECUTION (Not Used)

END OF SECTION 26 28 16
PART 1 – GENERAL

1.01 SUMMARY

A. Photovoltaic Modules, Frame, Junction Box, and Cables

B. Transition Box

1.02 RELATED SECTIONS

A. Section 26 27 17 – Equipment Wiring: Connection to facility power distribution.

B. Section 48 19 16 – Electrical Power Generation Inverters

1.03 REFERENCE STANDARDS

A. Photovoltaic modules


2. UL 1703 – Flat Plate Photovoltaic Modules and Panels; 2002.

3. UL 4703 – Photovoltaic Cable.

4. IEC 61215 – Crystalline Silicon Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval; 2005; ed. 2.

5. IEC 61730 – Photovoltaic (PV) Module Safety Qualification; 2004; Class A.

6. UL Fire Safety Class C.

B. Combiner Box


2. CAN/CSA C22.2 No. 0.4-04 Bonding of Electrical Equipment; 2004.

3. CAN/CSA C22.2 No. 0.12-M1985 Wiring Space and Wiring Banding Space in Enclosures for Equipment Rated 760 V or Less.

4. CAN/CSA-C22.2 No. 0-M91 General Requirements – Canadian Electrical Code, Part II.

1.04 SUBMITTALS

A. Construction Drawings: Wiring diagram
PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Sunpower

B. Wiley Electronics

2.02 MATERIALS

A. SunPower E19/240 Photovoltaic Modules
   1. Description: 72 silicon solar cells in frame, factory assembled with junction box, series interconnection cables, bypass diodes located in junction box; IEC 61215 compliant, UL 1703 listed.
   2. Maximum System Voltage (UL): 600 Volt
   3. Rated Power: 240 Watt
   4. Rated MPP Voltage: 40.5 Volt
   5. Rated MPP Current: 5.93 Amp
   6. Open Circuit Voltage: 48.6 Volt
   7. Short Circuit Current: 6.30 Amp
   8. Series Fuse Rating: 20 Amp
   9. To view this product’s technical data, CLICK HERE

B. Wiley Electronics ACE-2P Pass-through Box
   1. Description: 2-string, unfused, with anodized aluminum mounting bracket.
   2. To view this product’s technical data, CLICK HERE

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Provide DC and AC lightning protection devices to protect inverter and PV modules.

C. Provide minimum clearance of 7mm (1/4 inch) between PV panels to allow for thermal expansion of the frames.
D. Note: SunPower modules are positively grounded. See installation manual for grounding requirements.

3.02 SAFETY

A. Install according to manufacturer’s handling, installation, and fire safety requirements and recommendations.

3.03 INSPECTION

A. Provide the services of manufacturer-training personnel to inspect and commission the system:

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.


END OF SECTION 26 31 00
SECTION 26 51 00
INTERIOR LIGHTING

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. LED LIGHTING
   B. FLUORESCENT

1.02 RELATED REQUIREMENTS
   A. 26 06 50 Schedules for Lighting

1.03 REFERENCE STANDARDS
   A. UL listed, ETL listed

1.04 SUBMITTALS
   A. Product Data

PART 2 – PRODUCTS

2.01 LED
   A. BKSSL
      1. BQL-LED-E22-WHP-D, SL Brickstar Louvered 8 watt, e22 lamp, 2 Fixtures
   B. USAI
      1. 3140-10-S-LSTA4-8420-C1-20W-30-30-NC-120-DIML3, R1 BeveLED Adjustable 40 degree, 5 Fixtures
   C. ALKCO
      1. ARIS-21-40-120-PRL-HWC/AJC6, L1 LED Task Light, 4 Fixtures
      2. ARIS 41-40-120-PRL-HWC/AJC6, L2 LED Task Lamp, 1 Fixture
   D. Amerlux
      1. CNTRV22-12-LED-E—WT-C-120-NF-3000-DIM, R3 Canopy, 4 Fixtures
   E. Insight
1. 3140-10-S-LSTA4-8420-C1-20W-30-30-NC-120-DIML3, R1 BeveLED Adjustable 40 degree, 4 Fixtures

F. Philips

1. PW01L30SAU-LED-6W-3000K-120+SG02L, S1 Wall Mount, 2 Fixtures

2.02 FLUORESCENT

A. ADA

1. CSS2030-1-FC12T9-32W / 835-14, 1/2 inch to 3 inch, S2, 1 Fixture

B. ALKO

1. TAB125-ASY-120-BA/AL-CL+LS, F1 Surface Mount, 8 Fixtures

PART 3 – EXECUTION (Not Used)

END OF SECTION 26 51 00
SECTION 26 56 00

EXTERIOR LIGHTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Exterior House Lighting

1.02 RELATED REQUIREMENTS

A. 26 06 50 Schedules for Lighting

1.03 REFERENCE STANDARDS

A. UL listing

1.04 SUBMITTALS (Not Used)

PART 2 – PRODUCTS

2.01 HOUSE LIGHTING

A. Lumiere

1. 904-12WLEDN-3000K-12-BK-NBR, T2 Canopy, 9 Fixtures

2. 213-12WLEDW-3000K-12-BK-NBR, T1 Canopy, 2 Fixtures

PART 3 – EXECUTION (Not Used)

END OF SECTION 26 56 00
DIVISION 27 - COMMUNICATIONS

SECTION 27 21 00
DATA COMMUNICATION NETWORK EQUIPMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES
A. DATA LOGGING EQUIPMENT
B. RELATED SYSTEMS

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS
A. NFPA 70, Article 100, 2008 NEC

1.04 SUBMITTALS
A. Product datasheets

PART 2 – PRODUCTS

2.01 Manufacturers
A. Powerhouse Dynamics
B. Solectria Renewables

2.02 Dataloggers
A. eMonitoring System for energy consumption monitoring and logging.
B. Solrenview for PV production monitoring and logging, with revenue grade and weather station options.
C. For technical data on these products, CLICK HERE.

PART 3 – EXECUTION

3.01 INSTALLATION
A. Comply with product installation manual and related NEC codes
B. Connect the device to all the monitored sensors and systems

END OF SECTION 27 21 00

U.S. D.O.E. Solar Decathlon 2011
SECTION 27 21 33
DATA COMMUNICATION WIRELESS ACCESS POINTS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. WIRED DATA CONNECTIVITY EQUIPMENT
B. WIRELESS DATA CONNECTIVITY EQUIPMENT

1.02 RELATED REQUIREMENTS

A. Data communication modem and switch

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 Manufacturer

A. DLink

2.02 DIR-632 8 Port Wireless n Router

A. 802.3z, 10/100/1000 Mbps wired network access
B. 802.11n, for wireless standard
C. For datasheet on this product, CLICK HERE.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with product installation manual and related NEC codes
B. Service is used by all the devices connect to the Ethernet port and WIFI

END OF SECTION 27 21 33

U.S. D.O.E. Solar Decathlon 2011

Published 11/23/2010
PART 1 – GENERAL

1.01 SECTION INCLUDES

A. PERSONAL COMPUTER

1.02 RELATED REQUIREMENTS

REFERENCE STANDARDS

A. Electrical Components, Devices and Accessories Listed and labeled as defined in NFPA 70, Article 100

1.04 SUBMITTALS

A. Product datasheet: Manufacture specification sheets for all the products listed under products

PART 2 – PRODUCTS

2.01 Manufactures

A. Hewlett-Packard

2.02 Laptop

A. HP Pavilion dv7 Notebook PC

B. To view this product’s datasheet, CLICK HERE.

PART 3 – EXECUTION

3.01 INSTALLATION
A. Comply with product installation manual and related NEC codes

B. Connect the device to the communication network device

END OF SECTION 27 22 26
DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

SECTION 28 31 46
SMOKE DETECTION SENSORS

PART 1 – GENERAL

1.01  SECTION INCLUDES

A. Smoke detectors

1.02  RELATED SECTIONS

A. 27 15 00 COMMUNICATIONS HORIZONTAL CABLING

1.03  REFERENCE STANDARDS

A. UL 268, National Fire Alarm Code, NFPA 72, Article 760 NEC

1.04  SUBMITTALS

PART 2 – PRODUCTS

2.01  ALARM-INITIATING DEVICES

A. Kidde Firex i5000 Smoke detectors: UL-listed, 120 - Vac with 9-Vdc back-up, ionization type, hardwired.

1. For this product’s technical data, CLICK HERE.

2.02  NOTIFICATION APPLIANCES

A. Built-in piezoelectric horn rated at 85 decibels at 10 feet.
2.03 WIRE AND CABLING

A. General: UL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.

   1. Low-voltage Circuits: No. 16 AWG, minimum.
   2. Line-Voltage Circuits: No. 12 AWG, minimum.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install and test systems per manufacturer's instructions, NFPA 72 and NEC Article 760.

B. Wiring Method: Install wiring interior to walls and ceilings as indicated in schematics.

C. Wire all alarms to a single, continuous (non-switched) power line, not protected by a ground fault interrupter.

END OF SECTION 28 31 46
SECTION 28 31 49
CARBON MONOXIDE DETECTION SENSORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Carbon monoxide detector

1.02 RELATED SECTIONS

A. 27 15 00 COMMUNICATIONS HORIZONTAL CABLELING

1.03 REFERENCE STANDARDS

A. UL 268, National Fire Alarm Code, NFPA 72, Article 760 NEC

1.04 SUBMITTALS

PART 2 – PRODUCTS

2.01 ALARM-INITIATING DEVICES

A. First Alert C05120BN Carbon Monoxide Alarm

   1. For this product’s technical data, CLICK HERE.

2.02 NOTIFICATION APPLIANCES

A. Built-in piezoelectric horn rated at 85 decibels at 10 feet.

2.03 WIRE AND CABLELING

A. General: UL listed and labeled as complying with NFPA 70, Article 760.

Published 03/22/2011

U.S. D.O.E. Solar Decathlon 2011
B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.

   1. Low-voltage Circuits: No. 16 AWG, minimum.
   2. Line-Voltage Circuits: No. 12 AWG, minimum.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install and test systems per manufacturer’s instructions, NFPA 72 and NEC Article 760.

B. Wiring Method: Install wiring interior to walls and ceilings as indicated in schematics.

C. Wire all alarms to a single, continuous (non-switched) power line, not protected by a ground fault interrupter.

END OF SECTION 28 31 49
SECTION 31 05 00
SOILS FOR EARTHWORK

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Sand for Temporary Footings

1.02 RELATED SECTIONS
   A. 02 05 19.13 Geotextiles for Existing Conditions
   B. 05 50 00 Metal Fabrications

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

PART 2 – PRODUCTS
   A. Quikrete 50 pound All Purpose Sand

PART 3 – EXECUTION

END OF SECTION 31 05 00
DIVISION 32 – EXTERIOR IMPROVEMENTS

SECTION 32 90 00
PLANTING

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Plants
B. Planters

1.02 RELATED REQUIREMENTS

A. 32 06 90 Schedules for Planting
B. 26 56 00 Exterior Lighting

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

A. Care and Maintenance Instructions

PART 2 – PRODUCTS

2.01 PLANTS

A. Blue Sedge
B. Feather Reed Grass
C. Maiden Pink

2.02 PLANTERS

A. Custom, mobile style to be determined
PART 3 – EXECUTION

3.01 INSTALL

A. Furnish appropriate soil and nutrient mixtures for plantings

END OF SECTION 32 90 00
DIVISION 48 – ELECTRICAL POWER GENERATION

SECTION 48 19 16

ELECTRICAL POWER GENERATION INVERTERS

PART 1 – GENERAL

1.01 SECTION INCLUDES
   A. Photovoltaic inverter system

1.02 RELATED SECTIONS
   A. Section 26 31 00 – Photovoltaic Generation

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS
   A. Electrical wiring diagram.

1.05 QUALITY ASSURANCE
   A. Conform to requirements of NFPA 70.
   B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
   C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 – PRODUCTS

2.01 MANUFACTURERS
   A. Solectria Renewables

2.02 COMPONENTS
   A. Solectria inverter model PVI 4000

Published 03/22/2011

U.S. D.O.E. Solar Decathlon 2011
1. Product Data
   
a. DC Specifications
   1. Continuous Power: 4100 Watt
   2. Recommended Maximum PV Array Power, STC rating: 4900 Watt DC
   3. Maximum Input Voltage: 600 Volt
   4. Maximum Input Current: 20 Amp

b. AC Specifications
   1. Continuous Power: 3900 Watt
   2. Nominal Voltage: 240/208 Volt
   3. Continuous Current (Max.): 16.5 Amp
   4. Frequency: 60 Hz; ±1 percent
   5. Distortion Factor (THD): <3 percent
   6. Maximum Efficiency: 96.7 percent

c. Mechanical Specifications
   1. Aluminum housing, NEMA 3R, rainproof enclosure.
   2. Dimensions (L W H): 28.8 inch x 17.75 inch x 6.75 inch
   3. Weight: 50.7 pounds
   4. Ambient Temperature Range (full power operation): −13 degrees F to +131 degrees F

d. To view this product’s technical data, CLICK HERE

PART 3 – EXECUTION

3.01 INSTALLATION
   
A. Provide fire-resistant plywood backing as necessary to support the power conditioning unit.


END OF SECTION 48 19 16
Appendix Product Data Sheets

Division 11 – Residential Appliances

Refrigerator/Freezer

[Whirlpool Gold® Resource Saver™ ENERGY STAR® Qualified 19 cu. ft. Bottom Mount Refrigerator]

**why you’ll love it...**

- **Built-In Sensors Inside Help Keep Conditions Cool and Your Food Fresh**
  - Smart, built-in sensors enabled by 6th Sense™ technology do the thinking for you and adjust conditions inside helping keep your food fresh and cold.

- **Adjustable Storage Gives You Flexibility and Adaptability**
  - Arrange your fresh and frozen food exactly how you want it. Adjustable door bins, slide-out shelves, and more make it easy to find what you need.

- **Resource Saver™ Refrigerator**
  - This Resource Saver™ bottom mount refrigerator exceeds the minimum federal energy standard by 50% and uses less energy each year than a 60-watt light bulb.

**specifications...**

<table>
<thead>
<tr>
<th>Energy and Eco-Friendly Energy Star® Qualified: Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Style and Extras</strong></td>
</tr>
<tr>
<td>Lighting: 1 - 40 Watt Blue</td>
</tr>
<tr>
<td>Icemaker Type: Factory Installed</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
</tr>
<tr>
<td>Width: 29 5/8</td>
</tr>
</tbody>
</table>

U.S. D.O.E. Solar Decathlon 2011
**Description**

- 18.5 Cu. Ft. Bottom Freezer Refrigerator (Color: Stainless Steel) ENERG\-STAR 
  - ENERGY STAR® qualified
  - Electronic temperature controls; easily navigate with just a touch to instantly adjust refrigerator and freezer temperatures
  - Factory installed automatic ice maker
  - Freezer light illuminates the freezer compartment for easier access to all your frozen items
  - Lower wire freezer basket
  - Smooth door finish
  - Reversible door swing allows door swing to be changed to accommodate user preference
  - Resource Star™ refrigerator exceeds the minimum federal energy standards by 50% and uses less energy each year than a 60-watt light bulb
  - Adaptive Defrost System (ADS); depending upon usage, ADS models can have fewer defrosts, saving energy and preserving food more efficiently
  - Accu-Chill™ Temperature Management System
  - Humidity-controlled crispers help you preserve the freshness of your favorite fruits and vegetables with controlled humidity levels in the clear, extra-deep crisper
  - Half-width adjustable slide-out shelves
  - Adjustable door bins (1 gallon size) give you the flexibility to store beverages anywhere in the refrigerator door by moving bins where and when you need them
  - Drawer freezer door; generous storage baskets in the drawer slide out for easy access to items in the back
  - Upper slide-out freezer basket makes it even easier to quickly spot and grab what you're looking for

**Specifications**

<table>
<thead>
<tr>
<th>Appliance Color/Finish</th>
<th>Stainless steel</th>
<th>CEE Tier Qualified</th>
<th>CEE Tier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispenser Options</td>
<td>N/A</td>
<td>Height to Top of Case (Inches)</td>
<td>05.5</td>
</tr>
<tr>
<td>Child Safety Locks</td>
<td>No</td>
<td>Height to Top of Door Hinges (Inches)</td>
<td>06.0375</td>
</tr>
<tr>
<td>Water Filter Indicator</td>
<td>No</td>
<td>Width (Inches)</td>
<td>20.625</td>
</tr>
<tr>
<td>Door Alarm</td>
<td>No</td>
<td>Depth (Including Handles) (Inches)</td>
<td>30.375</td>
</tr>
<tr>
<td>Freezer Light</td>
<td>No</td>
<td>Freezer Capacity (Cu. Ft.)</td>
<td>5.6</td>
</tr>
<tr>
<td>Ice Maker</td>
<td>Single</td>
<td>Depth (Excluding Handles) (Inches)</td>
<td>30.875</td>
</tr>
<tr>
<td>Space-Saving In Door Ice</td>
<td>No</td>
<td>Depth (Less Door) (Inches)</td>
<td>26.126</td>
</tr>
<tr>
<td>Air Filtration</td>
<td>No</td>
<td>Depth with Door Open (Inches)</td>
<td>59.0</td>
</tr>
<tr>
<td>Feature</td>
<td>Specification</td>
<td>Color</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td>Dual Evaporator Cooling System</td>
<td>No</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Refrigerator Interior Lighting</td>
<td>Incandescent</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>Overall Capacity (Cu. Feet)</td>
<td>18.5</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>Electronic Temperature Control</td>
<td>Yes</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Shelf Options</td>
<td>Glass shelves</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Temperature Controlled Drawer</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Snack/Deli Drawer</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Pantry Drawer</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Door Shelves</td>
<td>3.0</td>
<td>Smooth</td>
<td></td>
</tr>
<tr>
<td>Gallon Door Storage</td>
<td>Yes</td>
<td>Limited</td>
<td></td>
</tr>
<tr>
<td>Humidity Controlled Crispers</td>
<td>2</td>
<td>1-year</td>
<td></td>
</tr>
<tr>
<td>Freezer Door Bin</td>
<td>0</td>
<td>Limited</td>
<td></td>
</tr>
<tr>
<td>Freezer Door Shelves</td>
<td>0</td>
<td>1-year</td>
<td></td>
</tr>
<tr>
<td>Refrigerator Capacity (Cu. Feet)</td>
<td>12.9</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>Freezer Baskets</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Freezer Shelves</td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Freezer Door Style</td>
<td>Pull-out shelves</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Frost-Free</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR Qualified</td>
<td>Yes</td>
<td>Standard</td>
<td></td>
</tr>
</tbody>
</table>

Cabinet Color: Black
Door Handle(s) Color: Stainless steel
Manufacturer Color/Finish: Stainless steel
Toe Grille Color: Black
Reversible Door: Yes
Custom Door Kit Compatible: No
Lowe's Exclusive: No
Door Finish: Smooth
Manufacturer's Warranty (Labor): Limited 1-year
Multifamily Unit Warranty (Pull): 1-year
Door Finish Family: Stainless steel
CSA Safety Listing: No
ETL Safety Listing: No
UL Safety Listing: Yes
Door Style: Flat
Hidden Hinge: No
Handicapped: Standard
Water Filtration: No
PERFORMANCE DATA SHEETS

Interior Water Filtration System
Model UKF8001AXX-750 Capacity 750 Gallons (2839 Liters)

System tested and certified by NSF International against NSF/ANSI Standard 42 for the reduction of Chlorine Taste and Odor, Particulate Class I, and against NSF/ANSI Standard 53 for the reduction of Lead, Mercury, Atrazine, Benzene, p-Dichlorobenzene, Carbofuran, Topazhane, Cyst, Turbidity, Asbestos, Tetrachloroethylene and Limdane.

This system has been tested according to NSF/ANSI Standards 42 and 53 for the reduction of the substances listed below. The concentration of the indicated substances in water entering the system was reduced to a concentration less than or equal to the permissible limit for water leaving the system, as specified in NSF/ANSI Standards 42 and 53.

<table>
<thead>
<tr>
<th>Contaminant Reduction</th>
<th>NSF Reduction Requirements</th>
<th>Average Influent</th>
<th>Influent Challenge Concentration</th>
<th>Maximum Effluent</th>
<th>Average Reduction</th>
<th>Minimum Reduction</th>
<th>Minimum% Reduction</th>
<th>Average% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead @ pH 6.5</td>
<td>0.010 mg/L</td>
<td>0.150 mg/L</td>
<td>0.150 mg/L x 1.5%</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&gt;99.50%</td>
</tr>
<tr>
<td>Mercury @ pH 8.5</td>
<td>0.001 mg/L</td>
<td>0.057 mg/L</td>
<td>0.057 mg/L x 1.5%</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&gt;99.90%</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.004 mg/L</td>
<td>0.039 mg/L</td>
<td>0.039 mg/L x 1.5%</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&lt; 0.001 mg/L</td>
<td>&gt;99.90%</td>
</tr>
<tr>
<td>p-Dichlorobenzene</td>
<td>0.075 mg/L</td>
<td>0.210 mg/L</td>
<td>0.210 mg/L x 1.5%</td>
<td>&lt; 0.005 mg/L</td>
<td>&lt; 0.005 mg/L</td>
<td>&lt; 0.005 mg/L</td>
<td>&lt; 0.005 mg/L</td>
<td>&gt;99.80%</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>0.045 mg/L</td>
<td>0.170 mg/L</td>
<td>0.170 mg/L x 1.5%</td>
<td>&lt; 0.010 mg/L</td>
<td>&lt; 0.010 mg/L</td>
<td>&lt; 0.010 mg/L</td>
<td>&lt; 0.010 mg/L</td>
<td>&gt;99.60%</td>
</tr>
<tr>
<td>Topazhane</td>
<td>0.003 mg/L</td>
<td>0.015 mg/L</td>
<td>0.015 mg/L x 1.5%</td>
<td>&lt; 0.003 mg/L</td>
<td>&lt; 0.003 mg/L</td>
<td>&lt; 0.003 mg/L</td>
<td>&lt; 0.003 mg/L</td>
<td>&gt;99.50%</td>
</tr>
<tr>
<td>Atrazine</td>
<td>0.000 mg/L</td>
<td>0.002 mg/L</td>
<td>0.002 mg/L x 1.5%</td>
<td>&lt; 0.000 mg/L</td>
<td>&lt; 0.000 mg/L</td>
<td>&lt; 0.000 mg/L</td>
<td>&lt; 0.000 mg/L</td>
<td>&gt;99.90%</td>
</tr>
<tr>
<td>Acetobacter</td>
<td>&gt;90%</td>
<td>126.5 MFL</td>
<td>126.5 MFL x 1.5%</td>
<td>&lt; 0.17 MFL</td>
<td>&lt; 0.17 MFL</td>
<td>&lt; 0.17 MFL</td>
<td>&lt; 0.17 MFL</td>
<td>&gt;99.90%</td>
</tr>
<tr>
<td>Lys Cystis</td>
<td>&gt;90%</td>
<td>126.5 MFL</td>
<td>126.5 MFL x 1.5%</td>
<td>&lt; 1 MFL</td>
<td>&lt; 1 MFL</td>
<td>&lt; 1 MFL</td>
<td>&lt; 1 MFL</td>
<td>&gt;99.90%</td>
</tr>
<tr>
<td>turbidity</td>
<td>0.6 NTU</td>
<td>50.000 NTU</td>
<td>50.000 NTU x 1.5%</td>
<td>&lt; 1 NTU</td>
<td>&lt; 1 NTU</td>
<td>&lt; 1 NTU</td>
<td>&lt; 1 NTU</td>
<td>&gt;99.90%</td>
</tr>
<tr>
<td>Limdane</td>
<td>0.063 mg/L</td>
<td>0.091 mg/L</td>
<td>0.091 mg/L x 1.5%</td>
<td>&lt; 0.005 mg/L</td>
<td>&lt; 0.005 mg/L</td>
<td>&lt; 0.005 mg/L</td>
<td>&lt; 0.005 mg/L</td>
<td>&gt;99.50%</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>0.003 mg/L</td>
<td>0.005 mg/L</td>
<td>0.005 mg/L x 1.5%</td>
<td>&lt; 0.000 mg/L</td>
<td>&lt; 0.000 mg/L</td>
<td>&lt; 0.000 mg/L</td>
<td>&lt; 0.000 mg/L</td>
<td>&gt;99.90%</td>
</tr>
</tbody>
</table>

Test Parameters: pH = 7.5 ± 0.5 unless otherwise noted. Flow = 0.78 gpm (2.9 Lpm). Pressure = 60 psig (413.7 kPa). Temp. = 68°F ± 5°F.

- It is essential that operational, maintenance, and filter replacement requirements be carried out for the product to perform as advertised.
- The disposable water filter should be replaced at least every 6 months.
- The filter monitor system measures the amount of water that passes through the filter and alerts you to replace the filter. When 90% of the filter’s rated life is used, the yellow (Cord) light comes on. When 100% of the filter’s rated life is used, the red (Replace) light comes on, and it is recommended that you replace the filter. For models without filter status lights, replace the filter every 6 months. Use replacement filter model UKF8001AXX-750. 2011 suggested retail price of $49.00 U.S./$40.00 Canada. Prices are subject to change without notice.
- The product is for cold water use only.
- Do not use with water that is microbiologically unsafe or of unknown quality without adequate disinfection before or after the system. Systems certified for cyst reduction may be used on disinfected waters that may contain filterable cysts.

*Class I particle size >0.5 to <1 um
**Test requirement is at least 100,000 particles/mL of AC Fine Test Dust.
*These contaminants are not necessary in your water supply. Performance may vary based on local water conditions.
*Fibers greater than 10 um in length
© NSF is a registered trademark of NSF International.

TO GO BACK, CLICK HERE
Dishwasher

Dishwashing

Single DishDrawer®
D024SCX6V2 E7Xleen Stainless Steel Single

Key Features
- Flow through detergent dispenser
- Folding trays
- Key lock and child lock option
- Three stage flood protection

Dimensions
H 16 3/32 x W 23 9/16 x D 22 7/16

Product Info
We imagined the ideal dishwasher... and the concept of the DishDrawer was born. Years of research and refinement have created an appliance that offers a compelling blend of form and function. Each drawer is independently operated, allowing you to wash small loads as economically as large ones. DishDrawer lets you match the wash programme to the contents, so dishes are better cared for.

Finishes

open in browser PRO version Are you a developer? Try out the HTML to PDF API

pdfcrowd.com
- EZKleen Stainless Steel

**Consumption Data**
- Energy Rating: ENERGY STAR rated

**Features**
- Quiet operation

**Performance Features**
- 163°F temperature in final rinse
- Choice of wash programmes
- Economical eco option
- Flow through detergent dispenser
- Heating element in each drawer
- Rinse aid dispenser
- Uses as little as 1.96 gallons of water per drawer

**Usability Features**
- Accomodates long stemmed wine glasses
- Easy to use, primary and secondary (concealed) control panels with single touch programming
- End of cycle beeps
- Energy saving, delay start option – up to 12 hours
- Flexible racking system
- Flood protection built in
- Folding times
- Fully adjustable racking system
- Holds 6 place settings
- Holds plates up to 11 1/2 inches
- Intelligent load sensing for optimum performance
- Key lock and child lock option
- Rinse aid indicator light
- Self diagnostics for servicing
- Smart Drive intelligent technology
- Three stage flood protection
- Wash progress and time remaining display

## Warranty
- 1 year parts & labor warranty

## Wash Programmes
- Delicate
- Delicate Eco
- Fast
- Fast Eco
- Heavy
- Heavy Eco
- Normal
- Normal Eco
- Rinse

## Dimensions
- A: Overall Height of product: 16 3/32
- B: Overall Width of Product: 23 9/16
- C: Overall Depth of Product: 22 7/16
- D: Depth of Draw (open): 20 1/2

## Contact Details

Fisher & Paykel Appliances Inc.
5900 Skylab Road
Huntington Beach CA 92647
USA
Phone: 1 888 936 7672
Fax: 1 800 547 1971

Continued on next page.
23.5-Inch Drawer Dishwasher (Color: Stainless Steel) ENERGY STAR

- Single drawer offers perfect ergonomics - no more bending
- Nine cycles for every washing need
- Superior washing performance incorporates the world's first flow-through detergent dispenser detergent burn so your dishes last longer
- The drawer is a carbon impregnated polymer tub which is seamless, stain resistant, and odor resistant

### Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Yes/No</th>
<th>Yes/No</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowe's Exclusive</td>
<td>No</td>
<td>Rinse and Hold Cycle</td>
<td>No</td>
</tr>
<tr>
<td>Removable Top Rack</td>
<td>No</td>
<td>The first dishwasher</td>
<td>with variable water</td>
</tr>
<tr>
<td>Fold-Down Tines</td>
<td>Lower rack only</td>
<td>'Scrub'</td>
<td>Unique or Exclusive Cycle</td>
</tr>
<tr>
<td>Removable Silverware Basket</td>
<td>Yes</td>
<td>Number of Drawers</td>
<td>1.0</td>
</tr>
<tr>
<td>Silverware Basket Covers</td>
<td>No</td>
<td>Hi-Temp Wash Option</td>
<td>No</td>
</tr>
<tr>
<td>Stemware Holder</td>
<td>Yes</td>
<td>NSF Certified Sanitization Option</td>
<td>No</td>
</tr>
<tr>
<td>Air Dry</td>
<td>Yes</td>
<td>Self-Cleaning Filter</td>
<td>No</td>
</tr>
<tr>
<td>Automatic Temperature Control</td>
<td>Yes</td>
<td>Steam Option</td>
<td>No</td>
</tr>
<tr>
<td>Direct Feed</td>
<td>Yes</td>
<td>Targeted Scouring Module</td>
<td>No</td>
</tr>
<tr>
<td>Number of Drawers</td>
<td>1.0</td>
<td>Targeted Silverware Wash Module</td>
<td>No</td>
</tr>
<tr>
<td>Wash System</td>
<td>The world's first</td>
<td>Rinse Aid Dispenser Indicator</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>variable water</td>
<td>Control Panel Color</td>
<td>Stainless</td>
</tr>
<tr>
<td></td>
<td>pressure</td>
<td>Control Panel Style</td>
<td>Hidden</td>
</tr>
<tr>
<td></td>
<td>and flow through</td>
<td>CEE Tier Qualified</td>
<td>CEE Tier I</td>
</tr>
<tr>
<td></td>
<td>detergent</td>
<td>Control Type</td>
<td>Electronic</td>
</tr>
<tr>
<td></td>
<td>dispenser</td>
<td>Custom Door Panel Color</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>and 180 F</td>
<td>Custom Door Panel Size</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>sanitizing</td>
<td>Tub Height</td>
<td>Standard</td>
</tr>
<tr>
<td></td>
<td>temperature</td>
<td>Height (inches)</td>
<td>16.1</td>
</tr>
</tbody>
</table>

Published 03/22/2011
<table>
<thead>
<tr>
<th>Feature</th>
<th>Direct Feed</th>
<th>Width (inches)</th>
<th>Depth - Door Shut (w/ Handle) (inches)</th>
<th>Depth - Door Shut (w/o Handle) (inches)</th>
<th>Depth with Door Open (inches)</th>
<th>Fill and Drain Hose Included</th>
<th>Rack Material</th>
<th>Power Cord Included</th>
<th>Manufacturer's Warranty (Labor)</th>
<th>Manufacturer's Warranty (Parts)</th>
<th>Color/Finish Family</th>
<th>ETL Safety Listing</th>
<th>CSA Safety Listing</th>
<th>UL Safety Listing</th>
<th>Tub Material</th>
<th>Adjustable Upper Rack</th>
<th>Rack Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash System Type</td>
<td>No</td>
<td>23.0</td>
<td></td>
<td>24.1</td>
<td>44.1</td>
<td>Yes</td>
<td>PVC</td>
<td>Yes</td>
<td>Full 1-year</td>
<td>Full 1-year</td>
<td>Stainless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Filtration</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Lock/Child Lock</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer Color/Finish</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Food Disposer or Filtration</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor Wash Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Sensor Wash Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gentle Wash Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heated/Hi-Temp Dry</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy/Pots and Pans Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Soak Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quick Rinse Cycle</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quick Wash Cycle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR Qualified</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TO GO BACK, CLICK HERE
ZSC1201NSS/ZSC1202NSS
GE Monogram® Built-In Advantium® 120 Oven

Features and Benefits

• Remarkable Versatility – Multiple cooking options create four ovens in one—Speedcook, True European convection, sensor microwave and warming ovens—to bake, broil, brown, roast and warm and proof foods.

• Speedcook Technology – Halogen light system combines with microwaves and speedcooks your favorite foods to delectable perfection in minutes, with no preheating.

• Powerful Performance – Oven-quality foods cook up to four times faster than a conventional oven, with no preheating required.

• Spacious Interior – Large 1.7-cu.ft. rounded oven cavity with 16” turntable allow full and continual rotation of a 9” x 13” casserole dish; removable oven rack offers the convenience of multi-level cooking.

• Installation Flexibility – Ovens can be installed in 30” wall cabinet and can also be installed below a countertop or below a GE Monogram electric radiant or gas-on-glass cooktop—models ZEU56R, ZEU5GR and ZEU36K.

• Sophisticated Styling – Integrated models make a singular architectural impression with sleek, horizontal lines set off by a tubular handle and stainless steel control knob.

• Professional Styling – Professional models exude power with a premium grade stainless steel exterior, chamfered edges and a die-cast control knob.

• Model ZSC1201NSS – Integrated stainless steel.

• Model ZSC1202NSS – Professional stainless steel.

• Optional Accessory Storage Drawer – ZK2201NSS (for use with ZSC1201NSS only).

For answers to your Monogram* GE Profile™ or GE® appliance questions, visit our website at ge.com or call GE Answer center® service. 800.626.2000.

imagination at work

Specification Created 11/08
1x1x16

Continued on next page
ZSC1201NSS/ZSC1202NSS
GE Monogram® Built-In Advantium® 120 Oven

Dimensions and Installation Information (in inches)

Installation Flexibility
The Monogram Advantium 120 built-in oven can be installed directly into a wall, or a 30” wide wall oven cabinet. Install it alone, with a wall oven, a microwave oven or a warming drawer.
- This oven may be installed below a cooktop or below a countertop
- Two Advantium 120 ovens may be installed side-by-side
- Two Advantium 120 ovens may be installed, stacked, one over the other
Always refer to each specific product installation instructions for details.

Electrical Requirements
Product rating is 120-volt, 60 Hz, 15 amp circuit and draws 18.8 kilowatts. It must be connected to a supply circuit of the proper voltage and frequency and protected by a time-delay fuse or circuit breaker.
- An Advantium 120 oven installed in combination with any other appliance must be supplied with separate electrical connections.

Installation Information - before installing, consult installation instructions packed with the product and available on-line at www.monogram.com for current dimensional data.

Installation below a 30” or 35” cooktop
This Advantium 120 oven can be installed below a countertop or beneath a 30 or 36” GE Monogram electric radiant or gas-on-glass cooktop. Models include ZEI36G, ZEI30G and ZEI36K. Install the oven in a 35” or wider base cabinet.

For answers to your Monogram® GE Profile™ or GE® appliance questions, visit our website at ge.com or call GE Answer Center® service 800.GE.3600.

imagination at work

Specification Created 11/08 130316

TO GO BACK, CLICK HERE

U.S. D.O.E. Solar Decathlon 2011

Published 03/22/2011
**41000 SERIES**

**TWO-SPEED NON-DUCTED RANGE HOOD**

Broan’s most economical non-ducted hood with filtration of airborne cooking contaminants.

**FEATURES**
- Recessed fan and light switches
- Polymeric blade and light lens (accepts up to 75W bulb)
- Non-ducted filter – effective non-ducted filtration system removes smoke and odors
- Mitered sides and hemmed bottom for safety and good looks
- Contemporary styling in White, Almond, Black and Stainless Steel
- Available in 24”, 30”, 36”, and 42” widths
- Special Order Size: 21”

**TYPICAL SPECIFICATION**
- Range hood shall be Broan Model 41000.
- Unit shall be non-ducted and have a non-ducted filter.
- Motor to be permanently lubricated. RPM not to exceed 2850.
- Unit shall have a two-speed fan switch and separate light switch.
- Sides shall be mitered and bottom edge hemmed – with no sharp edges.
- Unit shall be U.L. listed.

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>VOLTS</th>
<th>AMPS</th>
<th>RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>2.0</td>
<td>2850</td>
</tr>
</tbody>
</table>

Broan-NuTone LLC, 626 West State Street, Hartford, Wisconsin 53027 (1-800-657-1453)

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>QTY.</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Diagram**

- Dimensions:
  - 24.31” wide
  - 36.42” deep
  - 7.1” high

**UL**

Broan-NuTone LLC, 626 West State Street, Hartford, Wisconsin 53027 (1-800-657-1453)

<table>
<thead>
<tr>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
</tr>
<tr>
<td>Architect</td>
</tr>
<tr>
<td>Engineer</td>
</tr>
<tr>
<td>Contractor</td>
</tr>
</tbody>
</table>

**Submitted by**

**Date**
Washer/Dryer Combo

**LAUNDRY**

**WM3455HW\nWM3455HS**

**Front Load Compact Washer/Dryer Combo**

**HIGHLIGHTS**

- Ventless Condensing Dryer
- SensorClean™
- EcoDeco™ Quiet Operation

**FEATURES**

- 2.7 cu.ft. Capacity (ECI)
- Direct Drive Motor (10 year Warranty)
- 1200 RPM
- EcoDeco™ Quiet Operation
- Highly Energy and Water Efficient
- SenseClean™
- 9 Washing Cycles
- 6 Drying Cycles
- 5 Temperature Levels
- Sanitary Cycle
- Delay Wash (up to 19 hours)
- Upfront Electronic Control Panel with LED Display and One-A-Cycle™
- Chrome-Trimmed Inner with Glass Ventless Condensing Drying System

**IS IT A WASHER? OR SOMETHING BETTER?**

LG’s all-in-one washer and dryer combo does it all in just one machine. It’s great for those who want to be able to do laundry at home but don’t have an external venting source with conventional dryers. Perfect for homes, apartments, businesses and vacation homes where space is valuable.

Available colors:

- White
- Silvery

Continued on next page
# LAUNDRY

## WM3455HW

WM3455HS

Front Load Compact Washer/Dryer Combo

---

### Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>2.7 cu. ft.</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>Front Control</td>
</tr>
<tr>
<td><strong>Wash Cycles</strong></td>
<td>Cotton/Normal, Perm. Press, Delicates, Baby Perm.</td>
</tr>
<tr>
<td><strong>Dryer</strong></td>
<td>Speed Dry, Sanit.</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>Energy Star Compliant</td>
</tr>
</tbody>
</table>

---

### Warranty

1 Year Parts and Labor
10 Year Motor, Lifetime Drum
LG3-00036

WM3455HW: Combo Washer & Dryer - White 048231 098618
WM3455HS: Combo Washer & Dryer - Silver 048231 011227

---

### Control Panel

- [Image of control panel]

---

www.LG.com

LG Electronics U.S.A., Inc.

Dimensions and weights are approximate. Design, features and specifications subject to change without notice.

© 2010 LG Electronics USA, Inc. All rights reserved. "Life's Good" is a registered trademark of LG Corp. All other product and brand names are trademarks or registered trademarks of their respective companies.

Published 03/22/2011
# Specifications

<table>
<thead>
<tr>
<th>Power Source</th>
<th>TC-L37D2</th>
<th>TC-L42D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>AC 110-120 V / 60 Hz</td>
<td>DC 9 V / 3 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Display panel</th>
<th>TC-L37D2</th>
<th>TC-L42D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>1.5 W</td>
<td>3 W</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>16:9</td>
<td>16:9</td>
</tr>
<tr>
<td>Display screen size</td>
<td>37&quot; class (37.0 inches measured diagonally)</td>
<td>42&quot; class (42.0 inches measured diagonally)</td>
</tr>
<tr>
<td>(W x H x Diagonal)</td>
<td>32.2 &quot; x 18.5 &quot; x 37.3&quot; (879 mm x 469 mm x 947 mm)</td>
<td>36.6 &quot; x 20.6 &quot; x 40.6&quot; (930 mm x 523 mm x 1027 mm)</td>
</tr>
<tr>
<td>(No. of pixels)</td>
<td>2,073,600 (1920 x 1080)</td>
<td>3,170,400 (1920 x 1080)</td>
</tr>
<tr>
<td>Speaker</td>
<td>1-way 2 speakers dim under G.P. System</td>
<td></td>
</tr>
<tr>
<td>Audio Output</td>
<td>20 W x 10 W x 10 W (10 % THD)</td>
<td></td>
</tr>
<tr>
<td>PC signals</td>
<td>VGA, S-VIDA, XGA, WXGA, SXGA</td>
<td></td>
</tr>
<tr>
<td>Horizontal scanning frequency</td>
<td>31.5 kHz</td>
<td></td>
</tr>
<tr>
<td>Vertical scanning frequency</td>
<td>50 - 85 Hz</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel Capability -</th>
<th>TC-L37D2</th>
<th>TC-L42D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATV/NTSC (Digital/Analog)</td>
<td>VHF, UHF</td>
<td>2-69, CATV 1-135</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating Conditions</th>
<th>TC-L37D2</th>
<th>TC-L42D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>32 °F - 104 °F (0°C - 40°C)</td>
<td>32 °F - 104 °F (0°C - 40°C)</td>
</tr>
<tr>
<td>Humidity</td>
<td>25% - 85% RH (non-condensing)</td>
<td>25% - 85% RH (non-condensing)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connection terminals</th>
<th>TC-L37D2</th>
<th>TC-L42D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIDEO IN 1-2</td>
<td>Y, P, R</td>
<td>Y, P, R</td>
</tr>
<tr>
<td></td>
<td>COMPONENT IN</td>
<td>Y, P, R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AI/BX</td>
</tr>
<tr>
<td></td>
<td>HDMI 1-3</td>
<td>TYPE A connector x 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HDMI OUT x 1</td>
</tr>
<tr>
<td></td>
<td>DIGITAL AUDIO OUT</td>
<td>PCM / Sony Digital, Fiber Optic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>TC-L37D2</th>
<th>TC-L42D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>36.1 lb (16.4 kg)</td>
<td>40.8 lb (18.5 kg)</td>
</tr>
<tr>
<td>TV Set only</td>
<td>12.2 lb (5.5 kg)</td>
<td>15.4 lb (7 kg)</td>
</tr>
<tr>
<td>Including TV stand</td>
<td>29.0 lb (13.1 kg)</td>
<td>32.0 lb (14.5 kg)</td>
</tr>
</tbody>
</table>

*Note: Design and Specifications are subject to change without notice. Mass and Dimensions shown are approximate.*
19) An outside antenna system should not be located in the vicinity of overhead power lines, other electric light, power circuits, or where it can fall into such power lines or circuits. When installing an outside antenna system, extreme care should be taken to keep from touching such power lines or circuits as contact with them might be fatal.

20) Unplug this LCD TV from the wall outlet and refer servicing to qualified service personnel under the following conditions:
   a. When the power cord or plug is damaged or frayed.
   b. If liquid has spilled or objects have fallen into the LCD TV.
   c. If the LCD TV has been exposed to rain or water.
   d. If the LCD TV does not operate normally by following the operating instructions. Adjust only those controls that are covered by the operating instructions; an improper adjustment of other controls may result in damage and will often require extensive work by a qualified technician to restore the LCD TV to normal operation.
   e. If the LCD TV has been dropped or the cabinet has been damaged.

21) When the LCD TV exhibits a distinct change in performance - this indicates a need for service.

22) WARNING: TO REDUCE THE RISK OF FIRE OR ELECTRIC SHOCK, DO NOT EXPOSE THIS APPARATUS TO RAIN, MOISTURE, DRIPPING OR SPLASHING. DO NOT PLACE LIQUID CONTAINERS (FLOWER VASES, DRUMS, COSMETICS, ETC.) ABOVE THE SET (INCLUDING ON SHELVES ABOVE, ETC.).

23) WARNING: SMALL PARTS CAN PRESENT CHOKING HAZARD IF ACCIDENTALLY SWALLOWED. KEEP SMALL PARTS AWAY FROM YOUNG CHILDREN. DISCARD UNNEEDED SMALL PARTS AND OTHER OBJECTS, INCLUDING PACKAGING MATERIALS AND PLASTIC BAGS/SHEET/S TO PREVENT THEM FROM BEING PLAYED WITH BY YOUNG CHILDREN, CREATING THE POTENTIAL RISK OF DROWNING.

24) CAUTION: The power switch on this unit will not completely shut off all power from AC outlet. Since the power cord serves as the main disconnect device for the unit, you will need to unplug it from AC outlet to shut down all power. Therefore, unplug the main unit to disconnect the power cord, which is then safe to touch. To avoid fire hazard, the power cord should always be unplugged from AC outlet when left unused for a longer period of time (for example, when on vacation).

25) CAUTION: TO PREVENT ELECTRIC SHOCK, DO NOT USE THIS PLUG WITH A RECEPTACLE OR OTHER OUTLET UNLESS THE PLUG CAN BE FULLY INSERTED TO PREVENT BLAZE EXPOSURE.

26) CAUTION: USE WITH OTHER STAND/MAY RESULT IN INABILITY POSSIBLY CAUSING INJURY.

27) CAUTION: DANNERS OF EXPLOSION IF BATTERY IS INCORRECTLY REPLACED. REPLACE ONLY WITH THE SAME OR EQUIVALENT TYPE.

28) CAUTION: This LCD TV is for use only with the following optional accessory, use with any other type of optional accessories may create instability which could result in the possibility of injury.

NOTE: This equipment is designed to operate in North America and other countries where the broadcasting system and AC house current are exactly the same as in North America.

**FCC STATEMENT**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1) This device may not cause harmful interference.
2) This device must accept any interference received, including interference that may cause undesired operation.

FCC Caution:

To assure continued compliance, follow the attached installation instructions and use only shielded interface cables when connecting to computer or peripheral devices. Any changes or modifications not expressly approved by Panasonic Corp. of North America could void the user’s authority to operate this device.

FCC Declaration of Conformity

Model No. TC-L37D2, TC-L42D2

Responsible Party: Panasonic Corporation of North America
One Panasonic Way, Secaucus, NJ 07094

Contact Source: Panasonic Consumer Electronics Company
1-877-795-VIERA (843-782) 147795VIERA@hhc.panasonic.com

email: cn美洲{}europe{}panasonic.com

U.S. D.O.E. Solar Decathlon 2011

Published 03/22/2011
Safety Precautions (Continued)

CEA CHILD SAFETY NOTES: Flat panel displays are not always supported on the proper stands or installed according to the manufacturer’s recommendations. Flat panel displays that are inappropriately situated on dressers, bookcases, shelves, desks, speakers, chests or carts may fall over and may cause personal injury or death.

The consumer electronics industry (of which Panasonic is a member) is committed to making home entertainment enjoyable and safe. To prevent personal injury or death, be sure to follow the following safety guidelines:

TUNE INTO SAFETY:
- One size does NOT fit all. Follow the manufacturer’s recommendations for the safe installation and use of your flat panel display.
- Carefully read and understand all enclosed instructions for proper use of this product.
- Don’t allow children to climb on or play with furniture and television sets.
- Don’t place flat panel displays on furniture that can easily be used as steps, such as a chest of drawers.
- Remember that children can become excited while watching a program, especially if “lager than life” flat panel displays. Care should be taken to install the display where it cannot be pushed, pulled over, or indicted down.
- Care should be taken to ensure all cords and cables connected to the flat panel display so that they cannot be pulled or grabbed by curious children.

WALL MOUNTING: IF YOU DECIDE TO WALL MOUNT YOUR FLAT PANEL DISPLAY ALWAYS:
- Use a mounting kit that has been recommended by the display manufacturer and/or listed by an independent laboratory (such as UL, CSA, ETI).
- Follow all instructions supplied by the display and wall mount manufacturers.
- If you have any doubts about your ability to safely install your flat panel display, contact your retailer about professional installation.
- Make sure the wall where you are mounting the display is appropriate. Some wall mounts are not designed to be mounted to walls with sheet siding or old under-buck construction. If you are unsure, contact a professional installer.
- A minimum of two people are required for installation. Flat panel displays can be heavy.

The American Academy of Pediatrics discourages television viewing for children younger than two years of age.

This product incorporates the following software:
(1) software developed independently by or for Panasonic Corporation,
(2) software owned by a third party and licensed to Panasonic Corporation,
(3) software licensed under the GNU General Public License, Version 2 (GPL v2),
(4) software licensed under the GNU LESSER General Public License (LGPL) and/or
(5) open source software other than software licensed under the LGPL and/or LGPL.

For the software categorized as (2) or (3), please refer to the terms and conditions of GPL v2 and LGPL, as the case may be at http://www.gnu.org/licenses/gpl-2.0.html and http://www.gnu.org/licenses/lgpl-2.0.html. In addition, software categorized as (3) or (4) is copyrighted by several individuals and/or entities. Please refer to the copyright notice of those individuals at http://www.am-linux.us/DOT1107/

GPL/LGPL SOFTWARE IS DISTRIBUTED IN THE HOPE THAT IT WILL BE USEFUL, BUT WITHOUT ANY WARRANTY EXPRESS, IMPLIED OR STATUTORY, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY ON FITNESS FOR A PARTICULAR PURPOSE.
For at least three (3) years from delivery of products, Panasonic will give to anyone who contacts us at the address provided below, for a charge of no more than our cost of physically performing source code distribution, a complete machine-readable copy of the corresponding source code covered under GPL v2/LGPL.
Contact Information
code@am-linux.us
Source code is also freely available to you and any other member of the public via our website below.
http://www.am-linux.us/DOT1107

Published 03/22/2011
Sony

BDV-E770W

Blu-ray Disc™ Player Home Entertainment System

Experience full HD 1080p and powerful 5-channel Hi-Fi surround sound featuring wireless rear speakers with the Sony® BDV-E770W 3D Blu-ray Disc™ Home Theater System. Contact us for details or visit our website to learn more about a wide variety of options and prices and meet our personnel.

Specifications

- BDV-E770W 3D DVD player
- Wi-Fi
- Ethernet
- Direct USB playback
- DivX® HD
- JPEG
- H.264
- Xvideo Coding (XviD®)
- AC3
- DTS
- Dolby Digital
- DTS-HD Master Audio
- HDR
- Blu-ray Disc™
- 1080p resolution

Features

- Internet Video
- BDVideo
- BD-J
- BD-Live
- SD USB
- Wi-Fi
- Ethernet
- Direct USB playback
- DivX® HD
- JPEG
- H.264
- Xvideo Coding (XviD®)
- AC3
- DTS
- Dolby Digital
- DTS-HD Master Audio
- HDR
- Blu-ray Disc™
- 1080p resolution

Home Theater

Published 03/22/2011

U.S. D.O.E. Solar Decathlon 2011
### Amplifier

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio Power</td>
<td>200 W STEREO</td>
</tr>
<tr>
<td>A/D, D/A Standards</td>
<td>Yes</td>
</tr>
<tr>
<td>Inputs and Outputs</td>
<td>Includes Audio Inputs: 2 ( \times ) ( \text{RCA} )</td>
</tr>
<tr>
<td>Crossover</td>
<td>Audio ONLY</td>
</tr>
<tr>
<td>Treble</td>
<td>Yes</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>Yes</td>
</tr>
<tr>
<td>HDMI Capabilities</td>
<td>Yes</td>
</tr>
<tr>
<td>Component Video ( \text{Y}, \text{C}, \text{R}, \text{L} )</td>
<td>1 ( \times ) ( \text{RCA} )</td>
</tr>
<tr>
<td>Component Video ( \text{Y}, \text{C}, \text{R}, \text{L} )</td>
<td>1 ( \times ) ( \text{RCA} )</td>
</tr>
<tr>
<td>D.C.C. (Crystal Clear)</td>
<td>Yes</td>
</tr>
<tr>
<td>Line Inputs</td>
<td>Yes (3)</td>
</tr>
<tr>
<td>Line Outputs</td>
<td>Yes (3)</td>
</tr>
<tr>
<td>Inputs and Outputs</td>
<td>( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} )</td>
</tr>
</tbody>
</table>

### General

- **

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs and Outputs</td>
<td>( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} )</td>
</tr>
<tr>
<td>Audio Power</td>
<td>200 W STEREO</td>
</tr>
<tr>
<td>Audio Input</td>
<td>( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} )</td>
</tr>
<tr>
<td>Main Power</td>
<td>AC 220-240V 50/60Hz</td>
</tr>
<tr>
<td>Dimensions</td>
<td>( \text{W} \times \text{H} \times \text{D} )</td>
</tr>
<tr>
<td>Weight</td>
<td>8.9 kg</td>
</tr>
</tbody>
</table>

### Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio Power</td>
<td>200 W STEREO</td>
</tr>
<tr>
<td>Audio Input</td>
<td>( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} ) ( \times ) ( \text{RCA} )</td>
</tr>
<tr>
<td>Main Power</td>
<td>AC 220-240V 50/60Hz</td>
</tr>
<tr>
<td>Dimensions</td>
<td>( \text{W} \times \text{H} \times \text{D} )</td>
</tr>
<tr>
<td>Weight</td>
<td>8.9 kg</td>
</tr>
</tbody>
</table>

---

**U.S. D.O.E. Solar Decathlon 2011**

Published 03/22/2011
**Division 22 – Plumbing**

Fresh Water Storage Tank

**Product Description:** 1,500 Gallon Potable Water Tank

**Manufacturer:** AIRE Industrial Products

<table>
<thead>
<tr>
<th>Package Contents:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One (1) Bladder</td>
</tr>
<tr>
<td>One (1) Basic Repair Kit</td>
</tr>
<tr>
<td>One (1) Ground Pad</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bladder Width</th>
<th>ft</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder Length</td>
<td>ft</td>
<td>13</td>
</tr>
<tr>
<td>Height</td>
<td>inches</td>
<td>18</td>
</tr>
<tr>
<td>Valves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tie Down Points</td>
<td>ea.</td>
<td>4</td>
</tr>
<tr>
<td>Gal. Capacity</td>
<td>gal.</td>
<td>1500</td>
</tr>
<tr>
<td>Pad Area</td>
<td>Sq Ft</td>
<td>117</td>
</tr>
<tr>
<td>Fabric</td>
<td>22 oz PVC</td>
<td></td>
</tr>
<tr>
<td>Bladder Weight</td>
<td>lbs</td>
<td>70</td>
</tr>
</tbody>
</table>

Mfg Part #

950-02500

MFG Cage Code

1MDS4

Valve Upgrades available
### Fresh Water Transfer Pump

<table>
<thead>
<tr>
<th>Product Description</th>
</tr>
</thead>
</table>
| 3hp Hydro-Cascad® Craftsman Professional Shallow Well Water Pump capable of pumping up to 13.5 GPM. Performance based on 
| death to water of 20 ft. or less and a 4000 psi pressure rating. |
| Deadhead Check Valve - prevents pumped water from returning to source |
| Built-in shalow well jet - eliminates additional purchase |
| Dual voltage (115 or 230) |
| Capacitor start motor - more efficient motor start |
| Dual discharge - simplifies hookup |
| Draincock - simplifies draining and winterization |
| Limited 3 year warranty |

**Specifications**

- **DIMENSIONS:**
- **PRODUCT OVERVIEW:**
- **POWER:**
- **INSTALLATION REQUIREMENTS:**
- **QUALITY:**
- **PUMP:**
- **PERFORMANCE AT 40:**

*Added on February 12, 2006*
# Pressurization Tank

---

**WELL-X-TROL® PROAcces®**

Pre-pressurized diaphragm-type well tanks

Stainless steel system connection piped to the stand

---

## Stand Models

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WX-202P</td>
<td>76</td>
<td>0.57</td>
<td>803</td>
<td>31½</td>
<td>390</td>
<td>15%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-202XP</td>
<td>98.4</td>
<td>0.44</td>
<td>971.5</td>
<td>38½</td>
<td>390.5</td>
<td>15%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-203P</td>
<td>121</td>
<td>0.35</td>
<td>1181</td>
<td>46%</td>
<td>390</td>
<td>15%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-205P</td>
<td>129</td>
<td>1.00</td>
<td>752</td>
<td>29A</td>
<td>559</td>
<td>22%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-254P</td>
<td>167</td>
<td>0.77</td>
<td>914</td>
<td>36</td>
<td>559</td>
<td>22%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-251P</td>
<td>235</td>
<td>0.55</td>
<td>1187</td>
<td>46%</td>
<td>559</td>
<td>22%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-253P</td>
<td>306.6</td>
<td>0.41</td>
<td>1432</td>
<td>56%</td>
<td>598.8</td>
<td>27%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-302P</td>
<td>326</td>
<td>0.54</td>
<td>1200</td>
<td>47%</td>
<td>680</td>
<td>26%</td>
<td>38</td>
<td>125</td>
</tr>
<tr>
<td>WX-355P</td>
<td>450</td>
<td>0.39</td>
<td>1572</td>
<td>51½</td>
<td>680</td>
<td>26%</td>
<td>38</td>
<td>125</td>
</tr>
</tbody>
</table>

*135 PSI is 925 kPa.

---

## Max. Operating Conditions

**Operating Temperature**: 200°F (93°C)

**Working Pressure**: ≤25 PSI (162 kPa)

---

## Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>Steel</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>Butyl</td>
</tr>
<tr>
<td>Liner</td>
<td>Polypropylene</td>
</tr>
<tr>
<td>System Connection</td>
<td>Stainless Steel NF1F</td>
</tr>
</tbody>
</table>

---

**NSF**

Complies with Low Lead Plumbing Law

---

<table>
<thead>
<tr>
<th>Job Name</th>
<th>Model No. Ordered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump Cut-In: ____ PSI</td>
</tr>
<tr>
<td></td>
<td>Pump Cut-Out: _____ PSI</td>
</tr>
<tr>
<td></td>
<td>Pump GPM: _______ PSI</td>
</tr>
</tbody>
</table>

---

Rev. 03/10

**P/N 4400-003**

Submit data sheets can ONLY be ordered as a "Submit Data Sheet Pack", using MCH-440E. They are not available to order on an individual basis, however each data sheet is available on the AMTROL Web Site and can be downloaded and printed for use as needed. For the most updated technical specifications, please download sheet at www.amtrol.com

---

U.S. D.O.E. Solar Decathlon 2011

Published 03/22/2011

32 90 00 - 29
Grey Water Storage Tank

**Husky 1000 Gallon Potable Water Bladder Tank**

Bladder tanks have unlimited practical uses including:

- Providing drinking water storage for disaster area victims
- Additional fresh water for boats or RV
- Waste water containment
- Rain Water Collection for Irrigation Systems
- Pesticides and insecticides
- Nurseries
- Farming, watering livestock or treating with insecticides
- Fuel storage, diesel, gas, jet, etc.
- Gray water storage for pressure washing systems
- Fire Fighting
- Black Water (sewage)
- Flatbed Truck Tanks
- Railcar Tanks
  - Materials NSF-61 Approved (potable water)
  - 25-75 gal. comes with a 3/4" Flange and Ball Valve
  - 1 1/2" Flange and Ball Valve Standard on Sizes 100-1000 gal.
  - 4" Fill Cap or 7" Diameter Fill Sleeve
  - Easy to Handle, Folds down for Compact Storage

**Part Number:** HPC-BT-1000PW  
**Capacity:** 1000 Gallons  
**Size:** 108"L x 132"W x 16"H  
**Weight:** 60 lbs.

TO GO BACK, CLICK HERE
50 Gallon Back-Up Hot Water Tank

SELECT® High Efficiency
High-Efficiency Residential Electric Water Heaters

New, Higher Energy Factor of .93, meets efficiency requirements for most electric utility rebate programs — 2-1/2”-thick CFC-free foam insulation, heat trap nipples and other features produce performance that meets Energy Star Home Program recommendations.

Diffuser Dip Tube — Helps reduce lime and sediment buildup, maximizes hot water output. Made of State PEXAN™ a cross-link PEX polymer that can withstand long-term exposure to water temperatures up to 400°F.

Aluminum Anode Rod — Helps protect against corrosion for longer life.

Durable Tamper-Resistant Brass Drain Valve

Glass-Lined Tank — For long-lasting protection against rust and corrosion.

Upgrade Tank Warranty to 10 Years — See detail on page 2.

Certified and Rated Side-Mounted T&P Relief Valve — Top-Mounted T&P Relief Valve available as an option on some models.

6-Year Limited Tank and Parts Warranty

Code Compliance — Meets or exceeds federal minimum energy standards according to the latest edition of the National Appliance Energy Conservation Act (NAECA). Also complies with ASHRAE 90.1-2004 and current editions of ICC Codes and HUD Standards.
# SELECT® High Efficiency

**High-Efficiency Residential Electric Water Heaters**

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Peak Demand Output (For Year-Rating Gallons)</th>
<th>Energy Factor</th>
<th>Gallon Capacity (Standard)</th>
<th>Element Voltage (240VAC)</th>
<th>Recovery @ 90°F Rise</th>
<th>R Value</th>
<th>Dimensions in Inches</th>
<th>Approx. Shipping Weight (LBS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TALL MODELS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES6 40 DCC</td>
<td>54</td>
<td>.93</td>
<td>40</td>
<td>4500</td>
<td>6000</td>
<td>21</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>ES6 62 DCC</td>
<td>60</td>
<td>.93</td>
<td>62</td>
<td>4500</td>
<td>6000</td>
<td>21</td>
<td>20</td>
<td>56-1/2</td>
</tr>
<tr>
<td>ES6 96 DCC</td>
<td>76</td>
<td>.92</td>
<td>66</td>
<td>4500</td>
<td>6000</td>
<td>21</td>
<td>20</td>
<td>61-1/2</td>
</tr>
<tr>
<td>ES6 80 DCC</td>
<td>87</td>
<td>.93</td>
<td>80</td>
<td>4500</td>
<td>6000</td>
<td>21</td>
<td>20</td>
<td>61-1/2</td>
</tr>
<tr>
<td><strong>MEDIUM MODEL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES6 58 DCX</td>
<td>62</td>
<td>.93</td>
<td>58</td>
<td>4500</td>
<td>6000</td>
<td>21</td>
<td>20</td>
<td>49</td>
</tr>
</tbody>
</table>

- Resistors are mounted to rear of cabinet.
- Connections - 2" NPT male thread on all models.
- For 10-Year Tank Warranty, change "S" to "T" in Model Number (ES409DCX).

For complete information on limited warranties, consult written warranty, or contact the State Customer Care Center; 1-800-365-0024.

State Industries, Inc. reserves the right to make product changes or improvements without prior notice.

For more information on Select® contact:
State Water Heaters
500 Tennessee Waltz Parkway, Ashland City, TN 37015
800-365-0024 Toll-free USA
www.statewaterheaters.com
SESS0506s March 2011
Hot Water Air-Source Heat Pump

Features and Benefits

Highest Efficiency Water Heater
Instead of burning fuel, a Green Star Water Heater uses a heat pump to transfer solar heat from the surrounding air into your water tank. While the best fuel burning water heaters have a maximum efficiency of less than 95%, in warmer climates the efficiency of a heat pump water heater can exceed 300%. Even in 32°F air Green Star Water Heaters have an efficiency of 166%.

Retrofit for Existing Water Heater
A Green Star is mounted on top of or near an existing water heater and the its heat condenser is inserted into the heater tank. Green Star Water Heaters transfer solar heat from the surrounding air to the heat condenser which transfers the heat to the water in your tank.

Simplified Heat Control
Green Star heaters use a simple in-tank thermometer to directly measure the tank water temperature and maintain the water at the set temperature.

Low Cost & High Reliability
The simple, elegant design of the Green Star heater does not use any pumps, pump controllers or heat controllers making Green Star the most affordable, highest reliability water heater available – surpassing other type of solar water heaters which are much more expensive to buy and install.

Easy to Install
A Green Star heater can be easily installed using basic pipe fitting skills.

Low Maintenance
Green Star water heaters are virtually maintenance free, thousands have been installed.

Quiet
At 52dB a Green Star heater is quieter than a small window air conditioner.

Dehumidification & Air Conditioning
Green Star™ removes moisture and cools air as it moves heat from the air to the water in the water heater tank.

Making Your Water Heater Very Energy Efficient

Green Star water heaters replace the fuel burning heater in your water tank with a pump which uses solar heat in the air to heat your water. They produce more hot water per hour safely and more efficiently than other types of water heaters. According to Solar Energy International: “Heat Pump technology, when applied to the water heating industry, provides the highest energy efficient water heaters in the country.”

In addition to heating water, Green Star heaters emit cool, dry air which can providing additional savings by cooling your home in the summer (kit sold separately). Green Star heaters run on standard 110V and consume about as much energy as two coffee machines.

Compared to standard electric water heaters, Green Star heaters provide operating cost savings up to 70% while heating up to 29% more water per hour.

Utilities and other customers as well as articles such as Duke University’s recently published article on HPWH all conclude that the superior Green Star heater design makes it today’s leading Heat Pump Solar Water Heater:

1 Manufacturing Climate Solutions: Carbon Reducing Technologies and US Jobs
Chapter 6: Electric Heat Pump Water Heaters
**Specifications**

<table>
<thead>
<tr>
<th></th>
<th>WH-270</th>
<th>WH-320</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Water Temperature</td>
<td>135°</td>
<td>°C</td>
</tr>
<tr>
<td>Efficiency</td>
<td>258%</td>
<td>211%</td>
</tr>
<tr>
<td>Energy Factor</td>
<td>2.11</td>
<td>2.11</td>
</tr>
<tr>
<td>1 Hour Rating (40 gal tank)</td>
<td>50+</td>
<td>53+</td>
</tr>
<tr>
<td>Output</td>
<td>7000</td>
<td>12000</td>
</tr>
<tr>
<td>Dimensions</td>
<td>18x14x14</td>
<td>19x15x14</td>
</tr>
<tr>
<td>Weight</td>
<td>48</td>
<td>64</td>
</tr>
<tr>
<td>Noise Level</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>AC Power</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Current</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Startup</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Frequency</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

1. Minimum 5 inches clearance required above 14 height

All measurements made using DOE testing standards at ambient temperature of 68°F.

Installation indoors near a drain (high humidity results in up to a quart of condensate daily) where ambient temperatures are above 35°F is recommended.

**Green Star™ Water Heater Efficiency**

By comparison, standard water heaters have 65–95% COP.

**Estimated 5 Year Cost of Ownership**

Includes purchase, installation, 5 years maintenance & fuel.

**USI Green Energy**

960 Bridle Path Rd, Allentown PA 18103

Phone: 610.439.2122
Fax: 610.439.8242

www.usigreenenergy.com
SunDrum Solar Thermal Modules

SunDrum® Solar SDM100-10, -21, & -30 Collector Assembly Guide, Rev 004

SDM100 - 10
SDM100 - 21
SDM100 - 30
Hybrid Solar Collector
Assembly Guide

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Description</th>
<th>Date</th>
<th>Author</th>
<th>Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>Original Document</td>
<td>10/4/08</td>
<td>MGI</td>
<td></td>
</tr>
<tr>
<td>002</td>
<td>Release to Publication</td>
<td>11/6/08</td>
<td>MGI</td>
<td></td>
</tr>
<tr>
<td>003</td>
<td>Prepublication Format</td>
<td>11/6/08</td>
<td>MGI</td>
<td></td>
</tr>
<tr>
<td>004</td>
<td>Added SDM100-21, Clarified step 15 and added stacking warning</td>
<td>2/31/09</td>
<td>MGI</td>
<td>PR</td>
</tr>
</tbody>
</table>

SunDrum® Solar, LLC all rights reserved. Specifications subject to change without notice.

Page 1
**Sundrum® Solar SDM100-10, -21, & -30 Collector Assembly Guide, Rev 004**

**Parts List:**

<table>
<thead>
<tr>
<th>QTY</th>
<th>Description</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SDM100-10, -21, or -30 Collector</td>
<td>![Image]</td>
</tr>
<tr>
<td>4</td>
<td>Brackets with clamps (3 with 2 clamps per bracket, and 1 with only one clamp)</td>
<td>![Image]</td>
</tr>
<tr>
<td>2</td>
<td>Foil-Backed Insulation Panels</td>
<td>![Image]</td>
</tr>
<tr>
<td>2</td>
<td>Stainless Steel Compression Wedges (SDM100-10 only)</td>
<td>![Image]</td>
</tr>
<tr>
<td>1</td>
<td>Hardware kit: SDM100-10 &amp; -30: #10-32 lock nut, #10 star washer, ¼&quot;-20 bolt and nut, ¼&quot; star washer</td>
<td>![Image]</td>
</tr>
<tr>
<td></td>
<td>SDM100-21: #10-32 bolt, 2 #10-32 lock nuts, #10-32 star washer</td>
<td>![Image]</td>
</tr>
</tbody>
</table>
Steca TR 0301 U
3 inputs, 1 output

The Steca TR 0301 U controller was specially developed for the North American market based on the Steca TR 0301 basic controller. With its special certification (cETL) from a nationally recognized Testing laboratory (NRTL) in the US, the controller meets the safety standards and minimum requirements of the North American market.

A feature of the Steca TR 0301 series of controllers is the animated graphic display, which offers a complete visualisation of the solar energy system’s operating status and solar circuit.

The clearly arranged display ensures easy operation using pictograms. The controller was jointly designed with an internationally renowned design centre. The controller is used for monitoring and controlling solar thermal systems with one collector array and one storage tank. In addition, the controller performs important system monitoring and safety functions to ensure safe and long-lasting operation of the entire system. The numerous additional functions of the Steca TR 0301 U include a maximum storage tank temperature function, a tube collector function, an anti-freeze function, a holiday and storage reheat function as well as a choice of temperature indications in either degrees Celsius (°C) or Fahrenheit (°F). The operational safety of the system is supported by a sophisticated fault diagnosis. The multi-coloured LCD backlighting ensures clear and quick location of occurring errors and facilitates quick troubleshooting.

The Steca TR 0301 U controller is supplied with a pre-fitted US mains connection cable and a pre-assembled pluggable pump output.

Product features
- Compact, multipart designer casing
- Maximum storage tank temperature
- High level of operational safety through fault diagnosis
- Temperature display °C/°F
- Collector overtemperature disconnection
- Spring clamp terminals allow rapid and easy installation

Displays
- Graphical LCD display with backlighting
- Animated representation of the systems and operating states

Operation
- Non-verbal menu navigation
- Side switch for manual, auto, off

Functions
- Holiday (storage tank recoiling)
- Interval / tube collector
- Anti-freeze
- Display storage tank top

<table>
<thead>
<tr>
<th>TR 0301 U</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System voltage</td>
<td>120 V AC, 60 Hz optional 240 V AC, 60 Hz</td>
</tr>
<tr>
<td>Door operation</td>
<td>1 to 10 sec, 0.8 sec initial</td>
</tr>
<tr>
<td>Inputs</td>
<td>3</td>
</tr>
<tr>
<td>Output</td>
<td>1 x ambient output way (Tm), max. 400 W, 0.3 MPa (120 V AC) or 800 W, 1 HP, (208 V AC)</td>
</tr>
<tr>
<td>Line cord</td>
<td>75 cm, 3 x 1.0 AWG stranded</td>
</tr>
<tr>
<td>Turn on temperature difference</td>
<td>10 °F</td>
</tr>
<tr>
<td>Turn off temperature difference</td>
<td>0 °F</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>0 °C to 55 °C (-18 °C to 131 °F)</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 23 (NEMA 4X)</td>
</tr>
<tr>
<td>Dimensions (W x H x D)</td>
<td>160 x 157 x 47 mm (6.3 x 6.18 x 1.85 in)</td>
</tr>
<tr>
<td>Weight</td>
<td>150 g (12.35 oz)</td>
</tr>
<tr>
<td>Temperature sensors</td>
<td>2 x Pt100</td>
</tr>
<tr>
<td>Connection</td>
<td>1.5 m (50 ft)</td>
</tr>
<tr>
<td>Technical data</td>
<td>at 20 °C (68 °F)</td>
</tr>
</tbody>
</table>

System type
1. Matching array

Internal heat exchanger, intelligent pump control
Powered by the Impossible
– The next generation of circulators

The Grundfos ALPHA will change the way you view circulators. With its permanent magnet motor design, this energy efficient circulator reduces power consumption by 50% or more. The unique patented AUTOADAP™ feature controls pump performance automatically within defined performance range, ensuring lowest possible energy consumption without sacrificing comfort.

For installation, you now have the flexibility to use either our unique ALPHA Plug with line cord or the new ALPHA with terminal box for conduit connection applications. The choice is yours.

E TL FC

Think Innovate

Grundfos Alpha Solar Thermal Pump

Published 03/22/2011
THE UNIQUE FEATURES OF
THE GRUNDFOS ALPHA™

For installation, you now have the
flexibility to use either our unique ALPHA
pump with the card or the new ALPHA
with terminal box for conduit connection
applications. The choice is yours.
Solar Hot Water 80 Gallon Tank

SuperStor Contender Solar Water Heaters
with Boiler (SB Series) or Electric (SE Series) Back-Up

JOB NAME:
LOCATION:
ARCH./ENGR.:
WHOLESALE:
MECH. CONTRACTOR:
MODEL NUMBER:
BACK-UP WATER HEATING SYSTEM:

High Efficiency Solar Heat Exchanger
- Specially formulated Enamel Flow Coated steel solar heat exchanger provides maximum heat transfer of solar energy to domestic water and corrosion resistance
- Low pressure drop
- Gaskets: heat exchanger design
- 1" NPT solar heat exchanger outlet size – all models

Glass-Lined Tank
- Specially formulated Enamel Flow Coat guarantees 100% tank coverage, ensuring no exposed welds
- Insulated with environmentally safe, CFC free, water-blown, extra thick foam insulation
- Allows less than ½ degree Fahrenheit per hour heat loss
- Outer shell constructed of grey finished durable plastic for rust and impact resistance
- ¾" NPT inlet and outlet domestic connection size for 50 gallon models – 1 ½" NPT for 80 and 119 gallon models
- Included temperature and pressure relief valve
- Surface mounted sensor for accurate current temperature measurement inside vessel

SE Series Solar Water Heaters
- Back-up Electric Element – 4500W / 240V electric element provides back-up water heating if solar system fails to keep up with domestic hot water demand
- Surface-mounted control provides accurate temperature measurement to timely activate the back-up electric element

Additional Features
- Oversized anode rod protects tank from corrosion
- Limited warranty – 5 years residential and 5 years commercial coverage
- SRCC OG-300 Certified – applies to Federal Tax Credit when connected to a solar collector
- May qualify for additional State and Local incentives – ask your installer for more information

SB Series Solar Water Heaters
- Back-up Boiler Heat Exchanger – provides back-up water heating from the boiler if the solar system fails to keep up with domestic hot water demand
- Specially formulated Enamel Flow Coated steel heat exchanger provides maximum heat transfer of boiler energy to domestic water and corrosion resistance
- Gaskets: heat exchanger design
- 1" NPT boiler heat exchanger outlet size – all models
- Tank mounted boiler thermostat to control back-up operation

LP-197.pdf
Rev. 511.11

Published 03/22/2011

U.S. D.O.E. Solar Decathlon 2011
Division 23 – HVAC

Heat Recovery Ventilator
Model: ES100

VENTILATION PERFORMANCE

<table>
<thead>
<tr>
<th>PRESSURE in wg (Pa)</th>
<th>NET SUPPLY (cfm)</th>
<th>GROSS AIR FLOW (cfm)</th>
<th>EXHAUST (cfm)</th>
<th>SUPPLY TEMPERATURE (°C)</th>
<th>NET (Watts)</th>
<th>POWER (Watts)</th>
<th>SENSIBLE RECOVERY (%)</th>
<th>APPARENT SENSIBLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 (25)</td>
<td>147 (69)</td>
<td>150 (71)</td>
<td>172 (81)</td>
<td>+32 (0)</td>
<td>55 (29)</td>
<td>48</td>
<td>70</td>
<td>79</td>
</tr>
<tr>
<td>0.2 (50)</td>
<td>131 (61)</td>
<td>134 (63)</td>
<td>153 (72)</td>
<td>+32 (0)</td>
<td>66 (31)</td>
<td>52</td>
<td>68</td>
<td>76</td>
</tr>
<tr>
<td>0.3 (70)</td>
<td>118 (56)</td>
<td>121 (57)</td>
<td>135 (64)</td>
<td>+32 (0)</td>
<td>40 (88)</td>
<td>72</td>
<td>65</td>
<td>73</td>
</tr>
<tr>
<td>0.4 (100)</td>
<td>104 (49)</td>
<td>107 (50)</td>
<td>123 (58)</td>
<td>+32 (0)</td>
<td>25 (93)</td>
<td>58</td>
<td>56</td>
<td>80</td>
</tr>
<tr>
<td>0.5 (125)</td>
<td>91 (43)</td>
<td>93 (44)</td>
<td>111 (52)</td>
<td>+32 (25)</td>
<td>64 (30)</td>
<td>58</td>
<td>56</td>
<td>80</td>
</tr>
<tr>
<td>0.6 (150)</td>
<td>76 (36)</td>
<td>78 (37)</td>
<td>92 (43)</td>
<td>+32 (25)</td>
<td>66 (31)</td>
<td>58</td>
<td>56</td>
<td>80</td>
</tr>
<tr>
<td>0.7 (175)</td>
<td>54 (30)</td>
<td>66 (31)</td>
<td>79 (37)</td>
<td>+32 (25)</td>
<td>64 (30)</td>
<td>58</td>
<td>56</td>
<td>80</td>
</tr>
<tr>
<td>0.8 (200)</td>
<td>32 (24)</td>
<td>52 (25)</td>
<td>64 (30)</td>
<td>+32 (25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CABINET/CORE: The case is constructed of 0.032 painted aluminum with a white enameled finish. The cabinet is fully insulated with 1-inch polyurethane. The unit is equipped with a cross-flow heat exchange core.

ELECTRICAL: 120V 1/60 Hz. 84W, 0.7A

BLOWERS: Two backward curve impellers using PSC motors and permanently sealed bearings.

CERTIFICATION: HVI, CSA C22.2

REVERSIBLE: internal components can be accessed front or back

ADDITIONAL FEATURES:
- Built-in furnace interlock option commands furnace blower when HRV is on or just on high speed.
- Intelligent defrost adjusts to outdoor conditions below -5°C (23°F).
- Independent speed adjustment of either supply or exhaust motor in both high and low speed.
- 24V circuit protection with self-resetting fuse.
- Drain, hanger kit, polyester air filters included.
- 12 VDC AND/OR 24 V connection for remote control with mechanical switch or the following Nu-Air controls:

<table>
<thead>
<tr>
<th>ES Series</th>
<th>WINDSOR Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-M1: Off/ Sby/ Lo/ Hi</td>
<td>DSTAT-1: Humidity control</td>
</tr>
<tr>
<td>ES-M2: Off/ Sby/ Lo 20 Lo 40 Sby</td>
<td>Win-1: Humidity control/ OFF/ STBY/ Continuous/ Intermittent/ Full-time high speed</td>
</tr>
<tr>
<td>ES-M3: Off/ Sby/ Lo 20 Lo — 40 Recirculation</td>
<td>WIN-20: 24-minute timer (up to 6)</td>
</tr>
</tbody>
</table>

Defrost: When outdoor temperature is below -5°C (23°F), a defrost cycle is initiated for a fixed duration. The fresh air motor will go to high speed and the exhaust air motor will go to low speed. A damper will shut off the cold supply port, directing ambient air through the coil for defrosting. The unit will resume normal operation for a fixed duration, than the processor will read outdoor temperature and initiate defrost as necessary. Defrost times and intervals will vary according to temperature below -5°C (23°F).

Warranty: There is a 5-year warranty on all internal components. The heat recovery core has a lifetime warranty.

Notes:
This product earned the ENERGY STAR® by meeting strict energy efficiency guidelines set by Natural Resources Canada and the US EPA. It meets ENERGY STAR requirements only when used in Canada.

Nu-Air Ventilation Systems Inc. reserves the right to change specifications without notice.
## General Features
- Horizontal-ducted indoor unit for residential applications
- Ultra-thin body: 7.7/8" high
- Built-in drain mechanism for condensate removal: lifts to 21-11/16" above
- Air filter is included with indoor unit
- Quiet operation — as low as 23 dBA
- PAR-21MAA wired remote controller is included
- Indoor unit powered from outdoor unit using A-Control
- Automatic fan speed control
- Auto restart following a power outage
- Limited warranty: five years on parts and seven years on compressors

## Optional Accessories
### Indoor Unit
- M-NET Control Adapter (MAC-315MF)
- External Heat Adapter (PAC-YL25HT)
- CN24 Relay Kit (CN24RELAYKIT-CM)
- Three-pole Disconnect Switch (TAF-M303)

### Outdoor Unit
- Drain Pan Heater (MAC-640BH-U)
- Drain Socklet (MAC-900DS)

### Electrical Requirements
- Power Supply: 208 / 230V, 1-Phase, 60 Hz
- Breaker Size: 15 A

### Operating Range

<table>
<thead>
<tr>
<th>Condition</th>
<th>Indoor Intake Air Temp.</th>
<th>Outdoor Intake Air Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooling</strong></td>
<td>Maximum: 90°F (32°C) DB, 55°F (13°C) WB</td>
<td>115°F (46°C) DB</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>Maximum: 67°F (19°C) DB, 57°F (14°C) WB</td>
<td>4°F (16°C) DB</td>
</tr>
<tr>
<td><strong>Heating</strong></td>
<td>Maximum: 50°F (10°C) DB, 67°F (19°C) WB</td>
<td>70°F (21°C) DB, 65°F (18°C) WB</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>Maximum: 4°F (1°C) DB, 50°F (10°C) WB</td>
<td>4°F (1°C) DB</td>
</tr>
</tbody>
</table>

---

**Dimensions**

### UNIT INCHES / MM

<table>
<thead>
<tr>
<th>Component</th>
<th>W</th>
<th>D</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor Unit</td>
<td>31-1/8 / 790</td>
<td>27-6/16 / 700</td>
<td>7-7/8 / 203</td>
</tr>
<tr>
<td>Outdoor Unit</td>
<td>31-1/2 / 800</td>
<td>15-1/4 / 385</td>
<td>21-5/8 / 550</td>
</tr>
</tbody>
</table>

**Weight**

- 42 lbs. / 19 kg
- 66 lbs. / 30 kg

**Sound Pressure Level**

- Indoor: 46 dBA
- Outdoor: 50 dBA

**Refrigerant Type**

- R410A

---

**Published 03/22/2011**
REQUIRED SPACE

Basically open 4 inch or more without any obstruction in front and on both sides of the unit.

Open two sides of left, right, or rear side.

Published 03/22/2011
About the TrueDRY™ DR65 Dehumidifier

The Honeywell TrueDRY DR65 ensures the home is maintained at proper humidity levels through its high performance and efficiency.

Benefits
- Removes up to 65 pints (30.8 l) of water per day from the indoor air.
- Built-in humidity control requires no additional wiring to an external control. Just plug in and go! Choice of external control options also available for centrally ducted control.
- Feedback on operation and maintenance provided via intuitive on-board LED light interface.

Maintaining Ideal Humidity

Dew points and relative humidity (RH) affect the way your body senses heat. Higher humidity levels cause the air to feel much hotter than the actual temperature. When maintained properly, your cooling equipment may not run as much because dehumidified air feels cooler.

---

Dehumidifier

Ideal humidity is defined by industry experts as being between 40-60% on an average annual basis. When indoor humidity exceeds 60%, the home is more susceptible to mold and mildew growth. TrueDRY DR65 safeguards against excessive humidity in the home year-round.

*American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
### Specifications

Install TrueDRy UHR® according to National Electric Codes.

<table>
<thead>
<tr>
<th>Dry-Bulb Temp</th>
<th>Intake Humidity</th>
<th>Capacity (Pints/Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60°F (26.7°C)</td>
<td>60% RH</td>
<td>85</td>
</tr>
<tr>
<td>70°F (21.1°C)</td>
<td>60% RH</td>
<td>42</td>
</tr>
<tr>
<td>80°F (15.6°C)</td>
<td>60% RH</td>
<td>21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Home Size (square ft)</th>
<th>Dehumidifier Capacity Required to Maintain Desired Indoor RH*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60% RH Indoor (pints/day)</td>
</tr>
<tr>
<td>2000</td>
<td>49-54</td>
</tr>
<tr>
<td>2600</td>
<td>61-68</td>
</tr>
<tr>
<td>3120</td>
<td>75-82</td>
</tr>
</tbody>
</table>

* Based on extreme climates where outdoor humidity is 70-90% RH. For less extreme climates, larger homes can be adequately served with less capacity. Actual requirements may vary.

#### Dimensions in inches and (mm):

- Dimensions: 12 in. H x 15 in. W x 31 in. L
- Media Filter: MERV 11, 9 in. H x 11 in. W x 1 in. D
- Drain connection: 3/4-in. threaded female NPT connection, with attached 3/4-in. male connection.
- Duct connections: 3-in. round inlet and outlet, ABS plastic, compatible for connection to rigid or flexible ducting with sheet metal screws and/or tape.
- Cabinet: 20 gauge galvanized steel powder-coat painted.
- Insulation: R value 1
- Compressor: Rotary-style, 5.8 KBTU
- Refrigerant: R-410A, 15 oz.
- Operating Temp Range (outside cabinet): 34°F to 135°F (1.1°C to 57.2°C)
- Operating Humidity Range: 0-99% RH

#### Airflow versus external static pressure (0–1 in. water pressure) with collars attached:

- 0 in.: 160 CFM
- 0.2 in.: 140 CFM
- 0.4 in.: 120 CFM
- 0.6 in.: 100 CFM

#### Input ratings:
- Electrical input voltage: 120 VAC, 60 Hz nominal
- Input current: 5.2 A

#### Output ratings:
- Power transformer to R/C terminals: 24 VAC, 0.05 A
- Energy Performance: 2.22 liters (4.7 pints) per kilowatt hour (kWh)

#### Standards and approval body requirements:
- ETL Tested per standard UL 474 ducted dehumidifier. ENERGY STAR rated.
Division 26 – Electrical

Grounding Rods

ERITECH® Copperbonded Ground Rods

In a grounding system, the ground electrode provides the physical connection to the earth and is the instrument used to dissipate current into it. There are two main types of electrodes.

“Natural” electrodes are intrinsic to the facility and include metal underground water pipe, the metal frame of the building (if effectively grounded), and reinforcing bar in concrete foundations.

“Made” electrodes are installed specifically to improve the performance of the grounding system and include wire meshes, metallic plates, buried copper conductor and rods or pipe driven into the ground.

The ground rod is the most widely used grounding electrode. ERICO® is the world's largest manufacturer of ground rods and offers a complete line of rods and accessories to meet the needs of every user.

Features

Copperbonded Ground Rods

- Resist corrosion better than galvanized rods allowing for a 30-year service life in most soils
- State of the art manufacturing process ensures uniform plating thickness
- Average tensile strength of 80,000 psi and straightness tolerance of .010” per linear foot
- Exceed the requirements of ANSI/UL® 487-1984, CSA®, and ANSI/NEMA® GR-1

Pointed Copperbonded Ground Rods

- Manufactured of high strength 1035 cold drawn steel
- The ERICO preferred ground rod

Compression Couplers for Pointed Rods

- For use when coupling pointed rods

Sectional Copperbonded Ground Rods

- For use when it is necessary to deep-drive rods
- Cold-rolled threads - stronger than cut threads

Threaded Couplers for Sectional Rods

- For use when coupling sectional rods

Drive Studs for Sectional Rods

- Screws into threaded coupler while rod is being driven

Applications

ERICO has a complete line of ground rods and accessories to meet the needs of every user.

More Information

View product information by region: North & Latin America · Europe · Asia & Australia

Product Information - North & Latin America  Return to Top

Published 03/22/2011
<table>
<thead>
<tr>
<th>Part No.</th>
<th>Plating Thickness (mil)</th>
<th>Diameter (In)</th>
<th>Length (ft)</th>
<th>Standard Package</th>
<th>Weight per 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>613852</td>
<td>5</td>
<td>3/8</td>
<td>6</td>
<td>5</td>
<td>160</td>
</tr>
<tr>
<td>613862</td>
<td>5</td>
<td>3/8</td>
<td>6</td>
<td>5</td>
<td>198</td>
</tr>
<tr>
<td>613860</td>
<td>10</td>
<td>3/8</td>
<td>6</td>
<td>5</td>
<td>270</td>
</tr>
<tr>
<td>611255</td>
<td>5</td>
<td>1/2</td>
<td>5</td>
<td>5</td>
<td>296</td>
</tr>
<tr>
<td>611265</td>
<td>5</td>
<td>1/2</td>
<td>6</td>
<td>5</td>
<td>310</td>
</tr>
<tr>
<td>611285</td>
<td>5</td>
<td>1/2</td>
<td>8</td>
<td>5</td>
<td>482</td>
</tr>
<tr>
<td>611360*</td>
<td>10</td>
<td>1/2</td>
<td>5</td>
<td>5</td>
<td>553</td>
</tr>
<tr>
<td>611200*</td>
<td>10</td>
<td>1/2</td>
<td>10</td>
<td>5</td>
<td>557</td>
</tr>
<tr>
<td>611300*</td>
<td>10</td>
<td>1/2</td>
<td>10</td>
<td>5</td>
<td>738</td>
</tr>
<tr>
<td>615850</td>
<td>10</td>
<td>5/8</td>
<td>5</td>
<td>5</td>
<td>420</td>
</tr>
<tr>
<td>615860</td>
<td>10</td>
<td>5/8</td>
<td>6</td>
<td>5</td>
<td>509</td>
</tr>
<tr>
<td>615860*</td>
<td>10</td>
<td>5/8</td>
<td>6</td>
<td>5</td>
<td>500</td>
</tr>
<tr>
<td>615863*</td>
<td>10</td>
<td>5/8</td>
<td>8</td>
<td>5</td>
<td>590</td>
</tr>
<tr>
<td>615800*</td>
<td>10</td>
<td>5/8</td>
<td>10</td>
<td>5</td>
<td>680</td>
</tr>
<tr>
<td>615803*</td>
<td>13-REA</td>
<td>5/8</td>
<td>8</td>
<td>5</td>
<td>844</td>
</tr>
<tr>
<td>615812*</td>
<td>10</td>
<td>5/8</td>
<td>12</td>
<td>5</td>
<td>844</td>
</tr>
<tr>
<td>615815*</td>
<td>10</td>
<td>5/8</td>
<td>15</td>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>613460</td>
<td>10</td>
<td>3/4</td>
<td>6</td>
<td>5</td>
<td>750</td>
</tr>
<tr>
<td>613480*</td>
<td>10</td>
<td>3/4</td>
<td>8</td>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>613483*</td>
<td>10</td>
<td>3/4</td>
<td>8</td>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>613400*</td>
<td>10</td>
<td>3/4</td>
<td>10</td>
<td>5</td>
<td>1240</td>
</tr>
<tr>
<td>613412*</td>
<td>10</td>
<td>3/4</td>
<td>12</td>
<td>5</td>
<td>1480</td>
</tr>
<tr>
<td>613415*</td>
<td>10</td>
<td>3/4</td>
<td>15</td>
<td>5</td>
<td>1650</td>
</tr>
</tbody>
</table>

* UL Listed
WEEB Compression Clip

Note: the following listing document applies to all of the WEEB devices in this project manual.

**AUTHORIZATION TO MARK**

This authorizes the application of the Certification Mark(s) shown below to the models described in the Product(s) Covered section when made in accordance with the conditions set forth in the Certification Agreement and Listing Report. This authorization also applies to multiple listee model(s) identified on the correlation page of the Listing Report.

This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant: Wiley Electronics, LLC  
Address: 44 Peoples Rd  
Saugerties, NY 12477  
Country: USA  
Contact: Maggie Dulka / Mr. Brian Wiley  
Phone: 845-247-4708  
Fax: 845-247-7438  
Email: paul@we-elec.com

Manufacturer: Same As Applicant  
Address:  
Country:  
Contact:  
Phone:  
Fax:  
Email:

Party Authorized To Apply Mark: Same as Manufacturer  
Report Issuing Office: Lake Forest, CA

Control Number: 3098177  
Authorized by: [Signature]

William J. Starr, Certification Manager

This document supersedes all previous Authorizations to Mark for the noted Report Number.

The Certification Mark is for the exclusive use of Intertek's Client and is provided pursuant to the Certification Agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this Authorization to Mark. Only the Client authorized to permit copying or distribution of this Authorization to Mark and then only in its entirety. Use of Intertek's Certification mark is restricted to the conditions laid out in the agreement and in this Authorization to Mark. Any further use of the Intertek name for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. Intertek Factory Assessments and Follow up Services are for the purpose of ascertaining appropriate usage of the Certification mark in accordance with the agreement, they are not for the purposes of production quality control and do not relieve the Client of their obligations in this respect.

Intertek Testing Services NA Inc.  
165 Main Street, Cortland, NY 13045  
Telephone 800-345-3851 or 807-753-6711 Fax 807-756-6889


Product: Bonding Devices


ATM for Report 3098176-002  
Page 1 of 1  
ATM Issued: 14-Jul-2011  
ED 8.0.4 (0-Jan-10) Mandatory
WEEB Washer, Electrical Equipment Bond

The WEEB line of products is designed to bond solar PV modules to mounting structures and create an electrical path to ground. WEEBs eliminate the need for older, more costly grounding methods and greatly reduce the amount of labor and materials used in installations. The innovative WEEB design removes the need to run ground wire to each individual module and eliminates the need for surface preparation on anodized aluminum components. To install, WEEBs are placed between PV modules and mounting rails at clamping points or at bolted connections. When anti-seize is applied and the hardware is tightened down to the appropriate torque spec, the WEEBs’ specialized teeth embed into anodized aluminum, galvanized steel, or any electrically conductive metal to establish a gas tight electrical connection.

- Material: 304 stainless steel
- Listed to ANSI-UL 457 by Intertek ETL for use in Canada and the USA
- Maximum electrical equipment ground conductor size when used with 2 WEEBs contacting each module in an assembly: 6 AWG
- Outdoor rated

Contact us at: 845.247.4708  www.we-llc.com
WEEB Lug

The WEEB Lug consists of a WEEB (Washer, Electrical Equipment Bond), lay-in lug, and hardware. It is
used with one solid or stranded copper wire (6AWG to 14AWG), or two copper wires (10AWG to 12AWG)
to provide a continuous ground on roof or ground mounted solar systems. Unlike traditional lay-in lugs,
the WEEB Lug does not require surface preparation on rail or module to install. The WEEB Lug is
installed using a 1/4-20 stainless steel screw which tightens the WEEB, allowing the specialized teeth to
embed into anodized aluminum, galvanized steel, or any electrically conductive metal to establish a gas
tight electrical connection. The tin-plated Lug assures minimum contact resistance and protection against
corrosion. The copper wire is clamped by a 1/4-28 stainless steel screw, which is horizontal to the tang for
easy access when mounted under a PV module. The low profile of the WEEB Lug allows it to be installed
in a variety of positions and comes with hardware to mount it to a rail or through a 1/4 inch clearance hole.

- **Material:** 304 stainless steel, tin-plated copper, outdoor rated
- **Low profile design**
- **Multiple equipment ground conductor allowance:**
  One 14 AWG to 6 AWG or two 10 AWG, two 12 AWG
- **Listed to ANSI/UL 467 by Intertek ETL**

Contact us at: 845.247.4708  www.we-llc.com
WEEB Bonding Jumper

The WEEB Bonding Jumper is used to create an electrical connection between two pieces of anodized aluminum, galvanized steel, or any electrically conductive metal which has been mechanically spliced. Long spans of mounting rails are sometimes constructed from two shorter rail sections. Manufacturers may recommend that a floating splice be used to allow for thermal expansion. A floating splice is rigidly attached to only one rail, and allows the rails to expand and contract in line with each other. In such cases, via NEC code, it is also necessary to make an electrical splice, which can be done with a WEEB Bonding Jumper. The Bonding Jumper is constructed of tin plated, braided copper wire with a WEEB attached at each end of the Jumper. The WEEBs provide a reliable, gas tight electrical connection, and the braided copper wire allows for thermal expansion. The examples below illustrate two ways to install the WEEB Bonding Jumper.

Contact us at: 845.247.4708  www.we-llc.com
Electric Metallic Tubing

ALLIED KWIK-FIT® EMT

For Faster, Easier Installation...
Make It Kwik-Fit® EMT

KWIK-FIT® EMT is manufactured from high quality steel with a BUILT-IN set-screw coupling, eliminating the need to purchase, inventory, and install separate couplings.

On the job site, installation is much faster and you’ve reduced both material and labor costs. Even clean-up after installation is easier – no clutter of extra couplings and empty boxes!

- No separate couplings to purchase, store, carry or install
- High grade durable and ductile steel for long life
- Corrosion Resistant exterior and interior finishes
- UL listed and manufactured in accordance with ANSI C80.3
- Available in trade sizes 1 1/4 – 4

1. Insert plain end into integrated coupling.

2. Tighten set screws.

Patent No. US 7,404,582 B2

No separate couplings to purchase, store, carry or install! You always have the right type and size coupling with you – attached at the end of the EMT!

Contact your local Allied Tube & Conduit electrical distributor, or visit www.alliedeg.com.

ALLIED ELECTRICAL™ Group

Electrical Infrastructure Solutions™

www.alliedeg.com

Published 03/22/2011
# KWIK-FIT® EMT Specifications

**KWIK-FIT® SIGNIFICANTLY REDUCES INSTALLATION COST.**

Each 10' length of KWIK-FIT EMT has an integral steel set-screw coupling. These built-in couplings significantly reduce installation time, and eliminate the need to purchase, store, and install separate couplings. Simply insert the plain end of the KWIK-FIT into the coupling end and tighten the set-screws.

**SUPERIOR STRENGTH & CONSTRUCTION**

KWIK-FIT EMT is all steel for superior strength, performance and excellent ground return path. Allied EMT is hot galvanized using Allied’s patented in-line Flo-Coat® process. This process combines zinc, a conversion coating, and a clear organic polymer top-coat to form a triple layer of protection against corrosion and abrasion.

The interior of KWIK-FIT EMT is protected with Allied’s superior EZ PULL® coating. This interior coating makes wire-pulling even easier with a 30% lower coefficient of static friction.

**AVAILABLE SIZES**

KWIK-FIT EMT is available in 10' lengths, trade sizes from 1 1/4” – 4”.

**UL LISTED & APPROVED**

KWIK-FIT EMT is listed to UL Standard 757 Electrical Metallic Tubing – Steel, and to UL 514B Conduit, Tubing and Cable Fittings. KWIK-FIT EMT is manufactured in accordance with ANSI Standard C80.3.

## WEIGHTS AND DIMENSIONS FOR KWIK-FIT EMT

<table>
<thead>
<tr>
<th>Trade Size Designator</th>
<th>Approx. WL Per 100 Ft. (30.5M)</th>
<th>Nominal Outside Diameter</th>
<th>Nominal Wall Thickness</th>
<th>Master Bundles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in lb. kg</td>
<td>in. mm</td>
<td>ft. m</td>
<td>Approx. Wt.</td>
</tr>
<tr>
<td>U.S. Metric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/4</td>
<td>36</td>
<td>101</td>
<td>515.8</td>
<td>38.4</td>
</tr>
<tr>
<td>1 1/2</td>
<td>31</td>
<td>116</td>
<td>174.4</td>
<td>44.2</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>148</td>
<td>219.7</td>
<td>58.8</td>
</tr>
<tr>
<td>2 1/2</td>
<td>63</td>
<td>216</td>
<td>287.5</td>
<td>73.0</td>
</tr>
<tr>
<td>3</td>
<td>78</td>
<td>263</td>
<td>360.0</td>
<td>89.9</td>
</tr>
<tr>
<td>3 1/2</td>
<td>91</td>
<td>349</td>
<td>400.0</td>
<td>101.6</td>
</tr>
<tr>
<td>4</td>
<td>103</td>
<td>393</td>
<td>450.0</td>
<td>114.3</td>
</tr>
</tbody>
</table>

*Outside-diameter tolerances: 0.05 in. (1.27mm) for trade sizes 1” & 2”; 0.06 in. (1.55mm) for trade sizes 3” & 4”.*
ALLIED
RIGID STEEL CONDUIT

Quality Long Lasting GRC (Rigid) Steel Conduit...

Allied Rigid Steel Conduit is precision manufactured for dependable, long-lasting value and ultimate protection for electrical conductors. Highly resistant to damage from impact, it can be installed in all occupancies and in all locations, including Class I Division 1 hazardous locations.

Rigid steel conduit, covered by Article 344 in the National Electric Code® (NEC), is recognized as an equipment grounding conductor in Article 250-118 of the NEC and also provides excellent shielding from electromagnetic fields.

- Hot-dip galvanized to inhibit white rust and increase corrosion resistance
- High strength ductile steel for long life and easy bending
- Provides smooth, continuous raceways for fast wire-pulling
- UL listed to UL 6, manufactured in accordance with ANSI C80.1
- Available in trade sizes 1/2 – 6

Kwik-Couple® for Faster Installations

Get the Kwik-Couple® Connection

Innovation from the conduit leaders at Allied.

Allied’s patented Kwik-Couple rigid steel conduit cuts threaded conduit installation time and cost significantly. Kwik-Couple comes installed right on the conduit or elbows, right where you need it.

Just line up the ends, spin the coupling forward onto the next piece and wrench tighten. It’s that easy! Trade sizes 2-1/2 – 4.

Contact Allied for details.

* U.S. Patent Numbers 4258836, 4547051.

Contact your local Allied Tube & Conduit electrical distributor, or visit www.alliedeg.com.
### Allied Rigid Steel Conduit Specifications

**Full Electrical System Protection**

Manually from high-strength steel, Allied Rigid combines damage-resistant strength with an Ability to ensure easy bending, cutting, and joining. It also provides smooth, continuous raceways for fast wire-pulling. No need to worry about damage to the conduit system even when pulling through multiple 90° bends. Allied Rigid is hot-dipped galvanized inside and out. It's top-coated with a compatible organic layer to inhibit white rust and increase corrosion resistance. It's impact and crush resistant for maximum conductor protection.

The 3/4" tapers NPT threads (ANSI B1.20.1) are fully cut and hot galvanized after cutting. Color-coded end-cap thread protectors keep the threads clean, sharp, and also provide instant brand size recognition. Trade sizes are color-coded blue, 1/2" trade sizes black, and 1/4" trade sizes red.

**EMI Shielding**

Allied Rigid is very effective in reducing electromagnetic field levels for encased power distribution circuits, shielding computers and other sensitive electronic equipment from the effects of electromagnetic interference. Contact Allied for a free evaluation kit to obtain the GEMI (Grounding and Electro-magnetic Interference) software analysis program.

**Full Codes & Standards Compliance**

Allied Rigid is covered by article 344 of the National Electrical Code. It is listed by Underwriters Laboratories Safety Standard UL 8 and is manufactured to ANSI C80.1, both of which have been adopted as Federal Specifications in lieu of WMC 581. Allied Rigid is recognized as an equipment grounding conductor for NEC Article 250.

Installation of Rigid Metal Conduit shall be in accordance with the National Electrical Code and UL General Information card #DY1. Master bundles conform to NEMA standard RN2.

**Specification Data**

Rigid Metal Conduit shall be hot-dip galvanized steel equal to that manufactured by Allied Tube & Conduit Corporation. Threads shall be hot-galvanized after cutting. Rigid shall be produced in accordance with UL Safety Standard #8 and ANSI C80.1 and shall be listed by a nationally recognized testing laboratory with follow-up service. Where Kwik-Couple® Rigid is used it shall also meet UL Safety Standard 514-B. It is noted that these UL standards have been adopted by the federal government and separate military specifications no longer exist.

---

### Weights and Dimensions for Galvanized Rigid Tubing

<table>
<thead>
<tr>
<th>Trade Size Designator</th>
<th>Approx. Wt.* Per 100 Ft. (0.3m)</th>
<th>Nominal Outside Diameter</th>
<th>Nominal Wall Thickness</th>
<th>Quantity in Master Bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>16</td>
<td>82</td>
<td>37.2</td>
<td>21</td>
</tr>
<tr>
<td>3/4</td>
<td>21</td>
<td>109</td>
<td>49.4</td>
<td>60</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
<td>161</td>
<td>73.0</td>
<td>64</td>
</tr>
<tr>
<td>1-1/4</td>
<td>35</td>
<td>215</td>
<td>95.9</td>
<td>73</td>
</tr>
<tr>
<td>2</td>
<td>41</td>
<td>263</td>
<td>119.3</td>
<td>83</td>
</tr>
<tr>
<td>2-1/2</td>
<td>53</td>
<td>360</td>
<td>158.7</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>63</td>
<td>559</td>
<td>235.3</td>
<td>93</td>
</tr>
<tr>
<td>3-1/2</td>
<td>76</td>
<td>727</td>
<td>329.7</td>
<td>98</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>880</td>
<td>399.1</td>
<td>103</td>
</tr>
<tr>
<td>5</td>
<td>129</td>
<td>1400</td>
<td>634.9</td>
<td>118</td>
</tr>
<tr>
<td>5-1/2</td>
<td>154</td>
<td>1540</td>
<td>634.5</td>
<td>123</td>
</tr>
</tbody>
</table>

* For more information only; not a spec requirement.

**Weights and Dimensions for Kwik-Couple® Rigid**

<table>
<thead>
<tr>
<th>Trade Size Designator</th>
<th>Approx. Wt.* Per 100 Ft. (0.3m)</th>
<th>Nominal Outside Diameter</th>
<th>Nominal Wall Thickness</th>
<th>Quantity in Master Bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2</td>
<td>63</td>
<td>559</td>
<td>235.3</td>
<td>93</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>727</td>
<td>329.7</td>
<td>98</td>
</tr>
<tr>
<td>3-1/2</td>
<td>91</td>
<td>880</td>
<td>399.1</td>
<td>103</td>
</tr>
<tr>
<td>4</td>
<td>129</td>
<td>1400</td>
<td>634.9</td>
<td>118</td>
</tr>
<tr>
<td>5</td>
<td>154</td>
<td>1540</td>
<td>634.5</td>
<td>123</td>
</tr>
</tbody>
</table>

Outside diameter tolerances: ±.025 in. (±6.4mm) For information only, not a spec requirement.

For more information, contact Allied at (800) 882-5543, or visit our website at www.alliedeg.com.

---

**Electrical & Support Division**

Allied Tube & Conduit
1610 S. Lathrop Avenue, Harvey, IL 60426
Tel 708-339-1610 Fax 708-339-0615

© 2007-09 Tyco International, All rights reserved. ATC-L-746-0912

* Allied Tube & Conduit* · *AFC Cable Systems* · *Power-Stuf* & *UtilStuf* Metal & Fiberglass Framing · *Cope* Cable Tray

This trademark, logo, and service marks displayed on this brochure are owned or licensed by Tyco Int., or its subsidiaries, affiliates, and/or predecessor companies. Trademarks not owned by Tyco Int. are the property of their respective owners and are used with permission of the owner under applicable laws.

---

**Published 03/22/2011**

U.S. D.O.E. Solar Decathlon 2011

32 90 00 - 66
ELECTRICAL CONDUIT

SUBMITTAL AND DATA SHEET

SCHEDULE 40 AND SCHEDULE 80 CONDUIT NSF NRTL ANSI/UL 651 AND NEMA TC-2
RIGID NON-METALLIC CONDUIT FOR USE IN BOTH ABOVE GROUND AND UNDERGROUND INSTALLATIONS

### SCHEDULE 40 CONDUIT
Rated for 90°C Conductors

<table>
<thead>
<tr>
<th>SIZE</th>
<th>AVERAGE O.D.</th>
<th>NOM. I.D.</th>
<th>MIN. T.</th>
<th>APPROX. WT/100 FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.840</td>
<td>0.622</td>
<td>0.109</td>
<td>18</td>
</tr>
<tr>
<td>3/4</td>
<td>1.050</td>
<td>0.824</td>
<td>0.113</td>
<td>24</td>
</tr>
<tr>
<td>1</td>
<td>1.315</td>
<td>1.049</td>
<td>0.133</td>
<td>33</td>
</tr>
<tr>
<td>1-1/4</td>
<td>1.660</td>
<td>1.380</td>
<td>0.140</td>
<td>45</td>
</tr>
<tr>
<td>1-1/2</td>
<td>1.900</td>
<td>1.610</td>
<td>0.145</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td>2.375</td>
<td>2.067</td>
<td>0.164</td>
<td>76</td>
</tr>
<tr>
<td>2-1/2</td>
<td>2.875</td>
<td>2.469</td>
<td>0.203</td>
<td>126</td>
</tr>
<tr>
<td>3</td>
<td>3.500</td>
<td>3.068</td>
<td>0.216</td>
<td>163</td>
</tr>
<tr>
<td>3-1/2</td>
<td>4.000</td>
<td>3.548</td>
<td>0.226</td>
<td>197</td>
</tr>
<tr>
<td>4</td>
<td>4.500</td>
<td>4.026</td>
<td>0.237</td>
<td>234</td>
</tr>
<tr>
<td>5</td>
<td>5.563</td>
<td>5.047</td>
<td>0.288</td>
<td>319</td>
</tr>
<tr>
<td>6</td>
<td>6.625</td>
<td>6.065</td>
<td>0.280</td>
<td>411</td>
</tr>
<tr>
<td>8</td>
<td>8.625</td>
<td>7.942</td>
<td>0.322</td>
<td>522</td>
</tr>
</tbody>
</table>

Schedule 40 is furnished in standard 10' lengths with one bell end.
20' lengths are available upon request.
::: Non-UL or NSF listed

### SCHEDULE 80 CONDUIT
Rated for 90°C Conductors

<table>
<thead>
<tr>
<th>SIZE</th>
<th>AVERAGE O.D.</th>
<th>NOM. I.D.</th>
<th>MIN. T.</th>
<th>APPROX. WT/100 FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.840</td>
<td>0.546</td>
<td>0.147</td>
<td>22</td>
</tr>
<tr>
<td>3/4</td>
<td>1.060</td>
<td>0.742</td>
<td>0.164</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>1.315</td>
<td>0.957</td>
<td>0.179</td>
<td>42</td>
</tr>
<tr>
<td>1-1/4</td>
<td>1.660</td>
<td>1.278</td>
<td>0.191</td>
<td>60</td>
</tr>
<tr>
<td>1-1/2</td>
<td>1.900</td>
<td>1.590</td>
<td>0.200</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>2.375</td>
<td>1.939</td>
<td>0.218</td>
<td>98</td>
</tr>
<tr>
<td>2-1/2</td>
<td>2.875</td>
<td>2.323</td>
<td>0.276</td>
<td>160</td>
</tr>
<tr>
<td>3</td>
<td>3.500</td>
<td>2.900</td>
<td>0.300</td>
<td>213</td>
</tr>
<tr>
<td>3-1/2</td>
<td>4.000</td>
<td>3.364</td>
<td>0.316</td>
<td>256</td>
</tr>
<tr>
<td>4</td>
<td>4.500</td>
<td>3.826</td>
<td>0.337</td>
<td>310</td>
</tr>
<tr>
<td>5</td>
<td>5.563</td>
<td>4.813</td>
<td>0.375</td>
<td>430</td>
</tr>
<tr>
<td>6</td>
<td>6.625</td>
<td>5.761</td>
<td>0.432</td>
<td>590</td>
</tr>
</tbody>
</table>

Schedule 80 is furnished in standard 10' lengths with one bell end.
20' lengths are available upon request.

* NATIONAL RECOGNIZED TESTING LABORATORY (NRTL) BY OCCUPATIONAL HEALTH AND SAFETY ADMINISTRATION (OSHA)
### Technical Characteristics

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampere Rating</td>
<td>200A</td>
</tr>
<tr>
<td>Bus Material</td>
<td>Tin Plated Aluminum</td>
</tr>
<tr>
<td>Enclosure Type</td>
<td>Indoor</td>
</tr>
<tr>
<td>Box Number</td>
<td>9</td>
</tr>
<tr>
<td>Enclosure Rating</td>
<td>NEMA 1</td>
</tr>
<tr>
<td>Grounding Bar</td>
<td>Factory Installed</td>
</tr>
<tr>
<td>Maximum Single Pole Circuits</td>
<td>32</td>
</tr>
<tr>
<td>Application</td>
<td>Designed to meet residential, commercial and industrial requirements to protect electrical systems, equipment and people.</td>
</tr>
<tr>
<td>Short Circuit Current Rating</td>
<td>10kA</td>
</tr>
<tr>
<td>Maximum Tandem Circuit Breakers</td>
<td>16</td>
</tr>
<tr>
<td>Approvals</td>
<td>UL Listed</td>
</tr>
<tr>
<td>Main Type</td>
<td>Convertible - Factory Installed main lugs</td>
</tr>
<tr>
<td>Cover Type</td>
<td>Combination Flush/Surface</td>
</tr>
<tr>
<td>Marketing Trade Name</td>
<td>Homeline</td>
</tr>
<tr>
<td>Phase</td>
<td>1-Phase</td>
</tr>
<tr>
<td>Depth</td>
<td>3.75 inches</td>
</tr>
<tr>
<td>Height</td>
<td>29.85 inches</td>
</tr>
<tr>
<td>Spaces</td>
<td>16</td>
</tr>
<tr>
<td>Voltage Rating</td>
<td>120/240VAC</td>
</tr>
<tr>
<td>Wire Size</td>
<td>#4 to 250 AWG/kcmil (Al/Cu)</td>
</tr>
<tr>
<td>Wiring Configuration</td>
<td>3-wire</td>
</tr>
<tr>
<td>Width</td>
<td>14.25 inches</td>
</tr>
</tbody>
</table>

### Shipping and Ordering

- **Category**: 00045 - Load Centers, Type HOM 12 - 42 Circuit, NEMA1 Indoor
- **Discount Schedule**: DC3G
- **GTIN**: 0076590130938
- **Package Quantity**: 1
- **Weight**: 27.2 lbs.
- **Availability Code**: Stock Item: This item is normally stocked in our distribution facility.
- **Returnability**: Y
- **Country of Origin**: US

As standards, specifications, and designs change from time to time, please ask for confirmation of the information given in this document.
Product Data Sheet

QO612L100RB
LOAD CENTER QO MLO 240V 100A 1PH 6SP

Technical Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Circuit Current Rating</td>
<td>100A</td>
</tr>
<tr>
<td>Main Type</td>
<td>Fixed - Factory Installed main lugs</td>
</tr>
<tr>
<td>Maximum Single Pole Circuits</td>
<td>12</td>
</tr>
<tr>
<td>Maximum Tandem Circuit Breakers</td>
<td>6</td>
</tr>
<tr>
<td>Phase</td>
<td>1-Phase</td>
</tr>
<tr>
<td>Spaces</td>
<td>6</td>
</tr>
<tr>
<td>Ampere Rating</td>
<td>100A</td>
</tr>
<tr>
<td>Voltage Rating</td>
<td>120/240VAC</td>
</tr>
<tr>
<td>Wire Size</td>
<td>#6 to 1 AWG(A/Cu)</td>
</tr>
<tr>
<td>Wiring Configuration</td>
<td>3-Wire</td>
</tr>
<tr>
<td>Application</td>
<td>Designed to meet residential, commercial and industrial requirements to protect electrical systems, equipment and people.</td>
</tr>
<tr>
<td>Depth</td>
<td>4.27 inches</td>
</tr>
<tr>
<td>Approvals</td>
<td>UL Listed</td>
</tr>
<tr>
<td>Height</td>
<td>12.65 inches</td>
</tr>
<tr>
<td>Cover Type</td>
<td>Surface</td>
</tr>
<tr>
<td>Width</td>
<td>8.88 inches</td>
</tr>
<tr>
<td>Bus Material</td>
<td>Tin Plated Aluminum</td>
</tr>
<tr>
<td>Enclosure Type</td>
<td>Outdoor/Rainproof</td>
</tr>
<tr>
<td>Box Number</td>
<td>2R</td>
</tr>
<tr>
<td>Enclosure Rating</td>
<td>NEMA 3R</td>
</tr>
<tr>
<td>Grounding Bar</td>
<td>Order separately</td>
</tr>
</tbody>
</table>

Notes:
- 70A (max) branch circuit breaker and 70A (max) back fed main circuit breaker.

Shipping and Ordering

| Category                | 00101 - Load Centers, 1 Phase, NEMA1 & 3R, 2 - 8 Circuit, Type QO |
| Discount Schedule       | DCSA                    |
| GTIN                    | 0076590178590           |
| Package Quantity        | 1                       |
| Weight                  | 9.68 lbs.               |
| Availability Code       | Stock Item: This item is normally stocked in our distribution facility. |
| Retunability            | Y                       |
| Country of Origin       | MX                      |

© 2011 Schneider Electric. All rights reserved.
It’s all about SAFETY. HUBBELL SAFE.

Tamper-Resistant Receptacles
— the new standard in electrical safety.

Spring-loaded shutter mechanism allows plugs to enter—but resists access to single-pronged items like keys, hairpins, or nails.

The NEC® 2008 code:
NEC Article 406.11 requires tamper-resistant receptacles for dwelling units. “In all areas specified in 210.52, all 125 volt 15- and 20-ampere receptacles shall be listed tamper-resistant receptacles.” Article 210.52 specifies where receptacles shall be installed.

What this means to you:
All 15- and 20-amp, 125 volt residential receptacles must be of a type classified and listed as Tamper-Resistant (TR). This includes duplexes, GFCI's, single receptacles, clock hangars, floor boxes, and other specialty products with outlets. Receptacles, even if dedicated to a specific use and not readily accessible, must be tamper-resistant.
This affects all new construction and major renovations for single- and multi-family homes. In some instances, hotel rooms and college dormitories are classified as dwelling units.
Why Tamper-Resistant?
The tamper-resistant code requirement is all about safety.

- Approximately 2,400 children per year suffer electrical outlet related injuries.
- For years, the design and use of tamper-resistant receptacles have been proven effective in pediatric areas and hospital installations nationwide. It makes sense to have them in homes.
- The additional cost per device is minimal and well worth it.
- Required by states that adopt 2008 NEC®.

Tamper-Resistant Receptacles

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond</td>
<td>RR15SALTR</td>
<td>RR15QALTR</td>
<td>RRD15SALTR</td>
<td>RR15KALTR</td>
<td>RR15IALTR</td>
<td>RR20IALTR</td>
</tr>
<tr>
<td>Black</td>
<td>RR15SBKTTR</td>
<td>RR15QBTTR</td>
<td>RRD15SBKTTR</td>
<td>RR15KBKTTR</td>
<td>RR15IBKTTR</td>
<td>RR20IBKTTR</td>
</tr>
<tr>
<td>Brown</td>
<td>RR15STTR</td>
<td>RR15QTR</td>
<td>RRD15STTR</td>
<td>RR15KTR</td>
<td>RR15ITR</td>
<td>RR20ITR</td>
</tr>
<tr>
<td>Grey</td>
<td></td>
<td></td>
<td></td>
<td>RRD15SSGYTR</td>
<td>RR15GYTR</td>
<td>RR20GYTR</td>
</tr>
<tr>
<td>Ivory</td>
<td>RR15SITR</td>
<td>RR15QTRI</td>
<td>RRD15SITR</td>
<td>RR15KTRI</td>
<td>RR15ITR</td>
<td>RR20ITR</td>
</tr>
<tr>
<td>Light Almond</td>
<td>RR15SLATR</td>
<td>RR15QLATR</td>
<td>RRD15SLATR</td>
<td>RR15KLATR</td>
<td>RR15ILATR</td>
<td>RR20ILATR</td>
</tr>
<tr>
<td>White</td>
<td>RR15SWTR</td>
<td>RR15QWTR</td>
<td>RRD15SWTR</td>
<td>RR15KWSTR</td>
<td>RR15IWTR</td>
<td>RR20IWTR</td>
</tr>
</tbody>
</table>

Setting the standard, wire to wire.

Published 03/22/2011
Increasing awareness of child electrical safety

The National Electrical Manufacturers Association has developed a program titled Real Safety that identifies the dangers electrical receptacles may pose to children, educating users about tamper-resistant receptacle function. Real Safety targets electrical professionals, inspectors, distributors, builders and new homeowners. For more information visit the website at www.childoutletsafety.org.

Tamper-Resistant GFCIs and Specialty Items

<table>
<thead>
<tr>
<th>GFCI/Duplex 15A 120V</th>
<th>GFCI Duplex 20A 120V</th>
<th>GFCI Combo SP Switch 15A 120V</th>
<th>RJLOAD™ Multimedia Outlet 16A &amp; Jacks</th>
<th>RJLOAD™ Multimedia Outlet 20A &amp; Jacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond</td>
<td>GFTR15AL</td>
<td>GFTR20AL</td>
<td>GFSP15TRAL</td>
<td>RJ050ALTR</td>
</tr>
<tr>
<td>Black</td>
<td>GFTR15BK</td>
<td>GFTR20BK</td>
<td>GFSP15TRBK</td>
<td>RJ050BKTR</td>
</tr>
<tr>
<td>Brown</td>
<td>GFTR15S</td>
<td>GFTR20S</td>
<td>GFSP15TR</td>
<td>RJ050KBTR</td>
</tr>
<tr>
<td>Gray</td>
<td>GFTR15GY</td>
<td>GFTR20GY</td>
<td>GFSP15TRGY</td>
<td>RJ050GYTR</td>
</tr>
<tr>
<td>Ivory</td>
<td>GFTR15L</td>
<td>GFTR20L</td>
<td>GFSP15TRLA</td>
<td>RJ050LALTR</td>
</tr>
<tr>
<td>Light Almond</td>
<td>GFTR15LA</td>
<td>GFTR20LA</td>
<td>GFSP15TRLA</td>
<td>RJ050LATR</td>
</tr>
<tr>
<td>White</td>
<td>GFTR15W</td>
<td>GFTR20W</td>
<td>GFSP15TRW</td>
<td>RJ050WTR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clock Hanger 15A 120V</th>
<th>Single Receptacle Floor Box 16A 120V</th>
<th>Duplex Receptacle Floor Box Model 16A 120V</th>
<th>Duplex Receptacle Floor Box Stub-in-grade 16A 120V</th>
<th>Drop-in Floor Box 16A 120V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond</td>
<td>—</td>
<td>RF515AL</td>
<td>RF4015AL*</td>
<td>—</td>
</tr>
<tr>
<td>Black</td>
<td>—</td>
<td>RF515BK</td>
<td>RF4015BK*</td>
<td>—</td>
</tr>
<tr>
<td>Brown</td>
<td>—</td>
<td>RF515BN</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ivory</td>
<td>RR151GHTR</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>White</td>
<td>RR151GHWTR</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Brass</td>
<td>RR151GBSTR</td>
<td>RF515TR</td>
<td>RF515BS*</td>
<td>RF151TR*</td>
</tr>
<tr>
<td>Stainless</td>
<td>RR151GHSSTR</td>
<td>—</td>
<td>RF515SS</td>
<td>—</td>
</tr>
</tbody>
</table>

* Not CSA Approved
Residential Tamper-Resistant Performance

Protection is always there with the tamper-resistant receptacles. It is reliable, automatic and permanent. With attention to design and performance, Hubbell has developed a new shutter mechanism to enable tamper-resistance to be built into standard and decorator duplexes, single receptacles, floor boxes and other power devices. At Hubbell, performance is our history, safety is our goal—now for your home.

Look for the TR!

Spring-loaded shutter mechanism restricts access to an object in any one side of the receptacle.

Insertion of a two or three bladed plug will open the shutters, allowing electrical contact.
# Decora AC Quiet Rocker Switches

## 15 AMP Quickwire Push-In and Side Wired 120/277V AC

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>CAT. NO.</th>
<th>ROCKER/FRAKE COLOR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Pole</td>
<td>5601</td>
<td>Mahogany</td>
</tr>
<tr>
<td></td>
<td>5601-1</td>
<td>Ivory</td>
</tr>
<tr>
<td></td>
<td>5601-W</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>5601-2A</td>
<td>Almond</td>
</tr>
<tr>
<td></td>
<td>5601-2E</td>
<td>Ebony</td>
</tr>
<tr>
<td></td>
<td>5601-2Y</td>
<td>Gray</td>
</tr>
<tr>
<td>Double-Pole</td>
<td>5602-2</td>
<td>Mahogany</td>
</tr>
<tr>
<td></td>
<td>5602-2I</td>
<td>Ivory</td>
</tr>
<tr>
<td></td>
<td>5602-2W</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>5602-2Y</td>
<td>Gray</td>
</tr>
<tr>
<td></td>
<td>5602-2A</td>
<td>Almond</td>
</tr>
<tr>
<td></td>
<td>5602-2E</td>
<td>Ebony</td>
</tr>
<tr>
<td>Three-Way</td>
<td>5603</td>
<td>Mahogany</td>
</tr>
<tr>
<td></td>
<td>5603-1</td>
<td>Ivory</td>
</tr>
<tr>
<td></td>
<td>5603-W</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>5603-2A</td>
<td>Almond</td>
</tr>
<tr>
<td></td>
<td>5603-2E</td>
<td>Ebony</td>
</tr>
<tr>
<td></td>
<td>5603-2Y</td>
<td>Gray</td>
</tr>
<tr>
<td>Four-Way</td>
<td>5604-2</td>
<td>Mahogany</td>
</tr>
<tr>
<td></td>
<td>5604-2I</td>
<td>Ivory</td>
</tr>
<tr>
<td></td>
<td>5604-2W</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>5604-2A</td>
<td>Almond</td>
</tr>
<tr>
<td></td>
<td>5604-2E</td>
<td>Ebony</td>
</tr>
<tr>
<td></td>
<td>5604-2Y</td>
<td>Gray</td>
</tr>
</tbody>
</table>

Note: To order Decora rocker switches with grounding screw add suffix -2 (e.g. 5601-22)
All devices are UL Listed and CSA Certified.

## Specifications & Features
- Switch frame shields against dust and fits in wallplates to prevent rocker binding.
- Side Wire and Quickwire (No. 12 or No. 14 copper or copper-clad wire) push-in terminal wiring options.
- Shorty construction for long life.
- Full rated current capacity with junction, Receptacle or receptacle loads. Motor capacity is 50% of switch rating.
- Conform to all NEMA-standard specifications.

## Testing & Code Compliance
- UL Listed (File E5748)
- CSA Certified (File ALR-3413)
- NOM Certified (W05)
- Backed by a Limited Two-Year Warranty

### Color
- Rocker/Frame colors available as listed.

### Horse Power
- 15A
- 120V
- 2 G 240V

### Material Characteristics
- Environmental Flammability: UL-94, V2 Rating
- Operating Temperature: -40°C to 120°C

For answers to technical questions, call Leviton's Techline at 1-800-624-3005...Building a Connected World

---

U.S. D.O.E. Solar Decathlon 2011

Published 03/22/2011

32 90 00 - 78
### Product Schedule 410

#### Type UAT4 200A Residential Meter Mounting Devices

**Common Features**
- OHUG construction
- 200A continuous duty rated
- 250A max rated
- Quad ground on all devices
- Lay-in 350 kcmil max lugs
- Steel or aluminum construction
- Glass filled polyester block construction
- Ring or ringless style
- Horn bypass available

![Diagram of UAT4 Meter Socket](image)

**Optimal Field Replaceable 5th Terminal**

**Knockouts (inches):**
- S: 1, 3, 1/4, 1-1/2, 2, 2-1/2
- A8: 1/8, 1/8, 7/8
- RX: 02.750 HUB 0P

<table>
<thead>
<tr>
<th>Cover</th>
<th>Style</th>
<th>Terminal Connector</th>
<th>Voltage</th>
<th>Dimension</th>
<th>Hub Opening</th>
<th>Bore Size</th>
<th>Catalog Number</th>
<th>Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#4-20 none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>XX, C, Rats</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>XX Opening</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>2&quot; Hub Installed</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>2 1/2&quot; Hub Installed</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>XX, C, Rats</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>XX Opening</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>XX Opening</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>7/8&quot; Factory Installed</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>7/8&quot; Factory Installed</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
<tr>
<td>Single</td>
<td>OHUG</td>
<td>#6-350 kcmil none</td>
<td>11.0</td>
<td>14.0</td>
<td>4.5</td>
<td>Blank Top</td>
<td>NA</td>
<td>H659-0121</td>
</tr>
</tbody>
</table>

- Includes stainless steel latch and hasp.
- Includes cardboard metal opening cover.
- Includes 7/8" and 7/16" barrel lock K.O.
- Catalog numbers listed include KO and bracket for barrel lock.
## LANDIS & GYR Product Schedule 410

### CUSTOMIZED CATALOG NUMBER:

1. Select cover style and enclosure material
2. Select hub style
3. Select options

<table>
<thead>
<tr>
<th>1: Rings, Steel</th>
<th>UAT4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2: Ring Type, Steel</td>
<td></td>
</tr>
<tr>
<td>3: Rings, Aluminum</td>
<td></td>
</tr>
<tr>
<td>5: Rings, Ptd Aluminum</td>
<td></td>
</tr>
</tbody>
</table>

Consult the factory for other available options such as, but not limited to insulated 5th terminal, alternate jaw guide configuration, alternate base material and special labeling.

### GENERAL INFORMATION:

- **Capacity:** 200 ampere continuous, 600 volts a.c.
- **Application:** Single phase, 3 wire, self-contained, convertible to 5 terminal.
- **Enclosures:** All enclosures shown here are ringless, NEMA type 3R. All enclosures are available in either 16 gauge painted steel or aluminum in natural finish. (For painted aluminum enclosures, consult factory.)
- **Block Assembly:** Block assemblies are arc and track resistant thermostat.
- **Terminals:** Lay-in style, tin-plated, extruded aluminum 6061-T6.
- **UL:** All sockets are UL listed unless otherwise indicated.
- **ANSI C12.7:** All sockets meet or exceed ANSI C12.7 standards.
- **Stud-Style:** Optional stud-type connectors are available, consult factory.
- **Hub:** Hubs conform to ANSI standard 2.5 inch maximum. Base lock plug: includes bracket and knockout.
I-210+c® SmartMeter

SmartSynch’s residential smart metering solution features a communications module that is integrated into the GE I-210+c electricity meter. The I-210+c SmartMeter communicates over an existing cellular network with the SmartSynch Transaction Management System™ (TMS) or other C12.21 head-end system (such as MV-90) and complies with ANSI C12.19 protocols for data storage and transmission.

The I-210+c SmartMeter is a single-phase electronic watt-hour meter for use in residential and light commercial service locations. The I-210+c’s key features include Time of Use, Demand and Load Profile, Remote Connect/Disconnect, and C12.22/C12.21 compatibility. The I-210+c SmartMeter also includes an optional ZigBee® wireless component for in-premise communications and an optional Badger ORION® wireless component for gas and water meters.

Functions & Features

Wireless Communications
- GPRS
- ZigBee®
- Badger ORION®

Advanced Metering Functionality
- Remote Disconnect/Reconnect
- Flexible Two-Way Data Retrieval
- Scheduled & On-Demand Reads
- Interval Reads (5, 15, 30, 60 minutes)
- Real-Time Interval Reads
- Automatic register, self-test & TOU
- Demand resets
- Real-Time Meter Event & Alarm Retrieval
- Real-Time Power Outage & Restoration
- Service Diagnostics & Tamper Detection
- Tilt Detection
- Meter Clock Synchronization
- SmartMeter Status Display
- Automated Meter Registration
- Secure & Encrypted Data Transmissions
- Bi-Directional Metering
- Over-The-Air SmartMeter Module Firmware Upgrade

Supported Meter Forms
- Class 20: 35, 45
- Class 100: 15
- Class 200: 25, 105, 655
- Class 300: 25
- see back page for supported forms with Remote Disconnect

Hardware Components
- Remote Disconnect/Reconnect
- Radio Control Module Board (RCM)
- Capacitor Storage Bank (CSB)
- GSW/GPRS modem
- ZigBee Transceiver
- Badger ORION Receiver
- Internal Antenna

Operating Ranges
- Temperature: [-40°C, +85°C]
- Transmission (GPRS): [-40°C, +85°C]
- Humidity: 0% to 95% non-condensing
- Accuracy: Meets ANSI C12.20 for accuracy class 0.5%

Regulatory & Industry Specifications
- FCC Part 15 Class B
- ANSI C37.90.1 – 1998 (SWC)
- ANSI C12.20 [Class 0.5] – 1998
- PTCR8 Certified
- Network Carrier Certified
- Measurement Canada Certified

SmartSynch, Inc.
4400 Old Canton Road
Jackson, Mississippi 39211
1-888-362-1780
www.smartsynch.com
# Hardware Specifications

## Hardware Component

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Control Module Board (RCM)</td>
<td>32-bit ARM processor, 256K RAM, 512K flash</td>
</tr>
<tr>
<td>Capacitor Storage Bank (CSB)</td>
<td>Supplies peak power for data transmissions and all functions during power outages – no batteries required</td>
</tr>
<tr>
<td>GSM/GPRS Modem</td>
<td>GSM modem communicates with head-end using GPRS and SMS services</td>
</tr>
<tr>
<td>ZigBee Transceiver</td>
<td>Wireless component for in-premise two-way communications</td>
</tr>
<tr>
<td>Badger ORION Receiver</td>
<td>Wireless component for receiving gas and water reads</td>
</tr>
<tr>
<td>Internal Antenna</td>
<td>Flexible dual frequency GSM antenna for the modem</td>
</tr>
</tbody>
</table>

## Temperature Ranges

<table>
<thead>
<tr>
<th>Category</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating</td>
<td>[-40°C, +85°C]</td>
</tr>
<tr>
<td>Transmission (wires)</td>
<td>[-40°C, +85°C]</td>
</tr>
</tbody>
</table>

## Humidity Range

<table>
<thead>
<tr>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 95% non-condensing</td>
</tr>
</tbody>
</table>

## Accuracy

Meets ANSI | 2.20 for accuracy class 0.5%

## Supported Meter Forms

<table>
<thead>
<tr>
<th>Class</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 20</td>
<td>35, 45</td>
</tr>
<tr>
<td>Class 100</td>
<td>15</td>
</tr>
<tr>
<td>Class 200</td>
<td>25, 125, 255</td>
</tr>
<tr>
<td>Class 300</td>
<td>25</td>
</tr>
</tbody>
</table>

## With Disconnect

<table>
<thead>
<tr>
<th>Class</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 100</td>
<td>15</td>
</tr>
<tr>
<td>Class 200</td>
<td>23, 123, 235</td>
</tr>
<tr>
<td>Class 300</td>
<td>235</td>
</tr>
</tbody>
</table>

## Regulatory & Industry Certifications

- ANSI C37.90.1 – 10RF: Surge Withstand Capability (SWC)
- ANSI C12.20 (Class 0.5) – 1998
- PTCRB Certified
- Measurement Canada Certified
- Network Carrier Certified

## Input/Output Signal or Interface

<table>
<thead>
<tr>
<th>Description/Value</th>
<th>Definition/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module Power Input Voltage</td>
<td>120 - 240 VAC</td>
</tr>
<tr>
<td>Serial Interface</td>
<td>3.3V / TTL compatible asynchronous</td>
</tr>
</tbody>
</table>

## Integration

The SmartMeter module is a fully integrated, under-the-cover option inside the i-210+c meter. The i-210+c SmartMeter is shipped at one complete unit, ready for field deployment.

## Version and Compatibility Information

- i-210+c Meter Firmware: Supported meter forms, classes, and types, equipped with battery
- i-210+c Meter Firmware: Latest fully supported
- SmartModule: i-210+c GPRS SmartMeter Module
- SmartSynch TMS: Version 6.0 or higher

## About SmartSynch

Headquartered in Jackson, Miss., SmartSynch has been developing successful Smart Grid Intelligence solutions for the utility industry since 2000. The company’s clean-tech innovations in the two-way delivery of real-time energy usage data over cellular networks (AT&T, Rogers, etc.), in lieu of private network build-outs, have to date simplified SmartMeter deployments for 130 major North American utilities, while enabling green-energy initiatives and delivering significantly higher returns on resources.

Unlike proprietary, closed-architecture solutions, SmartSynch’s SmartMeters represent future-proof investments in technology. The standards-based IP connectivity enabled in every SmartMeter deployed makes them adaptable and remotely upgradable to support today’s sensor and communications needs, as well as tomorrow’s opportunities, better than any alternative.

---

Copyright © 2011 SmartSynch Inc., all rights reserved.
# Product Data Sheet

**DU322RB**  
Safety Switch, 60A, Non-Fusible, 3-Pole

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Poles</td>
<td>3-Pole</td>
</tr>
<tr>
<td>Terminal Type</td>
<td>Lugs</td>
</tr>
<tr>
<td>Type of Duty</td>
<td>General Duty</td>
</tr>
<tr>
<td>Maximum Voltage Rating</td>
<td>240VAC</td>
</tr>
<tr>
<td>Wire Size</td>
<td>#10 to #2 AWG(AI) - #14 to #2 AWG(Cu)</td>
</tr>
<tr>
<td>Depth</td>
<td>3.75 Inches</td>
</tr>
<tr>
<td>Height</td>
<td>9.63 Inches</td>
</tr>
<tr>
<td>Action</td>
<td>Single Throw</td>
</tr>
<tr>
<td>Ampere Rating</td>
<td>60A</td>
</tr>
<tr>
<td>Width</td>
<td>7.25 Inches</td>
</tr>
<tr>
<td>Approvals</td>
<td>UL Listed File Number E2875</td>
</tr>
<tr>
<td>Enclosure Rating</td>
<td>NEMA 3R</td>
</tr>
<tr>
<td>Enclosure Type</td>
<td>Ramproof and Seet/ice-proof (indoors/outdoor)</td>
</tr>
<tr>
<td>Factory Installed Neutral</td>
<td>No</td>
</tr>
<tr>
<td>Disconnected Type</td>
<td>Non-Fusible</td>
</tr>
<tr>
<td>Mounting Type</td>
<td>Surface</td>
</tr>
</tbody>
</table>

## Shipping and Ordering
- **Category**: 00105 - Safety Switch, General Duty, 30 - 200 Amp, NEMA3R
- **Discount Schedule**: DE1A
- **GTIN**: 007859101491767
- **Package Quantity**: 1
- **Weight**: 4.78 lbs
- **Availability Code**: Stock Item: This item is normally stocked in our distribution facility.
- **Returnability**: Y
- **Country of Origin**: MX

As standards, specifications, and designs change from time to time, please ask for confirmation of the information given in this document.

---

© 2010 Schneider Electric. All rights reserved.

---

U.S. D.O.E. Solar Decathlon 2011
PV Modules

**SUNPOWER**

**E19 / 240 SOLAR PANEL**
MAXIMUM EFFICIENCY AND PERFORMANCE

**BENEFITS**

**Highest Efficiency**
SunPower™ Solar Panels are the most efficient photovoltaic panels on the market today.

**More Power**
Our panels produce more power in the same amount of space—up to 50% more than conventional designs and 100% more than thin film solar panels.

**Reduced Installation Cost**
More power per panel means fewer panels per install. This saves both time and money.

**Reliable and Robust Design**
Proven materials, tempered front glass, and a sturdy anodized frame allow panel to operate reliably in multiple mounting configurations.

---

The SunPower™ 240 Solar Panel provides today’s highest efficiency and performance. Utilizing 72 all back-contact solar cells, the SunPower 240 delivers a total panel conversion efficiency of 19.3%. The panel’s reduced voltage-temperature coefficient, anti-reflective glass and exceptional low-light performance attributes provide outstanding energy delivery per peak power watt.

**SunPower’s High Efficiency Advantage**

![Graph showing SunPower’s efficiency advantage over other panels](image)

---

**Spr-240E-Wht-D**
Combiner Boxes

ACE Acme Conduit Entry Box

The ACE makes quick and simple transitions from USE-2 or PV array wire to conduit protected THWN-2 wire. The box features a compact two-piece UV resistant, NEMA3R rated, enclosure that allows ample wiring space and is compatible with any conduit type. The unique wire entry seals the enclosure even if entry slots are unused. Convenient side and bottom conduit drill out allow for easy conduit routing. The cover comes with captive screws for hassle-free assembly.

Contact us at: 845.247.4708  www.we-llc.com

Published 03/22/2011
U.S. D.O.E. Solar Decathlon 2011
### Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Wire Diameter Range</td>
<td>5.0 - 6.8 [0.20 - 0.27 in] 10-12 AWG USE-2/PV V</td>
</tr>
<tr>
<td>Maximum number of Input Conductor Slots</td>
<td>9</td>
</tr>
<tr>
<td>Maximum number of PV strings</td>
<td>4</td>
</tr>
<tr>
<td>Maximum number of Combined Strings</td>
<td>4</td>
</tr>
<tr>
<td>Equipment Ground Conductor Type</td>
<td>Bare solid or jacketed only</td>
</tr>
<tr>
<td>Equipment Ground Conductor Diameter Range</td>
<td>4.0-8.6mm [0.16-0.33 in]</td>
</tr>
<tr>
<td>Acceptable Conduit Sizes</td>
<td>16.05mm, 25.4mm [0.63in, 1.0in]</td>
</tr>
<tr>
<td>Internal Volume</td>
<td>1840cm [72in]</td>
</tr>
<tr>
<td>Internal Height</td>
<td>72.0mm [2.83 in]</td>
</tr>
<tr>
<td>Drill Out</td>
<td>Side, Bottom</td>
</tr>
</tbody>
</table>

### Configurations

<table>
<thead>
<tr>
<th>ACE Part Number</th>
<th>ACE Configuration</th>
<th>Terminal Block</th>
<th>Terminal Block Internal Bus</th>
<th>Fuse Holder</th>
<th>Fuse Combiner Bus</th>
<th>Grounding Terminal</th>
<th>DIN Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE-PT</td>
<td>Pass-Through using Butt Splices/Wire Nuts</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>ACE-1P</td>
<td>1-String Pass-through</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ACE-2P</td>
<td>2-String Pass-through</td>
<td>4</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ACE-3P</td>
<td>3-String Pass-through</td>
<td>6</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ACE-4P</td>
<td>4-String Pass-through</td>
<td>8</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ACE-2C</td>
<td>2-Strings Combiner</td>
<td>4</td>
<td>2X 2-Pole</td>
<td>N/A</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ACE-3C</td>
<td>3-Strings Combiner</td>
<td>3</td>
<td>1X 3-Pole</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ACE-4C</td>
<td>4-Strings Combiner</td>
<td>4</td>
<td>1X 4-Pole</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Mounting Bracket** is included with the purchase of the ACE. It is made of lightweight, corrosion resistant, anodized aluminum. The mounting bracket assembly includes:

- 1X ACE Mounting Bracket
- 4X Mounting Screws
- 2x Bonding Washers

Contact us at: 845.247.4708  [www.we-llc.com](http://www.we-llc.com)
AUTHORIZATION TO MARK

This authorizes the application of the Certification Mark(s) shown below to the models described in the Product(s) Covered section when made in accordance with the conditions set forth in the Certification Agreement and Listing Report. This authorization also applies to multiple listed model(s) identified on the correlation page of the Listing Report.

This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant: WILEY ELECTRONICS, LLC
Address: P.O. Box 381
SAUGERTIES, NY 12477
Country: USA
Contact: Mr. Brian Wiley
Phone: (845) 247-2875
Fax: (845) 246-0189
Email: btw@we-llc.com

Manufacturer: WILEY ELECTRONICS, LLC
Address: 1131 Kings Hwy
SAUGERTIES, NY 12477
Country: USA
Contact: Mr. Brian Wiley
Phone: (845) 247-2875
Fax: (845) 246-0189
Email: btw@we-llc.com

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Cortland, NY
Control Number: 3098177
Authorized by: William T. Starr, Certification Manager

This document supersedes all previous Authorizations to Mark for the noted Report Number.


Standard(s):

Product: PV Combiner boxes
Brand Name: N/A

ATM for Report 3145135CRT-002
Page 1 of 1
ATM Issued: 23-Jul-2009

TO GO BACK, CLICK HERE

Published 03/22/2011

U.S. D.O.E. Solar Decathlon 2011
Division 27 – Communications
1. Getting Started

*NOTE: Installation should not be started until the qualified installer has read this entire Installation Guide.*

**Important Safety Information**

The eMonitor is one of the first home energy management solutions that monitors all of the circuits in your home independently, and therefore is able to provide you with a detailed view of your electricity usage. In order to do this, sensors need to be installed on each circuit breaker inside your electrical panel. The installation is very straightforward, and every effort has been made to provide for the safe, secure installation of the eMonitor. However, the installation of the eMonitor requires the cover of the main electrical circuit breaker panel to be removed.

When this is done, there is the potential hazard of shock, burn, or even electrocution.

**ELECTRICAL HAZARD**

Even when the Main Circuit Breaker has been turned to the “OFF” position, there may still be areas within the circuit breaker panel that are electrified, or “hot”. **Installation should be performed by a licensed electrician.**

This model of the eMonitor is suitable for installation with 120/240V single-phase 60Hz service, normally found in North America (USA, Canada, Mexico and portions of the Caribbean). It is not suitable for 3-phase service, or for 230V 50Hz service commonly found in other regions of the world.

All wiring in the United States must be installed in accordance with the latest adopted edition of the National Electrical Code (ANSI/NFPA 70, NEC) and state or local requirements. All wiring in Canada must be installed in accordance with the latest adopted edition of the Canadian Electrical Code (CSA C22.2 CEC, Part I) and any provincial or local requirements.

A typical installation of a 24-channel eMonitor unit should take approximately one hour.
One of my appliances is using a lot less power than I would have expected

- The first thing to check is whether the sensor that is attached to the circuit that has that appliance is tightly connected to the eMonitor.

- If that is not the problem, it is possible that your circuit panel had the wrong label, and the eMonitor is not monitoring the appliance you think it is. The way to check that is to turn off the breaker which has the associated label, and see if the appliance turns off. If not, you will need to perform a little trial and error to find the correct circuit and channel.

- NOTE: before turning the breaker off, be sure to turn off any computers or medical devices on that circuit to avoid damage to them.

E. Specifications for the eMonitor

<table>
<thead>
<tr>
<th>Communication Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP-IP via Ethernet (802.3) 10/100base-T</td>
</tr>
<tr>
<td>Wireless ZigBee® (802.15) mesh networking</td>
</tr>
<tr>
<td>Local via high speed Serial port</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 VAC Power, 60 Hz</td>
</tr>
<tr>
<td>Calibrated Adapter:</td>
</tr>
<tr>
<td>Input 120 VAC 60 Hz 7W</td>
</tr>
<tr>
<td>Output: 12VAC 1000mA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>L x H x W: 8.80&quot; x 4.25&quot; x 1.75&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardware features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scans circuit and outlet power consumption every second, records average every minute</td>
</tr>
<tr>
<td>Backlit display (128 x 64 graphics dot Matrix LCD)</td>
</tr>
<tr>
<td>3 LED status lights</td>
</tr>
<tr>
<td>4 button membrane keypad</td>
</tr>
<tr>
<td>Embedded Web server provides local data access</td>
</tr>
<tr>
<td>8MB memory supports 1 day of data storage</td>
</tr>
<tr>
<td>Firmware remotely upgradable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature: -10°C to +60°C (14°F to +140°F)</td>
</tr>
</tbody>
</table>
- When the product exhibits a distinct change in performance – this indicates a need for service.

**Replacement Parts** – When replacement parts are required, be sure the service technician has used replacement parts specified by the manufacturer or that have the same characteristics as the original part. Unauthorized substitutions may result in fire, electric shock, or other hazards and voiding of warranties.

**Safety Check** – Upon completion of any service or repairs to this product, ask the service technician to perform safety checks to determine that the product is in proper operating condition.

**Heat** – The product should be situated away from heat sources such as radiators, heat registers, stoves, or other products that produce heat.

![FCC logo]

Declaration of Conformity:

FCC Class B approval

---

**Warranty**

Powerhouse Dynamics warrants this eMonitor unit against defects in materials and workmanship for the length of the initially contracted monitoring service. For the first two (2) years from the date of purchase, Powerhouse Dynamics will replace any defective product at no charge. Thereafter, if applicable, there will also be a $125 re-stocking charge for replaced products. The defective product must be returned to Powerhouse Dynamics; please ensure that the unit is properly packed before shipping. Powerhouse Dynamics will not provide reimbursement for shipping, removal, or reinstallation.

This Warranty does not cover damage from accident, misuse or abuse, incorrect installation, installation at environmental conditions outside the specifications, lack of reasonable care, or the fixing of any attachment that did not come with the product or is not specifically authorized by Powerhouse Dynamics. Powerhouse Dynamics will not provide reimbursement for any non-approved repair services or for any damage caused by such services, which would invalidate this Warranty.

THE FOREGOING EXPRESS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES WILL POWERHOUSE DYNAMICS BE RESPONSIBLE FOR ANY INDIRECT, CONSEQUENTIAL, SPECIAL OR INCIDENTAL DAMAGES, OR PROPERTY LOSS OR INJURY.

© 2010 Powerhouse Dynamics, Inc.
WEB-BASED MONITORING

Solectria Renewables' SolrenView web-based monitoring solution is available for use with any residential, commercial or SMARTGRID Inverters, allowing for real-time, seamless recording and reporting of PV system production. The SolrenView gateway hardware provides data via Ethernet (standard) or cellular modem. The SolrenView hardware comes standard and fully-integrated within all commercial and SMARTGRID inverters and is available for residential use with LCD or LITE gateway systems. The complete SolrenView series features inverter direct monitoring, revenue grade monitoring, agency reporting, SolZone sub-array monitoring, Kiosk View (flash view) system and a weather station.
SolrenView™ Inverter Direct
STANDARD DATA MONITORING PACKAGE

SolrenView™ Inverter Direct monitoring allows customers to view detailed inverter data (DC and AC) using a web browser. This standard package allows customers to view data daily, weekly, and monthly graphs over a range of time periods. The package includes email and cell phone alerts with detailed descriptions of system issues and a recommended course of action. This service is available for the industry-leading Solectria PVI and SGI series inverters.

SolrenView™ Revenue Grade Energy Production
OPTIONAL MONITORING PACKAGE

SolrenView™ Revenue Grade Energy Production monitoring package option keeps an accurate count of every kWh produced by the customer’s PV system. The energy produced is automatically reported to a solar program agency for convenience, if the agency reporting option is chosen. This package option also includes email alarms with detailed descriptions of system problems and a recommended course of action. This package option is available for systems 1 kW – multi-MW utilizing any inverter make and model.

SolrenView™ Weather Station
OPTION

The real-time weather package allows customers to view accurate readings for crucial environmental information. The weather station comes standard with a solar/irradiance sensor as well as temperature sensors for ambient and module measurements. Wind speed and wind direction sensors are options that may be added to the weather station. This is a great educational tool and a must for PPA.

Viewable Measurements:

- Solar/irradiance
- Ambient Temperature
- Module Temperature
- Wind Speed (optional)
- Wind Direction (optional)

SolrenView™ SolZone™ Sub-Array Monitoring
OPTION

While SolrenView™ provides the customer the ability to view the total system performance, SolZone™ provides an extra level of granularity to see multiple sub-array DC currents.

SolZone™ has the ability to compare individual PV zones against each other based on the number of sub-array fuses or “zones” built into a Solectria factory-installed DC sub-combiner. Each sub-array zone may be monitored and compared against each other. The data collected, monitored and displayed via web browser is viewable in various modes. SolZone™ is also compatible with many third party monitoring systems.

SolrenView™ Agency Reporting
OPTION

The SolrenView™ Agency Reporting is an ideal option for customers that require Revenue Grade reporting to be sent to an agency such as PTI, CCSE, and PGE. A report is generated from SolrenView™ Revenue Grade outputs and sent directly to the agency of choice.

SolrenView™ Kiosk View (Flash View)
OPTION

The Kiosk View (Flash View) option provides customers with a clean, simple view and quick, easy access to a customer’s PV system performance. This is a great tool for advertising and public viewing. This option includes custom Flash Programming only. The Kiosk View must be ordered in addition to a SolrenView™ service package. This option requires a dedicated computer and monitor, purchased elsewhere (not available for purchase through Solectria Renewables).
Laptop

HP Pavilion dv7t series

**Processors** Intel 2nd gen Core  
**Usage** Business  
**Type** THE ultimate entertainment and performance machine.  
**Battery Life** Up to 5.25 hours of battery life (6 cell)+++

**Memory card reader** Multi-Format Digital Media Card Reader  
**Accessible memory slots** 2  
**Maximum Memory Expansion** 8GB  
**Ports** 4 USB (2 USB 2.0 and 2 SuperSpeed USB 3.0), HDMI, VGA  
**Additional Ports** RJ-45, HDMI  
**Chassis** aluminum chassis in dark umber color (metal)  
**Hard Drive Protection** HP ProtectSmart protects the hard drive & data  
**Audio** Beats(TM) audio + HP Triple Bass Reflex Subwoofer  
**ENERGY STAR Qualified** Yes  
**DLNA Certified** Yes  
**Adapter** 120W AC  
**Dimensions** 16.38" (W) x 10.83" (D) x 1.24" (min H)/1.42" (max H)  
**Thinness** 1.24"  
**Weight** 6.72 lbs  
**Network Card** 10/100/1000 Gigabit Ethernet LAN (RJ-45 connector)  
**Optical Drive** Internal  
**Blu-ray Drive** Optional  
**Webcam** HP TrueVision HD Webcam  
**Fingerprint Reader** Included  
**CoolSense** Included  
**Security SW** Norton Internet Security 60-day subscription  
**Included SW** HP Games, Windows Live  
**Warranty** 2-year hardware limited warranty

CLICK HERE TO GO BACK
Division 28 – Electronic Safety and Security
Smoke Detector

120V AC Wire-In Smoke Alarm

Slide Load Front Battery Door, Alkaline Battery, 10 Yr Warranty
Model i5000

Description

The Kidde i5000 is an AC/DC powered, ionization smoke alarm that operates on a 120V power source with 9V alkaline battery backup.

This alarm uses ionization sensing technology. Ionization sensing alarms may detect invisible fire particles (associated with flaming fires) sooner than photoelectric alarms. Photoelectric sensing alarms may detect visible particles (associated with smoldering fires) sooner than ionization alarms.

Kidde strongly recommends that both ionization and photoelectric smoke alarms be installed to help insure maximum detection of the various types of fire that can occur within the home.

The front-loading battery door allows user to change the battery without removing the alarm from the mounting bracket making battery replacement easy and convenient. This smoke alarm is available in a 6-piece cut case with tray for easy display as well as a 6-piece bulk pack for contractors and property owners. This unit is a UL Listed product with a 10-year limited warranty.

Install Confidence:

Easy Installation
- Front battery pull tab allows battery activation without removing alarm from mounting bracket.
- Large mounting base makes mounting easier, protects surface paint from dirt and covers imperfections.
- Pre-stripped wiring harness with easy off cap does not require stripper tool. Tinned strands increase conductivity and wire nut grip.

Fewer Callbacks
- Large centrally located Test/Hush alarm control button.
- Dust cover protects sensor from contaminates during construction reducing nuisance alarms.

User-Friendly Features
- Easy access front loading battery door.
- Battery backup provides protection in case of power failure.
- Interconnectable with up to 24 devices (of which 18 can be initiating) including smoke, CO and heat alarms.

See user's guide for complete instructions.
**120V AC Wire-in Smoke Alarm**

**Slide Load Front Battery Door**

**Model I5000**

---

**Architectural and Engineering Specifications**

The smoke alarm shall be Kidde Model I5000 or approved equal. It shall be powered by a 120VAC, 60Hz source along with a 9V alkaline battery backup. The unit shall incorporate an ionization sensor with nominal sensitivity of 6.50 to 10.00 kV/m. The fire alarm operating range shall be between 40°F and 100°F (4°C and 38°C) and the humidity operating range shall be up to 85% relative humidity.

The smoke alarm may be installed on any standard single gang electrical box, up to a 4” octagon junction box. The electrical connection to the alarm shall be made with a plug-in connector. A maximum of 24 Kidde devices can be interconnected at a multiple station arrangement.

The interconnect system must not exceed the NFPA (National Fire Protection Association) limit of 18 interconnecting devices, of which 12 can be smoke alarms. With 18 interconnecting devices (Smokes, Heat, CO, etc.) interconnected, it is still possible to interconnect 6 smoke alarms and/or relay modules. The alarm shall provide optional tamper resistance that detects removal of the unit from the wall or ceiling. No additional pieces shall be required to activate this feature.

The alarm shall include an easy access battery compartment that is opened and closed by sliding the battery door. The 9V battery will ensure proper battery backup protection by not allowing the battery door to close if the battery is placed in the unit incorrectly or if a battery is not present.

The unit shall include a piezoelectric horn that is rated at 85 decibels at 10 feet. The unit shall include the SmartHush™ feature that silences the unit for approximately 8 minutes if a nuisance condition occurs.

The unit shall incorporate red and green LED indicators. The green LED (when illuminated) indicates the presence of AC power. The red LED (illuminated under the FES/Reach button) has four modes of operation:

- **Standby Condition**: The red LED will flash every 30-40 seconds to indicate that the smoke alarm is operating properly.
- **Alarm Condition**: When the alarm versus products of combustion and goes into alarm the red LED will flash the flash per second. The flashing LED and pulsating alarm will continue until the air is cleared. When units are interconnected, the red LED of the alarm that senses the smoke or is being tested (the originating unit) will flash. All other units in the interconnected system will声音 alarm but the red LED will not flash. **Alarm Memory**: This smoke alarm is equipped with an alarm memory, which provides a visual indication when an alarm has been activated. The red LED will illuminate for about 1.5 seconds every 60 seconds to indicate the memory condition. SmartHush™ Mode: The red LED will illuminate for 1.5 seconds every 5 seconds indicating that the smoke alarm is in the SmartHush™ Mode. The unit shall at a minimum meet the requirements of UL 217, NFPA 72, and (Chapter 11), The State of California Fire Marshal, NFPA101 (Fire and life safety code), Federal Housing Authority (FHA), Housing and Urban Development (HUD).

---

**Installation of Smoke Alarm**

The smoke alarm should be installed in accordance with all local codes having jurisdiction in your area. Article 760 of the National Electric Code, and NFPA 72. Make certain all alarms are wired in a single, continuous (non-wired) power line, which is not protected by a ground fault interrupter. A maximum of 100 ft. of wire can be used in the interconnect system. The standard 18 volt household wire is required by code.

**Technical Specifications**

<table>
<thead>
<tr>
<th>Model:</th>
<th>I5000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UPC:</strong></td>
<td>0-47871-07582-9</td>
</tr>
<tr>
<td><strong>Power Source:</strong></td>
<td>120VAC (9V battery)</td>
</tr>
<tr>
<td><strong>Sensor:</strong></td>
<td>Ionization</td>
</tr>
<tr>
<td><strong>Audio Alarm:</strong></td>
<td>85dB at 10ft</td>
</tr>
<tr>
<td><strong>Temperature Range:</strong></td>
<td>40°F (4.4°C) to 100°F (37.8°C)</td>
</tr>
<tr>
<td><strong>Humidity Range:</strong></td>
<td>Up to 85% relative humidity (RH)</td>
</tr>
<tr>
<td><strong>Size:</strong></td>
<td>5.6” in diameter x 1.8” depth</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>.5lbs</td>
</tr>
<tr>
<td><strong>Interconnects:</strong></td>
<td>Up to 24 Kidde devices</td>
</tr>
<tr>
<td><strong>LED:</strong></td>
<td>Green, receiving ac power</td>
</tr>
<tr>
<td><strong>Function:</strong></td>
<td>Red, 4 modes of operation</td>
</tr>
<tr>
<td><strong>Warranty:</strong></td>
<td>10 year limited</td>
</tr>
</tbody>
</table>

---

**Ordering Information**

<table>
<thead>
<tr>
<th>Ordering Number</th>
<th>UPC</th>
<th>IDFS</th>
<th>Cut Case (6 Units)</th>
<th>Dimensions (w x d x h inches)</th>
<th>Weight</th>
<th>Skid</th>
</tr>
</thead>
<tbody>
<tr>
<td>I5000</td>
<td>210071382</td>
<td>0-47871-07582-9</td>
<td>100-47871-07582-9</td>
<td>8.63 x 13.25 x 6.25</td>
<td>3 lbs</td>
<td>1008</td>
</tr>
</tbody>
</table>

Not sold by individual unit

---

**Distributed by:**

Kidde

1016 Corporate Park Drive

Mebane NC 27302

1-800-880-6788

www.kidde.com

---

CLICK HERE TO GO BACK
Carbon Monoxide Detector

**Features**
- Centered "Quick Connect" wiring harness.
- Universal mounting bracket.
- Easy opening, preset side-load 9V battery compartment.
- 9V battery is pre-inserted.
- Interconnectable—up to 12 multiple station CO51208 alarms.
- 3rd Generation electronic CO sensing circuit.
- Operates on 120VAC with 9V battery back-up.
- Latching alarm indicator.
- Single Test/Silence button.

**Benefits**
- Provides quick and easy connection to AC power.
- Center mounts to any standard electrical junction box up to 4” octagonal without screw removal. Large opening for wiring connects to unit every 60 degrees for easy alignment and quick installation. Does not warp due to drywall impingement. Same size footprint as other BRK Electronics® smoke alarms.
- No need to remove the unit from the ceiling to replace the 9V battery.
- Pull the mylar tab from the battery drawer and the battery is connected.
- Unit that detects carbon monoxide identifies itself, and sends alarm signal to other units connected in series.
- Low power consumption — .085 watts standby, .087 watts in alarm.
- Reduces nuisance alarms.
- Bed LED indicates which power supply is active — AC or DC.
- The latching alarm feature indicates which unit(s) in an interconnected series has/have detected alarm levels of CO.
- Dual Function:
  - Tests all functions by electronically simulating the presence of CO
  - Silences the alarm while the occupant(s) respond to an alarm. After the initial silence period, if levels of CO present still indicate a potentially dangerous situation, the alarm will sound again.
Cat. No. **CO5120B**

**APPLICATION**

BKR Electronics’ Model CO5120B is a 120V, hardwired carbon monoxide alarm with 9V battery backup. It can be operated as a single station unit or interconnected to other BKR Electronics' Carbon Monoxide Alarms. A flashing alarm indicator shows which alarm(s) in an interconnected series detects an alarm level of carbon monoxide. These models also have a dual function test/Attention button; during testing it will electronically simulate the presence of carbon monoxide, causing the unit to alarm; during an alarm it will temporarily simulate the horn while residents take corrective action.

The CO5120B has been fully tested and complies with Underwriters Laboratories, Inc. Safety Standard 2034 for single and multiple station carbon monoxide alarms, and with model building codes published by ICBO, SBCCI, BOCA and CANB. The CO5120B has a spooling temporary horn pattern: 4 toots, pause, 4 toots, pause. The alarm has been specifically designed for residential and institutional applications including single family homes, multi family homes, sleeping rooms of hotels, hotels, motels, dormitories, and other mixed occupancy dwellings as defined in standard NFPA 101. The sensor is a third generation metal oxide type. It is adjustable not to distort CO levels below 50 PPM. This unit will not alarm when exposed to a constant level of 300PPM for 30 days. It will alarm at the following levels under 30% to 70% relative humidity (86):

- 400 PPM CO between 4 and 15 minutes
- 150 PPM CO between 10 and 50 minutes
- 70 PPM CO between 100 and 240 minutes

According to Underwriters Laboratories, Inc., UL 2034 section 7.2, “Carbon monoxide alarms covered by these requirements are intended to respond to the presence of Carbon Monoxide from sources such as, but not limited to, exhaust from internal combustion engines, abnormal operation of fuel-fired appliances and furnaces. CO alarms are intended to alarm at Carbon Monoxide levels below those that can cause a too high level to react to the danger of Carbon Monoxide exposure. The CO alarm monitors the air and is designed to alarm before CO levels become serious.

This alarm should be designed to locate, install, and maintain as described in the user’s manual.

The Consumer Products Safety Commission (CPSC) recommends the use of at least one CO alarm per household, located near the sleeping area. For additional protection, install additional CO alarm on every level of the home, in each separate bedroom, and near each separate sleeping area.

It is recommended that Model CO5120B alarm be interconnected. Refer to the Model CO5120B User’s Manual for more information on the proper location, installation, and operation of the CO5120B.

**ARCHITECTURAL AND ENGINEERING SPECIFICATIONS**

The Carbon Monoxide Alarm shall be BKR Electronics Model CO5120B or approved equal and shall provide, at a minimum, the following features:

1. A third generation sensor calibrated to meet UL 2034 October 1, 1998.
2. The unit should be 120V hard wired with 9V battery backup.
3. In battery back up mode, the battery must last for 8 hours minimum in standby and 71 hour minimum in alarm.
4. The unit should be self-diagnostic and have a visual and audible alarm to indicate a malfunction.
5. The alarm unit must have a button that will test the alarm by simulating CO and silence any nuisance alarm.
6. A solid state Pico alarm horn rated 85dB@1 ft. that provides a temporary tone: 4 beeps, pause, 4 beeps, pause.
7. The alarm unit will have a red LED to indicate the status of the power supply (AC or DC).
8. The CO alarm will have a dual function test/Attention button that will indicate which CO alarm(s) in the series detected alarm levels of CO. Lamp is manually reset.
9. The CO alarm shall have an interlock panel to prevent the insertion of outside air that might otherwise inhibit the unit and clean carbon monoxide from the sensing chamber.
10. The unit shall be capable of operating between 40°F and 100°F (-4°C to 38°C) and relative humidity of 30% to 70%.
11. The CO alarm will be interconnected with up to 12 units of its own type.

**TECHNICAL SPECIFICATIONS**

- **Alarm Test**
  - 50% duty cycle
- **Operating Voltage**
  - 120VAC, 50/60 Hz back-up
- **Operating Ambient Temp. Range**
  - 40°F to 100°F (-4°C to 38°C)
- **Alarm Horn Back-up**
  - 12 hour
- **Alarm Pack**
  - Automatic when CO alarm
- **Single Hardwired Signal**
  - Nate hardwired by electronically simulating the presence of CO.
- **Silencing the alarm while occupant is present**
  - Yes, after the initial devices, if levels of CO present will indicate a potentially dangerous situation, the alarm will be deactivated.

**Alarm Status Indicator**

- **Battery Status Indicator**
  - Red LED flashes once every minute when unit is operating or battery power only. When unit is not operating battery power only.
- **Service Status Indicator**
  - If unit is not operating properly, Red LED flashes three times in rapid succession every minute, turn on circuit uncompleted.
- **CO Level Status Indicator**
  - Red LED flashes rapidly from sounds in repeating pattern (6 times, pause, 4 beeps, pause)... when unit has detected CO to trigger an alarm.

**Unit Dimensions**

- 6.8" (H) x 4.1" (W) x 1.6" (D)
- **Weight**
  - 7.5 lbs.
- **Test**
  - 1000V
- **Unit Per Case**
  - 12 units

**MANUFACTURED BY:**

BKR Electronics 100 Safety Road East Aurora, New York 14012

**DISTRIBUTED BY:**

For Technical Help or Representative nearest you:

Phone 1-800-223-9005

**U.S. D.O.E. Solar Decathlon 2011**

Published 03/22/2011

32 90 00 - 109
PVI 4000 Inverters

**String Inverters**

- **PVI 3000**
- **PVI 4000**
- **PVI 5000**
- **PVI 5300**
- **PVI 6500**
- **PVI 7500**

**Features**

- 96% CEC efficiency
- Wide input operating voltage window
- 208 VAC, 240 VAC or 277 VAC
- Fully-integrated design
- Detachable wiring box
- Standard 10 year warranty
- RS232/RS485 communications
- User interactive LCD display

**Options**

- Integrated panel assembly
- Web-based monitoring

---

At 96% CEC efficiency, the Solectria Renewables string inverter series, ranging from 3.0 kW to 7.5 kW, is the most efficient transformer isolated string inverter on the market. The PVI 3000-PVI 7500 series of inverters consist of six power ratings to optimally match your grid-tied PV system, and boasts fully-integrated DC and AC disconnects, an LCD display, and a 3, 4, or 5 fuse string combiner all contained within a detachable wiring box. This feature allows for a clean, simple, and safe installation with easy serviceability. The integrated panel assembly option allows for this inverter series to be pre-wired and mounted on an industrial grade aluminum panel with kWh meter and optional AC visible-blade disconnect or circuit breakers on a two-inverter panel assembly.

---

Built for the real world
### Specifications

<table>
<thead>
<tr>
<th></th>
<th>PV3000</th>
<th>PV4000</th>
<th>PV5000</th>
<th>PV5300</th>
<th>PV6500</th>
<th>PV7500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DC Inlet</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Maximum Input Voltage</td>
<td>600 VDC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPPT Input Voltage Range</td>
<td>300-550 VDC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Operating Input Current</td>
<td>16 A</td>
<td>20 A</td>
<td>25 A</td>
<td>25 A</td>
<td>35 A</td>
<td>35 A</td>
</tr>
<tr>
<td><strong>AC Output</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal Output Voltage</td>
<td>208 or 240 VAC</td>
<td>208, 240 or 277 VAC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous Output Power</td>
<td>208 VAC 2700W</td>
<td>340W</td>
<td>4300W</td>
<td>6500W</td>
<td>6500 W</td>
<td>7500 W</td>
</tr>
<tr>
<td>260 VAC 2900W</td>
<td>3900W</td>
<td>4900W</td>
<td>5200W</td>
<td>6500 W</td>
<td>7500 W</td>
<td></td>
</tr>
<tr>
<td>277 VAC</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Continuous Output Current</td>
<td>208 VAC 13 A</td>
<td>16.3 A</td>
<td>20.7 A</td>
<td>22.1 A</td>
<td>33.3 A</td>
<td>36.1 A</td>
</tr>
<tr>
<td>260 VAC 13 A</td>
<td>16.3 A</td>
<td>20.7 A</td>
<td>22.1 A</td>
<td>33.3 A</td>
<td>36.1 A</td>
<td></td>
</tr>
<tr>
<td>277 VAC</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>25.5 A</td>
<td>27.1 A</td>
</tr>
<tr>
<td>Maximum Backfeed Current</td>
<td>0 A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal Output Frequency</td>
<td>60 Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Frequency Range</td>
<td>58.3-60.5 Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Factor</td>
<td>Unity &gt;0.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Efficiency</td>
<td>208 VAC 96.4%</td>
<td>98.5%</td>
<td>96.4%</td>
<td>96.2%</td>
<td>96.0%</td>
<td>96.3%</td>
</tr>
<tr>
<td>260 VAC 96.7%</td>
<td>98.7%</td>
<td>96.7%</td>
<td>96.4%</td>
<td>96.3%</td>
<td>96.5%</td>
<td></td>
</tr>
<tr>
<td>277 VAC</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>CEC Efficiency</td>
<td>208 VAC 95.5%</td>
<td>95.5%</td>
<td>96.0%</td>
<td>95.5%</td>
<td>95.5%</td>
<td></td>
</tr>
<tr>
<td>260 VAC 96.0%</td>
<td>96.0%</td>
<td>96.0%</td>
<td>96.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>277 VAC</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td><strong>Tare Loss</strong></td>
<td>0.5 W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Integrated String Combination</strong></td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Fused String Inputs</strong></td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient Temperature Range (Full power)</td>
<td>-13°F to +104°F (-25°C to +45°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-3°F to +122°F (-20°C to +50°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Humidity (non-condensing)</td>
<td>95%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Monitoring Options</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web-based Monitoring (Inverter Direct)</td>
<td>SolenView</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue Grade Monitoring</td>
<td>External</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Party Compatibility</td>
<td>Standard via RS232/RS485</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wiring &amp; Grounding</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Listings &amp; Certifications</td>
<td>UL 1741/IEEE 1547, IEEE 1547.1, CSA C23.3#107.5, PCC part 5B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Testing Agency</strong></td>
<td>ETL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Warranty</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Standard</strong></td>
<td>10 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC/DC Disconnects</td>
<td>Standard, fully-integrated (internal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions (H x W x D)</td>
<td>28.0 in x 17.9 in x 4.9 in (712 mm x 454 mm x 125 mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>47 lbs (21.4 kg)</td>
<td>48 lbs (21.6 kg)</td>
<td>56.2 lbs (25.4 kg)</td>
<td>60 lbs (27.4 kg)</td>
<td>88.9 lbs (40.4 kg)</td>
<td></td>
</tr>
<tr>
<td>Enclosure Rating</td>
<td>NEMA 3R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enclosure Finish</td>
<td>Painted aluminum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

U.S. D.O.E. Solar Decathlon 2011

Published 03/22/2011