



Missouri University of Science and Technology

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As-Built Specifications and Project Manual

August 10th, 2017

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Summary of Changes

Significant changes to the Project Manual that have occurred between submissions have been outlined below.

November 18th, Revision

- Water Budget
 - Added 280 gallon fire suppression system to the water budget.
- Construction Specifications
 - Updated spray foam specifications.
 - Updated rainwater harvesting section.

February 17th, Revision

- Rules Compliance Checklist
 - Rule 4-2, 4-6, 7-2, 8-1, 8-2, 8-4, 8-6, 9-4, 9-8, 9-9 updated with locations of drawings.
- Interconnected Application Form
 - Completed and filled out electrical and PV sizing information
- Electrical Calculations
 - Updated calculations
- Energy Analysis & Model
 - Added details.

February 17th, Revision

- Included bookmarks
- Structural Calculations
 - Included structural calculations to Appendix B
- Added crane manufacturer
- Added cost estimate
- Included spec sheet appendix

August 5th, Revision

- Added Division 28 to construction specifications
- Updated Logo
- Updated water budget
- Updated cost estimate

Project Overview

Missouri University of Science and Technology's Solar House Design Team empowers the next generation of leaders to build a sustainable future. This is accomplished by developing a sustainable, innovative, and original design for the U.S. Department of Energy Solar Decathlon. The S&T Team is creating a home to be highly competitive in each of the 2017 contests at the Solar Decathlon with SILO. SILO is a Smart Innovative Living Oasis designed for people who are looking for a place to relax and rejuvenate. SILO will feature a solar array, solar thermal system, moveable green wall, water wall, a sloped walking surface, accordion doors, modular design, and a curved ceiling and roof supported by steel trusses. SILO will also feature forced air HVAC, radiant flooring, grey water reclamation, a heat pump, custom made furniture, and modern standard home appliances.

Rules Compliance Checklist

Rule	Rule Description	Location Description	Location
Rule 4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site	O-101, O-102
Rule 4-2	Construction Equipment	Specifications for heavy machinery	01 54 19
Rule 4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	S-101, S-501
Rule 4-4	Impact within the Solar Envelope	Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope	S-101, L-102, L-104
Rule 4-5	Generators	Specifications for generators (including sound rating)	N/A
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
Rule 4-6	Spill Containment	Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event	11 30 00, 22 40 00, 33 16 20, 44 40 10
Rule 4-7	Lot Conditions	Calculations showing that the structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists	S-101, S-501
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-501, S-502
Rule 5-1	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	G-104
Rule 5-1	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references	N/A
Rule 6-1	Structural Design Approval	List of, or marking on, all drawing and project manual sheets that will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual	S-001, S-101, S-102, S-103, S-104, S-201, S-202, S-203, S-301, S-302, S-501, S-502, S-503, S-504, S-505 Appendix C

Rule	Rule Description	Location Description	Location
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	N/A
Rule 6-3	Constructed Footprint	Drawing(s) showing total square footage of the footprint of the home	G-102
Rule 6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route	G-103, G-105
Rule 7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	L-104
Rule 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater irrigation systems	P-601
Rule 8-1	PV Technology Limitations	Specifications for photovoltaic components	Appendix B, 48 14 00
Rule 8-2	Energy Monitoring	Drawing(s) showing the location of the energy monitoring equipment	N/A
Rule 8-3	Energy Sources	Drawings of energy generating products	N/A
Rule 8-4	Batteries	Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices	E-103, E-201
Rule 8-4	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices	Appendix B
Rule 8-5	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	N/A
Rule 8-5	Desiccant Systems	Specifications for desiccant system components	N/A
Rule 8-6	Village Grid	Completed interconnection application form	Page 9
Rule 8-6	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E-104, E-105
Rule 8-6	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	Appendix B 48 14 00
Rule 8-6	Village Grid	One-line electrical diagram	E-602, E-603
Rule 8-6	Village Grid	Calculation of service/feeder net computed load per NEC 220	E-601

Rule	Rule Description	Location Description	Location
Rule 8-6	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	L-103, G-103
Rule 8-6	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment	E-104, 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. PDT or between 8 a.m. and 4 p.m. solar time on October 1	P-101, P-301
Rule 9-2	Team-Provided Liquids	Quantity, specifications, and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation	N/A
Rule 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems	P-102, P-603
Rule 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	N/A
Rule 9-5	Evaporation	Drawing(s) showing the location of evaporation methods	N/A
Rule 9-6	Thermal Mass	Drawing(s) showing the locations of liquid-based thermal mass systems	N/A
Rule 9-6	Thermal Mass	Specifications for components of liquid-based thermal mass systems	N/A
Rule 9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of greywater heat recovery systems	N/A
Rule 9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events	O-101, P-101
Rule 9-8	Water Delivery	Specifications for the containers to which water will be delivered	11 30 00, 22 40 00, 33 16 20, 44 40 10
Rule 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	O-102, P-102
Rule 9-9	Water Removal	Specifications for the containers from which water will be removed	11 30 00, 22 40 00, 33 16 20, 44 40 10
Rule 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G-103



Structural Calculations

See Appendix B.

Detailed Water Budget

Contest	Amount Drawn (Gal.)	Number of Draws	Total (Gal.)
Clothes Washer	14	5	70
Cooking	1.6	6	10
Hot Water	15	14	210
Plants	100	1	100
Safety Factor	90	1	90
Fire Suppression	280	1	280
Water Heater (Initial Fill)	40	1	40
Total			800

Summary of Unlisted Electrical Components

There are no unlisted electrical components in SILO.

Summary of Reconfigurable Features

For public and jury tours, team members will demonstrate the following features:

Murphy Bed

SILO will feature a murphy bed that will be located in the office/spare bedroom. Most of the time this will be closed to provide a large area to work. During the public and jury tours this will be displayed in the bed position. Specific references include A-501.

Movable Green Wall

SILO will also feature two moveable green walls that can be moved on the south side of the house. These will be large structures that block sunlight and grow an assortment of plants. During public and jury tours they will be moved out of the way and then moved to showcase when necessary.

Energy Analysis & Model

The Team has done various calculations and models to see how the house will use its energy.

REScheck



Generated by REScheck-Web Software

Compliance Certificate

Project SILO 2017

Energy Code: **2015 IECC**
 Location: **Denver, Colorado**
 Construction Type: **Single-family**
 Project Type: **New Construction**
 Orientation: **Bldg. faces 180 deg. from North**
 Conditioned Floor Area: **981 ft²**
 Glazing Area: **42%**
 Climate Zone: **5 (6020 HDD)**

Compliance: Passes using UA trade-off

Compliance: **1.6% Better Than Code** Maximum UA: **314** Your UA: **309**

The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules. It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Wall South Kitchen/Bath: Wood Frame, 16in. o.c. Orientation: Front	270	36.0	0.0	0.045	7
Accordion Door: Glass Orientation: Front	98			0.300	29
Front Door: Solid Orientation: Front	21			0.170	4
Wall North Bedrooms: Wood Frame, 16in. o.c. Orientation: Back	208	36.0	0.0	0.045	9
Office Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	12			0.300	4
Wall West Entry: Wood Frame, 16in. o.c. Orientation: Left side	238	36.0	0.0	0.045	5
Curtain Wall: Metal Frame, 2 Pane w/ Low-E Orientation: Left side	130			0.300	39
Wall East Bath: Wood Frame, 16in. o.c. Orientation: Right side	238	36.0	0.0	0.045	5
Curtain Wall: Metal Frame, 2 Pane w/ Low-E Orientation: Right side	109			0.300	33
Curtain Wall Door: Glass Orientation: Right side	21			0.300	6
Wall West Bedroom: Wood Frame, 16in. o.c. Orientation: Left side	90	36.0	0.0	0.045	4
Wall East Bedroom: Wood Frame, 16in. o.c. Orientation: Right side	90	36.0	0.0	0.045	2
	52			0.300	16
Wall South Bedroom: Wood Frame, 16in. o.c. Orientation: Front	50	36.0	0.0	0.045	2
Wall North Bath/Entry: Wood Frame, 16in. o.c. Orientation: Back	30	36.0	0.0	0.045	1
Wall North Center: Wood Frame, 16in. o.c. Orientation: Back	214	36.0	0.0	0.045	1
Curtain Wall: Metal Frame, 2 Pane w/ Low-E Orientation: Back	121			0.300	36
Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	11			0.300	3
Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	11			0.300	3
Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	11			0.300	3
Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	11			0.300	3
Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	11			0.300	3
Window: Metal Frame, 2 Pane w/ Low-E Orientation: Back	11			0.300	3
Wall South Center: Wood Frame, 16in. o.c. Orientation: Front	31	36.0	0.0	0.045	1
Floor: Steel Frame, 16in. o.c., 2x6, Over Outside Air	993	26.0	0.0	0.058	58
Ceiling: Flat or Scissor Truss	683	38.0	0.0	0.030	20
Ceiling: Structural Insulated Panels	310		36.0	0.029	9

Compliance Statement: The proposed building design described here is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2015 IECC requirements in REScheck Version 5.5.0 and to comply with the mandatory requirements listed in the REScheck Inspection Checklist.

PVWatts: Monthly PV Performance

PVWatts:	Monthly PV Performance Data
Requested Location:	Denver
Location:	DENVER INTL AP, CO
Lat (deg N):	39.83
Long (deg W):	104.65
Elev (m):	1650
DC System Size (kW):	8.64
Module Type:	Standard
Array Type:	Fixed (roof mount)
Array Tilt (deg):	9.46
Array Azimuth (deg):	180
System Losses:	7
Invert Efficiency:	96
DC to AC Size Ratio:	1.1
Average Cost of Electricity Purchased from Utility (\$/kWh):	0.11
Capacity Factor (%)	17.2

Month	AC System Output(kWh)	Solar Radiation (kWh/m ² /day)	Plane of Array Irradiance (W/m ²)	DC array Output (kWh)	Value (\$)
1	747.7110596	3.18256831	98.65961456	782.3875122	82.62
2	806.2214966	3.7450428	104.8611984	843.1986694	89.09
3	1202.991333	5.18751955	160.8131104	1255.842773	132.93
4	1138.910889	5.03661251	151.0983734	1190.219727	125.85
5	1439.081909	6.47291517	200.6603699	1502.139282	159.02
6	1493.613525	7.34368896	220.310669	1559.150757	165.04
7	1434.527344	6.81357241	211.2207489	1497.554321	158.52
8	1325.770264	6.25065136	193.7701874	1383.437866	146.5
9	1166.995972	5.63492584	169.0477753	1217.474854	128.95
10	958.7006836	4.2620883	132.1247406	1000.946167	105.94
11	686.4268799	3.01854491	90.55635071	718.1557617	75.85
12	624.3762207	2.68365645	83.19335175	655.2173462	68.99
Total	13025.32758	59.63178657	1816.31649	13605.72504	1439.3

Interconnection Application Form

PV Systems

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
LG	24 LG 360 W panels arranged in a 2x12 array in two branches wires in parallel	8.6 kW

Inverters

Inverter Manufacturer	Model Number	Voltage	Rating	Quantity
Enphase	IQ6+	240	235W-400W	24

Required Information

	Location
One-Line Electrical Schematic	E-602, E-603
Calculations of service/feeder net computed load and neutral load (NEC 220)	E-601
Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center	L-103, G-103

Electrical Contact

The Team's electrical engineer is Colleen Kohrmann. Her contact information is provided in the "Team Officer Contact Info" database.

Energy Analysis Results and Discussion

The Team used REScheck and pvwatts software tools to calculate panel sizing. From previous experience these results were fairly under-estimated compared to the actual measured electrical load needs found at competition. SILO will include more panels than needed from the calculation. The consumption values were measured during the competition over an eight-day period.

Electrical Calculations

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

Mechanical Load Estimates				
Item	#	Load Value (W)	Estimated Use (hours)	Total Contest Week Consumption (kWh)
HVAC / ERV	1	8,300	8	66.4
			Total	66.4

Appliance Load Estimations			
Load Type	Load Value (W)	Estimated Competition Use (hours)	Total Contest Week Consumption (kWh)
Washer	1,200	5	6
Dryer	6,240	5	31.2
Oven	9,600	2	19.2
Garbage Disposal – 1/3 HP	800	0.5	0.4
Radiant Water Heater	8,000	5	40
Water Heater	4,500	3.15	14.175
Television (40”)	-	5	0.42
Computer	100	5	1.5
Refrigerator	-	-	12.56
Induction Cooktop	3,700	5	18.5
Dishwasher	1200	0	0
			143.955

Other Load Estimations				
Item	#	Load Value (W)	Estimated Competition Use (hours)	Total Contest Week Consumption (kWh)
Lighting (LED)	24	324	31	10.044
Electrical Vehicle Charger – Level II	1	6,480	6	38.88
Total				48.924

Overall Consumption Estimate

259.279 kWh

Days in Competition = 9 (days)

Sun Hours/Day in Denver, CO = 4.87 $\left(\frac{\text{sun hour}}{\text{day}}\right)$

Ideal Panel Angle in Denver, CO = 40°

Efficiency Adjustment = 20%

$$\text{Array Size Estimate Before Adjustment} = \frac{\frac{\text{Overall Consumption Estimate}}{\text{Days in Competition}}}{\frac{\text{Sun Hours}}{\text{Day}} \text{ in Denver, CO}} = 5.916\text{kW}$$

$$\text{Adjusted Array Size Estimate} = \frac{(\text{Array Size Estimate Before Adjustment})}{0.8} = 7.394\text{kW}$$

Quantity Takeoff of Competition Prototype House

	DESCRIPTION	QTY	UNIT
A10 FOUNDATIONS			
A1020 SPECIAL FOUNDATIONS	Temporary Foundation: W6x15	182	lf
	Screw jack support base	45	ea
B10 SUPERSTRUCTURE			
B1010 FLOOR CONSTRUCTION	Steel Joist: 600S250-68	1048	lf
	Steel Joist Track: 600T250-68	204	lf
	(2L) 3/4" plywood sub floor	993	sf
	3" closed cell spray foam insulation	993	sf
B1020 ROOF CONSTRUCTION	Wood Monotruss	35	ea
	3/4" Plywood roof sheathing	993	sf
	Steel Bar Joist	7	ea
	Steel Box Beam: 2x1000S250-118	32	lf
	Steel Box Beam: 2x600S250-68	64	lf
B20 EXTERIOR CLOSURE			
B2010 EXTERIOR WALLS	Exterior walls: 2x6 wood stud wall, zip exterior plywood, 5.5" foam insulation, drywall	1773	sf
	Siding	1113	sf
B2020 EXTERIOR WINDOWS	Storefront	232	sf
	Accordion Doors	161	ea
	Windows; aluminum framed	103	sf
B2030 EXTERIOR DOORS	3'0"x7'0" Exterior Door	1	ea
	6'0"x7'0" Double Pocket door	1	ea
	3'0"x7'0" Storefront Door	1	ea
B30 ROOFING			
B3010 ROOF COVERINGS	Roofing at main living area; standing seam and 6" insulation	352	sf
	Roofing at modules: standing seam and batting insulation	788	sf
	Solar panel assembly, sloped	382	sf
C10 INTERIOR CONSTRUCTION			
C1010 PARTITIONS	Interior wall: 2x4 stud wall, denim batting insulation, drywall	368	sf
C1020 INTERIOR DOORS	3'-0 x 7'-0" Pocket door	1	ea
	3'-0"x7'-0" single flush door	2	ea
C1030 FITTINGS			

C30 INTERIOR FINISHES			
C3010 WALL FINISHES	American Clay Plaster	1207	sf
	Paint	320	sf
	Ceramic wall tile; subway tile	60	sf
C3020 FLOOR FINISHES	Hardwood	908	sf
	Ceramic tile	85	sf
	Lamenant flooring, Mechanical room	72	sf
C3030 CEILING FINISHES	Paint exposed deck	352	sf
	Painted gyp. Board	788	sf
D20 PLUMBING			
D2010 PLUMBING FIXTURES	Domestic water pump	1	ea
	Solar tube collector	1	ea
	Collector controls	1	ls
	Expansion tank	1	ea
	Kitchen sink & faucet	1	ea
	Vanity sink & faucet	1	ea
	Shower/tub & mixing valve	1	ea
	Water closet	1	ea
	500-gallon gray water tank	1	ea
	Dishwasher connection	1	ea
	Washer connection	1	ea
D2020 DOMESTIC WATER DISTRIBUTION	Plumbing supply pipe; PEX	160	lf
	Misc valves & fittings	1	ls
D2030 SANITARY WASTE	Waste & vent piping; PVC	110	lf
D30 MECHANICAL			
D3040 DISTRIBUTION SYSTEMS	Refrigeration piping	1	ls
	Rigid ductwork	130	lf
	Flex duct	25	lf
D3050 TERMINAL & PACKAGE UNITS	Air handler	1	ea
	Heat pump; 2-ton outdoor unit	1	ea
	Energy recovery ventilator	1	ea
	Outside grille for intake/exhaust	1	ea
D3060 CONTROLS & INSTRUMENTATION	Collector controls	1	ls
	Temperature control	1	ls

D40 FIRE PROTECTION			
D4010 SPRINKLERS	Fire protection	1	ea
E10 EQUIPMENT			
E1010 COMMERCIAL EQUIPMENT	Dishwasher	1	ea
	Range	1	ea
	Refrigerator	1	ea
	Stacking washer & dryer	1	ea
	Tools	1	ea
	Safety Equipment	1	ea
	Range hood, assumed	1	ea
F10 SPECIAL CONSTRUCTION			
F1010 SPECIAL STRUCTURES	South Deck	528	sf
	Deck: Serenity	170	sf
	Access Ramp	400	sf

Construction Documents

See attached document for construction drawings.

Refer to Appendix A for construction specifications.



Cost Estimate

SILO
Missouri University of Science and Technology
Solar Decathlon 2017
Pre-construction Estimates
Denver, CO
February 19, 2017

Estimate was created from the estimation template provided by Faithful & Gould. Numbers were generated from RS means and previous team's cost estimates. Detail sheet can be provided if necessary. Note that some data is missing and estimate should be included in the future.

SYSTEM DESCRIPTION			SUB-TOTAL	TOTAL	\$/SF	%
A10	FOUNDATIONS					
	A1020	Special Foundations	\$8,427			
	A1030	Lowest Floor Construction	\$0	\$8,427	\$7.65	3.31%
B10	SUPERSTRUCTURE					
	B1010	Upper Floor Construction	\$46,345			
	B1020	Roof Construction	\$7,408	\$54,214	\$49.24	21.31%
B20	EXTERIOR CLOSURE					
	B2010	Exterior Walls	\$14,391			
	B2020	Windows	\$22,700			
	B2030	Exterior Doors	\$1,000	\$42,591	\$38.68	16.74%
B30	ROOFING					
	B3010	Roof Coverings	\$1,785			
	B3020	Roof Openings	\$0	\$1,785	\$1.62	0.70%
C10	INTERIOR CONSTRUCTION					
	C1010	Partitions	\$2,613			
	C1020	Interior Doors	\$700			
	C1030	Specialties/Millwork	\$11,928	\$15,241	\$13.84	5.99%
C20	STAIRCASES					
	C2010	Stair Construction	\$0			
	C2020	Stair Finishes	\$0	\$0	\$0.00	0.00%
C30	INTERIOR FINISHES					
	C3010	Wall Finishes	\$4,409			
	C3020	Floor Finishes	\$10,044			
	C3030	Ceiling Finishes	\$3,442	\$17,895	\$16.25	7.03%
D10	CONVEYING					
	D1010	Elevator	\$0			
	D1020	Escalators and Moving Walkways	\$0			
	D1090	Other Conveying Systems	\$0	\$0	\$0.00	0.00%

SYSTEM DESCRIPTION			SUB-TOTAL	TOTAL	\$/SF	%
D20	PLUMBING					
	D2010	Plumbing Fixtures	\$4,124			
	D2020	Domestic Water Distribution	\$2,767			
	D2030	Sanitary Waste	\$0			
	D2040	Rain Water Drainage	\$2,683			
	D2090	Other Plumbing Systems	\$0	\$9,574	\$8.70	3.76%
D30	MECHANICAL					
	D3010	Energy Supply	\$0			
	D3020	Heat Generating Systems	\$0			
	D3030	Cooling Generating Systems	\$0			
	D3040	Distribution Systems	\$3,353			
	D3050	Terminal & Package Units	\$9,150			
	D3060	Controls & Instrumentation	\$1,500			
	D3070	Systems Testing & Balancing	\$0	\$14,003	\$12.72	5.50%
D40	FIRE PROTECTION					
	D4010	Fire Protection	\$3,021			
	D4020	Standpipes	\$0			
	D4030	Fire Protection Specialties	\$0	\$3,122	\$2.74	1.19%
D50	ELECTRICAL					
	D5010	Electrical Service & Distribution	\$4,349			
	D5020	Lighting & Branch Wiring	\$13,080			
	D5030	Communications & Security Systems	\$590			
	D5090	Other Electrical Systems	\$21,909	\$39,928	\$36.27	15.69%
E10	EQUIPMENT					
	E1010	Commercial Equipment	\$0			
	E1020	Institutional Equipment	\$0			
	E1030	Vehicular Equipment	\$0			
	E1090	Other Equipment	\$4,050	\$4,050	\$3.68	1.60%

SYSTEM DESCRIPTION			SUB-TOTAL	TOTAL	\$/SF	%
E20	FURNISHINGS					
	E2010	Fixed Furnishings	\$0			
	E2020	Movable Furnishings	\$0	\$0	\$0.00	0.00%
F10	SPECIAL CONSTRUCTION					
	F1010	Special Structures	\$10,079			
	F1020	Integrated Construction	\$0			
	F1030	Special Construction Systems	\$0			
	F1040	Special Facilities	\$0	\$10,079	\$9.15	3.96%
F20	SELECTIVE BUILDING DEMOLITION					
	F2010	Building Elements Demolition	\$0			
	F2020	Hazardous Components Abatement	\$0	\$0	\$0.00	0.00%
G10	SITE PREPARATION					
	G1010	Site Clearing	\$0			
	G1020	Site Demolition and Relocations	\$0			
	G1030	Site Earthwork	\$0			
	G1040	Hazardous Waste Remediation		\$0	\$0.00	0.00%
G20	SITE IMPROVEMENT					
	G2010	Roadways	\$0			
	G2020	Parking Lots	\$0			
	G2030	Pedestrian Paving	\$0			
	G2040	Site Development	\$7,360			
	G2050	Landscaping	\$4,000	\$11,360	\$10.32	4.47%



SYSTEM DESCRIPTION			SUB-TOTAL	TOTAL	\$/SF	%
G30	SITE MECHANICAL UTILITIES					
	G3010	Water Supply	\$0			
	G3020	Sanitary Sewer	\$0			
	G3030	Storm Sewer	\$0	\$0	\$0.00	0.00%
G40	SITE ELECTRICAL UTILITIES					
	G4010	Electrical Distribution	\$0			
	G4020	Site Lighting	\$0			
	G4030	Site Communications and Security	\$0			
	G4090	Other Electrical Utilities	\$0	\$0	\$0.00	0.00%

TOTAL DIRECT COST (Trade Costs)					\$223,800	\$203.27	91.00%
MARKUPS	General Conditions, Overhead & Profit		0.00%	\$0	\$0	0	0.00%
SUBTOTAL CONSTRUCTION					\$232,168	\$210.87	91.25%
CONTINGENCIES/ESCALATION	Design and Pricing Contingency			\$0			
	Trucking	3	trucks	\$6,000			
	Crane time	1	days	\$1,625			
	Lull/Forklift	9	days	\$14,625	\$22,250	\$20.21	9.00%
TOTAL PROJECT COST					\$254,418	\$231.08	100.00%

APPENDIX A
CONSTRUCTION
SPECIFICATIONS

DIVISION 00
PROCUREMENT AND
CONTRACTING
REQUIREMENTS

1.1 PRELIMINARY BUILDING SCHEDULE BY PHASE

A. Schematic Design Phase	October 2015 – April 2016
B. Design Development Phase	April 2016 – October 2016
C. Construction Documents Phase	October 2016 – March 2017
D. Construction Phase	October 2016 – July 2017
E. System and Building Testing Phase	August 2017-September 2017
F. Competition Phase	October 2017

1.2 PROJECT BUDGET

- A. Construction Budget: \$450,000
- B. Total Project Budget: \$600,000

1.3 CONSTRUCTION FACILITY

- A. SILO will be constructed on the permanent foundation at Missouri S&T.
 - 1. 913 Innovation Dr. Rolla, MO 65401

END OF SECTION 00 31 00

DIVISION 01
GENERAL REQUIREMENTS

SECTION 01 81 30**SECTION 01 81 30****GREEN POWER REQUIREMENTS****PART 1 GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Green Power contracting requirements.

1.2 DEFINITIONS

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

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

1.5 MAINTENANCE

- A. Green Power: Provide service contract for 2 years with options for annual renewal thereafter.

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

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Photovoltaic Module with built in Microinverter

1. TBD
 - a. Power Output = TBD
 - b. Nominal Voltage = TBD
 - c. Normal Frequency = TBD
 - d. Nominal Output Current = TBD

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

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

END OF SECTION

SECTION 01 54 19
TEMPORARY CRANES

PART 1 GENERAL

1.1 SUMMARY

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

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Grove TMS

2.2 TEMPORARY CRANES

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

PART 3 EXECUTION

3.1 INSTALLATION

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

END OF SECTION

DIVISION 05

METALS

SECTION 05 10 00
STRUCTURAL STEEL

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes:

1. Structural steel.

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

1. Recycled Content:

- a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
- b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
- c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
- d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.

2. Local/Regional Materials:

- a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
- b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
- c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
- d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

B. Certifications and Registrations:

1. Environmental Management System (EMS): Submit evidence of an EMS for the steel manufacturers providing material for work of this section. For each steel manufacturing facility, submit copy of registration as per ISO 14001.
2. Chain-of-custody certification: Submit manufacturer's certification that no open hearth furnaces were utilized in the production of structural steel to be incorporated into the Work. Submit evidence of energy efficiency for steel manufacturers providing material for work of this section. Acceptable certification includes:
 - a. Bill of Lading indicating source of manufactured steel as North American facility; or,
 - b. Manufacturer's certification that structural steel complies with CO₂ limitations for crude steel production. Indicate method for calculating CO₂ emissions; or,
 - c. Manufacturer's certification that structural steel complies with energy efficiency requirements for steel production. Include description of energy efficient processes utilized.

- d. Participation in CO₂ Breakthrough Program: Manufacturer's certification of participation in CO₂ Breakthrough Program.

1.2 QUALITY ASSURANCE

A. Toxicity/IEQ:

1. Carbon Dioxide Emissions: Not to exceed 1.6 tons of CO₂ per 1 ton of crude steel produced.
2. Energy Efficiency:
 - a. Integrated Steel Making: Not to exceed 19 GJ/ton.
 - b. Steel produced from scrap: Not to exceed 7GJ/ton.

PART 2 PRODUCTS

2.1 MATERIALS

A. Execution

1. Fabricate and Erect in accordance with A.I.S.C.
2. Fabricate and assemble structural assemblies in shop to greatest extent possible.
3. Weld in accordance with A.W.S. D1.1.
4. Bolted connections in accordance with AISC

B. Certifications and Registrations:

1. Environmental Management System (EMS): Submit evidence of an EMS for the steel manufacturers providing material for work of this section. For each steel manufacturing facility, submit copy of registration as per ISO 14001.
2. Chain-of-custody certification: Submit manufacturer's certification that no open hearth furnaces were utilized in the production of structural steel to be incorporated into the Work. Submit evidence of energy efficiency for steel manufacturers providing material for work of this section. Acceptable certification includes:
 - a. Bill of Lading indicating source of manufactured steel as North American facility; or,
 - b. Manufacturer's certification that structural steel complies with CO₂ limitations for crude steel production. Indicate method for calculating CO₂ emissions.; or,
 - c. Manufacturer's certification that structural steel complies with energy efficiency requirements for steel production. Include description of energy efficient processes utilized.
 - d. Participation in CO₂ Breakthrough Program: Manufacturer's certification of participation in CO₂ Breakthrough Program.

2.3 FACTORY FINISHING

A. Finishing System:

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

PART 3 EXECUTION**3.1 SITE ENVIRONMENTAL PROCEDURES**

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

END OF SECTION

DIVISION 06

WOOD, PLASTICS, AND

COMPOSITES

SECTION 06 05 73
WOOD TREATMENT

PART 1 GENERAL

1.1 SUMMARY

- A. This Section includes:
1. Wood Treatment.
 2. Natural Decay and Insect Resistant Wood.

1.2 SUBMITTALS

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

PART 2 PRODUCTS

2.1 MATERIALS

A. Preservative Pressure Treatment:

1. Toxicity/IEQ: Products containing chromium will not be permitted. Products containing arsenic will not be permitted
2. Waterborne Wood Preservatives:
 - a. Wood products shall be treated with waterborne wood preservatives listed in Section 4 of AWPAs Standards U1, excluding those which contain arsenic and/or chromium.
 - a. Pressure treatment of wood products shall conform to the requirements of AWPAs Standards U1 and T1.
 - b. Retention of preservatives as prescribed in AWPAs Standard U1 for the following Use Categories (material conforming to a higher AWPAs Use Category may be specified):
 - UC1: Interior construction - above ground, dry conditions.
 - UC2: Interior construction - above ground, damp conditions.
 - UC3A: Exterior construction - above ground, coated and with rapid water runoff.
 - UC3B: Exterior construction - above ground, uncoated or poor water runoff.
 - UC4A: General purpose soil or fresh water contact - heavy duty above ground.
 - UC4B: Heavy duty soil or fresh water contact - critical or difficult to replace components.
 - UC4C: Extreme duty soil or fresh water contact - critical structural components.
3. Boron-based preservatives:
 - a. Impregnate lumber with preservative treatment conforming to AWPAs Standard U1.

B. Fire Retardant Treatment:

1. Toxicity/IEQ: Fire-retardant-treated wood products shall be free of halogens, sulfates, ammonium phosphate and formaldehyde.
2. Fire Retardant Formulations:
 - a. Wood products shall be treated with fire retardants listed in AWPAs Standard U1.
 - b. Fire retardant treatment of wood products shall conform to the requirements of AWPAs Standard U1, Commodity Specification H and AWPAs Standard T1, Section H.

C. Natural Decay and Insect Resistant Wood:

1. Resource Management: Provide sustainably harvested; certified or labeled in accordance with **FSC** guidelines. Naturally Durable Wood is the heartwood of the following species with the exception that an occasional piece with corner sapwood is permitted if 90 percent or more of the width of each side on which it occurs is heartwood. Acceptable species include:
 - a. Decay resistant. Redwood, South American ipe, bald cypress, cedar, black locust and black walnut.
 - b. Termite resistant. Redwood and Eastern red cedar.

PART 3 EXECUTION**3.1 INSTALATION**

- A. All installation will follow procedures given on each of the wood treatment containers and applicators.

END OF SECTION

SECTION 06 10 00
ROUGH CARPENTRY

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes:

1. Wood Framing
2. Wood Decking
3. Wood Sheathing

2.2 SUBMITTALS

A. Recycled Content:

- a. Engineered Wood Products:
- b. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
- c. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
- d. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
- e. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
- f. Salvaged Lumber: Provide documentation certifying products are from salvaged lumber sources.
- g. Recovered Lumber: Provide documentation certifying products are from recovered lumber sources.

B. Local/Regional Materials:

- a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
- b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
- c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
- d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

C. Other Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.

3. For fire-retardant treatments specified to be High-Temperature (HT) type, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 1. Factory mark each piece of lumber with grade stamp of grading agency.
 2. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece.
 3. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.
 4. Provide dressed lumber, S4S, unless otherwise indicated.
- B. Sheathing products:
 1. Sustainable Hardwood Wood Veneer Plywood: 1/40 inch thick veneer panels made from certified sustainably harvested lumber veneer, over a formaldehyde-free substrate.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, blocking, grounds, and similar supports to comply with requirements for attaching other construction.
- B. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.
 1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches o.c.
- C. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated or as required by the authority having jurisdiction.
- D. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- E. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight

connections between members. Install fasteners without splitting wood; do not countersink nail heads, unless otherwise indicated.

END OF SECTION

SECTION 06 20 00
FINISH CARPENTRY

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes:

1. Exterior Millwork, including: standing and running trim.
2. Interior Millwork, including: standing and running trim, cabinets and countertops.

B. Related Sections:

1. (06 05 73) - Wood Treatment.
2. (06 10 00) – Rough Carpentry

1.2 SUBMITTALS

A. Product data as specified in Section (06 05 73) – Wood Treatment and (06 10 00) – Rough Carpentry.

PART 2 PRODUCTS

2.1 MATERIALS

A. As specified in Section (06 05 73) – Wood Treatment and (06 10 00) – Rough Carpentry.

2.2 FABRICATION

A. Exterior Millwork:

1. Trim, Trellis, Lattice and miscellaneous millwork:

- a. Dimensional lumber of rot resistant species.
- b.

B. Interior Millwork:

1. Base, casing, trim, interior rail and wall caps and miscellaneous millwork: Select from the following, unless otherwise indicated:

- a. Hardwood derived from certified sustainable sources.
- b. Salvaged lumber.
- c. Finger jointed pine or any western softwood species.
- d. Low-emission Medium Density Fiberboard.

2. Veneer panels:

- a. Substrate: Select from the following, unless otherwise indicated:

- b. Cellulose honeycomb core.
 - c. Medium Density Fiberboard.
 - d. Compressed straw particleboard.
3. Veneer: Select from the following, unless otherwise indicated.
- a. Certified sustainably harvested lumber.
 - b. Bio-composite
4. Countertops
- a. Marble
 - b. Bio-composite
 - c. Composite

PART 3 EXECUTION

- 3.1** As specified in Section (06 10 00) – Rough Carpentry.

END OF SECTION

DIVISION 07

THERMAL AND MOISTURE

PROTECTION

SECTION 07 20 00
THERMAL PROTECTION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation.
 - a. Cotton Batt (Denim)
 - b. Spray Foam Insulation.
2. Insulation accessories.

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this section:

1. Recycled Content:

- a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
- b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
- c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
- d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.

2. Local/Regional Materials:

- a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
- b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
- c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
- d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

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

C. Operating And Maintenance Manuals Submittals:

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

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

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

2.2 ACCESSORIES

- A. Adhesive
 1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, GS-36 for Commercial Adhesive.

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Coordinate with manufacturer for take-back program. Set aside scrap to be returned to manufacturer for recycling into new product.

END OF SECTION

DIVISION 08

OPENINGS

1.1 SUMMARY

A. Section Includes:

1. Aluminum and wood windows.

1.2 SUBMITTALS

- A. **Product Data:** Include construction details, material descriptions, fabrication methods, dimensions of individual components and profiles, hardware, finishes, and operating instructions for each type of window indicated. Window attachment performance requirements and design criteria, including analysis data shall be signed and sealed by a qualified professional engineer.
- B. **Shop Drawings:** Include plans, elevations, sections, details, hardware, attachments to other work, operational clearances, installation details, and the following:
1. Mullion details, including reinforcement and stiffeners.
 2. Joinery details.
 3. Expansion provisions.
 4. Flashing and drainage details.
 5. Weather-stripping details.
 6. Thermal-break details.
 7. Glazing details.
- C. **Samples for Initial Selection:** For units with factory-applied color finishes.
1. Include similar samples of hardware and accessories involving color selection.
- D. **Product Schedule:** For windows, using the same designations indicated on Drawings.
- E. **Maintenance Data:** For finishes, include in maintenance manuals.
- F. **Warranty:** Special warranty specified in this section.

1.2 QUALITY ASSURANCE

- A. **Structural Performance:** Provide aluminum windows capable of withstanding the effects of the project loads, based on testing units representative of those indicated for the project.
- B. **Design Wind Loads:** ASCE 7-05 and the Requirements of the Authority having jurisdiction.
1. **Deflection:** Design glass framing system to limit lateral deflections of glass edges to less than 1.
 2. L/175 of glass-edge length or 3/4 inch, whichever is less, at design pressure based on testing performed according to AAMA/WDMA 101/I.S.2/NAFS, Uniform Load Deflection Test or structural computations.
- C. **Windborne-Debris Resistance:** Provide glazed windows capable of resisting Large Missile impact from windborne debris, based on the pass/fail criteria as determined from testing glazed windows identical to those specified, according to ASTM E 1886 and testing information in ASTM E 1996 for large missile impact and the requirements of authorities having jurisdiction.

D. Thermal Movements: Provide aluminum windows, including anchorage, that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F material surfaces.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Wood
- B. Aluminum

PART 3 WINDOWS

3.1 TYPES

- A. Window types:
 1. Vertical Sliding
 2. Clerestory
 3. Storefront
 4. Accordion
 5. Other

3.2 PERFORMANCE

- A. Thermal Transmittance: Provide aluminum windows with a whole-window, U-factor maximum indicated at 15-mph exterior wind velocity and winter condition temperatures when tested according to AAMA 1503, ASTM E 1423.
 1. U-Factor: 0.29 winter nighttime; 0.28 summer daytime.
- B. Solar Heat-Gain Coefficient (SHGC): Provide aluminum windows with a whole-window SHGC maximum of 0.17, determined according to NFRC 200 procedures.
- C. Sound Transmission Class (STC): Provide glazed windows rated for not less than 30 STC when tested for laboratory sound transmission loss according to ASTM E 90 and determined by ASTM E 413.
- D. Air Infiltration: Maximum rate not more than indicated when tested according to AAMA/WDMA 101/I.S.2/NAFS, Air Infiltration Test.
- E. Maximum Rate: 0.1 cfm/sq. ft. of area at an inward test pressure of 6.24 lbf/sq. ft.
- F. Water Resistance: No water leakage as defined in AAMA/WDMA referenced test methods at a water test pressure equaling that indicated, when tested according to AAMA/WDMA 101/I.S.2/NAFS, Water Resistance Test.
- G. Test Pressure: 20 percent of positive design pressure, but not more than 15 lbf/sq. ft.

- H. Life-Cycle Testing: Test according to AAMA 910 and comply with AAMA/WDMA 101/I.S.2/NAFS.
- I. Operating Force and Auxiliary (Durability) Tests: Comply with AAMA/WDMA 101/I.S.2/NAFS for operating window types indicated.

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

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

END OF SECTION

DIVISION 09
FINISHES

SECTION 09 29 00**GYPSUM BOARD****PART 1 GENERAL****1.1 SUMMARY**

A. This Section includes:

1. Interior gypsum wallboard.
2. Exterior gypsum board panels for ceilings and soffits.

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

1. Recycled Content:
 - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
2. VOC data: For adhesives used to laminate gypsum board panels to substrates, including printed statement of VOC content.

1.3 PROJECT CONDITIONS

- A. Do not install interior products until installation areas are enclosed and conditioned.
- B. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.
 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 PRODUCTS**2.1 MATERIALS**

A. Gypsum Board:

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

2.3 ACCESSORIES

A. Reinforcing Tape:

1. Toxicity/IEQ: Sheetrock Joint Tape. Paper; fiberglass joint tape not permitted.

B. Joint-Treatment Materials:

1. Toxicity/IEQ: Lime compound. All-purpose joint and texturing compound containing inert fillers and natural binders. Pre-mixed compounds shall be free of antifreeze, vinyl adhesives, preservatives, biocides and other slow releasing compounds

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Indoor Air Quality:

1. Temporary ventilation: Provide temporary ventilation for work of this section.
2. Multi-layer gypsum board: Screw attach. Adhesive attachment will not be permitted.

B. Waste Management: As specified in Section 01 74 19 (01351) – Construction Waste Management and as follows:

1. Select panel sizes and layout panels to minimize waste; reuse cutoffs to the greatest extent possible.

END OF SECTION

SECTION 09 30 00**TILE****PART 1 GENERAL****1.1 SUMMARY**

A. This Section includes:

1. Ceramic tile backsplash.

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this section:

1. Recycled Content:

- a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.

2. Samples for Initial Selection:

- a. For each type of tile and grout indicated. Include Samples of accessories involving color selection.

3. Submit manufacturer's product data for adhesives. Indicate VOC limits of the product. Submit MSDS highlighting VOC limits.

4. Submit Green Seal Certification to GS-36 and description of the basis for certification.

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

1.3 QUALITY ASSURANCE

A. VOC emissions: Provide low VOC products.

1. Aerosol adhesives: Comply with Green Seal GS-36
2. Hard surface flooring: Comply with FloorScore

PART 2 PRODUCTS**2.1 TILE**

A. Ceramic tile:

1. Recycled Content: Minimum 5 percent post-consumer recycled content, or minimum 20 percent pre-consumer recycled content at contractor's option.

B. Porcelain tile:

1. Recycled Content: Minimum 5 percent post-consumer recycled content, or minimum 20 percent pre-consumer recycled content at contractor's option.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that substrates for setting tile are firm, dry, clean, free of coatings that are incompatible with tile-setting materials including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.

3.2 PREPARATION

- A. Subcontractor shall fill cracks, holes, and depressions in concrete substrates for tile; with trowelable leveling and patching compound specifically recommended by tile setting material manufacturer.

3.3 TILE INSTALLATION

- A. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
- B. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- C. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

END OF SECTION

SECTION 09 90 00
PAINTING & COATING

PART 1 GENERAL

1.1 SUMMARY

- A. This section includes:
1. Interior paint, except clear finishes and stains.
 2. Exterior paint, except clear finishes and stains.

1.2 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this section:
1. Samples for initial selection.
 2. VOC data: Submit Green Seal Certification to GS-11 and description of the basis for certification.
 3. Bio-based materials:
 - a. Indicate type of bio-based material in product.
 - b. Indicate the percentage of bio-based content per unit of product.
 - c. Indicate relative dollar value of bio-based content product to total dollar value of product included in project.
- B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

1.2 QUALITY ASSURANCE

- A. VOC Content: Determine VOC (Volatile Organic Compound) content of solvent borne and waterborne paints and related coatings in accordance with EPA Method 24 or ASTM D3960. Provide low VOC products. Comply with:
1. Interior architectural paints: Comply with Green Seal GS-11
 2. Anti-corrosive paints: Comply with Green Seal GS-11
 3. Clear wood finishes: Comply with SCAQMD #1113

PART 2 PRODUCTS

2.1 MATERIALS

- A. Paints and primers:
1. Recycled Content: Minimum 20 percent post-consumer recycled content for light colors; minimum 50 percent post-consumer recycled content for dark colors.

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

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Indoor Air Quality: Provide temporary ventilation as specified in Section 01 57 19.11 (01352) – Indoor Air Quality (IAQ) Management.
- B. Documentation of manufacturer’s take-back program for insulation materials. Coordinate with construction waste management. Include the following:
 1. Set aside scrap to be returned to manufacturer for recycling into new product. Close and seal all partially used containers of paint to maintain quality as necessary for reuse.

3.2 PREPARATION

- A. Remove plates, machined surfaces, and similar items already in place that are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface applied protection before surface preparation and painting.
- B. Clean substrates of substances that could impair bond of paints, including dirt, oil, grease, and incompatible paints and encapsulates.

3.3 APPLICATION

- A. Apply paints according to manufacturer's written instructions.
 - 1. Use applicators and techniques suited for paint and substrate indicated.
 - 2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 - 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.

- B. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

END OF SECTION

DIVISION 11
EQUIPMENT

SECTION 11 30 00
RESIDENTIAL EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. This section includes:

1. Refrigerators
2. Clothes Washers
3. Dishwashers
4. Freezers

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this section:

1. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:
 - a. Clothes washers.
 - b. Dishwashers.
2. Energy Efficiency:
 - a. Submit documentation for Energy Star qualifications for equipment provided under work of this section.

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

C. Documentation of manufacturer's maintenance agreement for each type of equipment. Include the following:

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

1.3 MAINTENANCE

A. Operational Service: Service shall not landfill or burn reclaimed materials.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Refrigerator:

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

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

B. Clothes Washer:

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

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

C. Dishwasher:

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

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

D. Freezer:

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

FEMP Performance Requirement for Federal Purchases		
Freezer Type–Defrost	Total Volume	Annual Energy Use
Chest–Manual	≤ 6.4 cu. ft.	230 kWh/year or less
Chest–Manual	6.5 to 8.4 cu. ft.	260 kWh/year or less
Chest–Manual	8.5 to 10.4 cu. ft.	290 kWh/year or less
FEMP Performance Requirement for Federal Purchases		
Freezer Type–Defrost	Total Volume	Annual Energy Use
Chest–Manual	10.5 to 12.4 cu. ft.	320 kWh/year or less
Chest–Manual	12.5 to 14.4 cu. ft.	350 kWh/year or less
Chest–Manual	14.5 to 16.4 cu. ft.	380 kWh/year or less
Chest–Manual	16.5 to 18.4 cu. ft.	410 kWh/year or less
Chest–Manual	18.5 to 20.4 cu. ft.	440 kWh/year or less
Chest–Manual	≥ 20.5 cu. ft.	470 kWh/year or less
Upright–Manual	≤ 6.4 cu. ft.	305 kWh/year or less
Upright–Manual	6.5 to 8.4 cu. ft.	330 kWh/year or less
Upright–Manual	8.5 to 10 cu. ft.	355 kWh/year or less
Upright–Manual	10.5 to 12.4 cu. ft.	380 kWh/year or less
Upright–Manual	12.5 to 14.4 cu. ft.	405 kWh/year or less
Upright–Manual	14.5 to 16.4 cu. ft.	430 kWh/year or less
Upright–Manual	16.5 to 18.4 cu. ft.	455 kWh/year or less
Upright–Manual	18.5 to 20.4 cu. ft.	480 kWh/year or less
Upright–Manual	≥ 20.5 cu. ft.	505 kWh/year or less
Upright–Automatic	≤ 12.4 cu. ft.	530 kWh/year or less
Upright–Automatic	12.5 to 14.4 cu. ft.	565 kWh/year or less
Upright–Automatic	14.5 to 16.4 cu. ft.	600 kWh/year or less
Upright–Automatic	16.5 to 18.4 cu. ft.	635 kWh/year or less
Upright–Automatic	18.5 to 20.4 cu. ft.	670 kWh/year or less
Upright–Automatic	≥ 20.5 cu. ft.	705 kWh/year or less

E. Room Air Conditioner:

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

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

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

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

END OF SECTION

DIVISION 22
PLUMBING

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Faucets and aerators
2. Toilets
3. Showerheads

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this section:

1. Water efficiency: Indicate water consumption rates in gallons per day (gpd) per unit for the following:
 - a. Plumbing fixtures.

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

1.3 QUALITY ASSURANCE

A. Water flow and consumption rates for plumbing fixtures:

1. Comply with requirements in Public Law 102-486, Energy Policy Act.
2. Provide WaterSense labeled products for:
 - a. High-Efficiency Lavatory Faucets.
 - b. High-Efficiency Toilets - Tank-Type Dual Flush.

PART 2 PRODUCTS

2.1 MATERIALS

A. Fixtures:

1. Water management: Provide low flow fixtures and automatic, sensor operated faucets and flush valves. Provide automatic, sensor operated faucets and flush valves to comply with ASSE 1037 and UL1951.
 - a. Faucets and aerators: WaterSense labeled. Maximum 1.5 gal/min when measured at a flowing water pressure of 60 pounds per square inch; and, minimum flow rate shall not be less than 0.8 gpm (3.0 L/min) at a pressure of 20 psi at the inlet, when water is flowing.
 - b. Showerheads: 2.2 gal/min when measured at a flowing water pressure of 80 pounds per square inch.

2. Toxicity/IEQ:

- a. Traps: Provide traps with removable access panels for easy clean-out at sinks and lavatories.
- b. Water filter systems: Provide filters for chlorine at sinks, lavatories, and showerheads.
- c. Low corrosion flux for copper pipe: Comply with ASTM B813.

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

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

END OF SECTION

DIVISION 23
HEATING, VENTILATION, AND
AIR CONDITIONING

SECTION 23 30 00

HVAC AIR DISTRIBUTION

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Ductwork
2. Filters

1.2 SUBMITTALS

A. Product data.

1.3 QUALITY ASSURANCE

A. Energy Efficiency: Meet or exceed ASHRAE 90.1.

B. Indoor Environmental Quality:

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

PART 2 PRODUCTS

2.1 MATERIALS

A. Ductwork:

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

B. Filters:

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

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Commissioning: The project will have selected building systems commissioned. Coordinate with commissioning as specified in Section 01 91 00 (01810) - Commissioning.
- B. Indoor Air Quality:
 - 1. Temporary ventilation: as specified in Section 01 57 19.11 (01352) – Indoor Air Quality (IAQ) Management, and as follows:
 - a. Degrease sheet metal air ducts.
 - b. Seal air ducts to prevent HVAC system air leakage.
 - c. Install duct insulation so that unfaced fiberglass and mineral fiber insulation are not in contact with airstream.
 - d. Clean ductwork in accordance with manufacturer’s recommendations and the NAIMA Guide on Cleaning Fibrous Glass Insulated Air Duct Systems.
- C. Resource Management:
 - 1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

END OF SECTION

DIVISION 26
ELECTRICAL

SECTION 26 05 00**COMMON WORK RESULTS FOR ELECTRICAL****PART 1 GENERAL****1.1 SUMMARY**

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

PART 2 PRODUCTS**2.1 CONDUCTORS AND CABLES**

- A. Conductors
 - 1. Conductors, No. 12 AWG and Smaller: Solid copper
 - 2. Conductors, No. 10 AWG and Larger: Stranded copper
 - 3. Insulation: Thermoplastic, rated at 75 deg C minimum
 - 4. Wire Connectors and Splices: Units of size, ampacity rating, material, type and class suitable for service indicated.

2.2 GROUNDING MATERIALS

- A. Conductors: Solid for No. 12 AWG and smaller, and stranded for No. 8 AWG and larger unless otherwise indicated.
 - 1. Insulated Conductors: Copper wire or cable insulated for 600 V unless other required by applicable Code or authorities having jurisdiction
 - 2. Bare, Solid-Copper Conductors: Comply with ASTM B 3
 - 3. Bare, Stranded-Copper Conductors: Comply with ASTM B 8
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts with clamp-type pipe connectors sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 ELECTRICAL IDENTIFICATION MATERIALS

- A. Conductor Identification Materials: Color-Coding Conductor Tape: Self-adhesive vinyl tape ½ to 2 inches wide.
- B. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with circuit identification legend machine printed by thermal transfer or equivalent process.

2.4 SUPPORT AND ANCHORAGE COMPONENTS

- A. Raceway and Cable Supports: As describe in NECA 1
- B. Conduit and Cable Devices: Steel and malleable iron hangers, clamps and fittings

- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded malleable iron body and insulation wedging.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plated shapes and bars, black and galvanized.

PART 3 EXECUTION

3.1 GENERAL ELECTRICAL EQUIPMENT INSTALLATION REQUIREMENTS

- A. Install electrical equipment to allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
- B. Install electrical equipment to provide for ease for disconnecting the equipment with minimum interference to other installations.
- C. Install electrical equipment to allow right of way for piping and conduit installed at required slope.
- D. Install electrical equipment to ensure that connecting cable and wire ways are clear of obstructions and of the working and access space of other equipment.
- E. Install sleeve and sleeve seals of type and number required for sealing electrical service penetrations of exterior walls.
- F. Comply with the NECA 1.

3.3 RACEWAYS AND CABLE INSTALLATION

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

3.4 GROUNDING

- A. Grounding Conductors: Install bar copper conductor, #4 AWG minimum.
- B. Pipe and equipment grounding conductor terminations: Bolted
- C. Connection to Structural Steel: 2 hole compression lug. All structural steel shall be grounded.
- D. Install ground rod driven into ground according to ground rod manufacturer's instructions.
- E. Making Connections without exposing steel or damaging coating.
- F. Install bonding straps and jumpers in locations accessible for inspection and maintenance, except where routed through short lengths conduit.
- G. Bond straps directly to basic structure, take care not to penetrate any adjacent parts.
- H. Test completed grounding system at each location where a maximum ground-resistance level is specified at service disconnect enclosure grounding terminal.
 - 1. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - 2. Perform tests by fall-of-potential method according to IEEE 81
 - 3. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity 500 kVA and less: 10 Ohms
 - b. Power Distribution Units or panel boards Serving Electronic Equipment: 5 Ohms

4. Excessive Ground Resistance: If resistance to ground exceeds specified values, include recommendations to reduce ground resistance.

3.5 IDENTIFICATION

- A. Power-Circuit Conductor Identification: For No. 8 AWG conductors and larger, at each location where observable, identify phase using color-coding conductor tape.
- B. Warning Labels for Enclosures for Power and Lighting: Comply with 29 CFR 1910.145; identify system voltage with black letters on an orange background. Apply to the exterior of the door cover
- C. Equipment Identification Labels
 1. Labeling instructions
 - a. Indoor Equipment: Adhesive film label with clear protective overlay. Provide a single line of text with ½ inch high letters on 1 ½ inch high label; where two lines of text are required, use labels 2 inches high
 - b. Outdoor Equipment: Engraved, Laminated acrylic or melamine label. Drilled for crew attachment
 - c. Elevated Components: Increase sized of labels and legend to those appropriate for viewing from the floor.
 2. Equipment to be labeled
 - a. Panelboards, electrical cabinets, and enclosures
 - b. Motor-control centers
 - c. Disconnect switches
 - d. Enclosed circuit breakers
 - e. Motor Starters
 - f. Power Transfer equipment
 - g. Contractors
- A. Verify identity of each item before installing identification products
- B. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance.
- C. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- D. Install system identification color banding for raceways and cables at 50 foot maximum intervals in straight runs, and a 15 foot maximum intervals in congested areas.
- E. Color Coding for Phase Identification, 600V and Less: Underground service, feeder and branch-circuit conductors
 1. Colors for 240/120-V Circuits
 - a. Phase A: Black
 - b. Phase B: Red
 - c. Neutral: White
 2. Field Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points.

3. INSTALLATION OF HANGERS AND SUPPORTS

- A. Fasten hangers and supports securely in place, with provision for thermal and structural movement. Install with concealed fasteners unless otherwise indicated.
- B. Separate dissimilar metals and metal products from contact with cement or wooden materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation
- C. Multiple Cables: Install on trapeze-type supports fabricated with steel slotted channel
- D. Strength of Support Assemblies: Where not indicated, select sized of components so strength will be adequate to carry present and future static loads within specified loading limit. Minimum static design load used from strength determination shall be weight of supported components plus 200 lb
- E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical item and their supports to building structural elements by the following methods unless otherwise indicated or required by Code:
 - 1. To wood: Fasten with lag screw or through bolts
 - 2. To steel: beam clamps (MSS Type 19. 21. 23. 25. Or 27) complying with MSS SP-69 or spring tension clamps
 - 3. To light steel: sheet metal screws
 - 4. Items mounted on hollow walls and nonstructural building surfaces: mount on slotted channel racks attached to substrate

3.7 SLEEVE AND SLEEVE-SEALS INSTALLATION

- A. Cut sleeves to length for mounting flush with both wall surfaces.
- B. Extend sleeves installed in floors 2 inches about finished floor level
- C. Size pipe sleeves to provide ½ inch annular clear apace between sleeve and cable unless sleeve seal is to be installed.
- D. Interior Penetrations of Non-Fire rated Wall and Floors: Seal annular space between sleeve and cable using joint sealant appropriate for size, depth and location of joint according to Division 07 Section “Joint Penetration”
- E. Roof-Penetrations Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applies in coordination with roofing work.
- F. Aboveground Exterior Floor Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals

END OF SECTION

SECTION 26 05 19

CONDUCTORS

PART 1 GENERAL

1.2 DESCRIPTION OF WORK

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

1.3 QUALITY ASSURANCE

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

1.4 REFERENCES

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

1.5 SUBMITTALS

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

PART 2 PRODUCTS

2.1 MANUFACTURERS

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

- a. Advance Wire and Cable, Inc.
- b. Cerro Wire and Cable, Co.
- c. Electrical Conductors, Inc.
- d. General Cable Corp.
- e. Hitemp Wires, Inc.
- f. Rome Cable Corp.
- g. Southwire Company
- h. The Okonite Company

2. Connectors:

- a. Amp, Inc.
- b. Burndy Corp.
- c. Eagle Electric Mfg. Co., Inc.
- d. Gould, Inc.
- e. Ideal Industries, Inc.
- f. Joselyn Mfg. and Supply Co.
- g. O-Z/Gedney Co.
- h. Pyle National Co.
- i. Thomas and Betts Co.

2.2 WIRE, CABLE, AND CONNECTORS

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

<u>PHASE</u>	<u>120/208 VOLT</u>	<u>277/480 VOLT</u>
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	*White	*White

Ground

Green

Green

*Except as provided in paragraph 200.6 of the NEC.

C. Connections

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

PART 3 EXECUTION

3.1 INSTALLATION

- A. General: Install electric cables, wires and connectors as indicated in compliance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices.
- B. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.
- C. Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes. Junction boxes may be utilized wherever required.
- D. Splicing: No splicing or joints will be permitted in either feeder or branch circuits except at outlet or accessible junction boxes.
- E. Wire shall not be installed in raceways until the concrete work and plastering is completed and all conduits in which moisture has collected have been swabbed out. Insulation resistance to ground shall not be less than that approved by NEC. Eliminate splices wherever possible.
- F. Use pulling compound or lubricant where necessary. Compound must not deteriorate conductor insulation.

- G. Prior to energization, check cable and wire for continuity of circuitry, and for short circuits. Correct malfunctions when detected.
- H. Bury a continuous, pre-printed, bright colored plastic ribbon cable marker with each underground cable, regardless of whether conductors are in conduit. Locate each directly over cables 12" below finished grade.
- I. Conductor Installation: Install all conductors in a single raceway at one time, insuring that conductors do not cross one another while being pulled into raceway. Leave sufficient cable at all fittings or boxes and prevent conductor kinks. Keep all conductors within the allowable tension and exceeding the minimum bending radius.
- J. Conductor Support: Provide conductor supports as required by the code and recommended by the cable manufacturer. Where required, provide cable supports in vertical conduits similar to OZ Type C.M.T., and provide the lower end of conduit with OZ Type KVF ventilators.
- K. Conductor Termination: Provide all power and control conductors that terminate on equipment or terminal strips, with solderless lugs or fork and flanged tongue terminals. Provide T and B "sta-kon" tongue terminal. This type conductor termination is not required when the equipment is provided with solderless connectors.
- L. Many circuits are shown on the drawings to be provided with dedicated neutral and ground conductors. Carefully review circuiting and the electrical abbreviations and symbols legend and provide the number of conductors indicated.
- M. Unless otherwise indicated provide dedicated neutral conductors for all branch circuits. Neutral conductors shall not be shared between circuits. Where the drawings indicate shared neutral conductors, for a multi-wire branch circuit, group the breakers together in accordance with NEC requirements.

3.2 CONDUCTOR ARCPROOFING

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

END OF SECTION

SECTION 26 05 33**RACEWAYS****PART 1 GENERAL****1.2 DESCRIPTION OF WORK**

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

1.3 REFERENCES

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

1.4 SUBMITTALS

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

PART 2 PRODUCTS**2.1 STEEL CONDUIT**

- A. Steel Conduit: Rigid steel conduit, intermediate metal conduit and steel electrical metallic tubing shall be hot-dipped, galvanized or sheradized as manufactured by Youngstown Sheet and Tube Company, National Electric, General Electric, or equal.
- B. Joints: Raintight non-insulated throat type compression fittings (connectors and couplings) shall be provided for electrical metallic tubing systems. All fittings shall be of the steel type with steel locknuts equal to Appleton 95 Series.
- C. Expansion Joints: Provide expansion fittings, O.Z. Type AX with bonding jumper for rigid conduit and O.Z. Type TX with bonding jumper for electrical metallic tubing. Where embedded raceways cross building expansion joints, provide combination deflection/expansion fittings, O.Z. Type AXDX, or equal.

2.2 RIGID NON-METALLIC (PVC) CONDUIT

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

2.3 FLEXIBLE METAL CONDUIT

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

2.4 LIQUID-TIGHT, FLEXIBLE METAL CONDUIT

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

2.5 WIREWAYS

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

PART 3 EXECUTION

3.1 GENERAL

- A. Install electric raceways where indicated; in accordance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation" and complying with recognized industry practices.
- B. Raceways embedded in concrete or in earth below floor slabs shall be rigid steel conduit, intermediate metal conduit or rigid schedule 40 PVC conduit. Rigid PVC conduit shall be provided with rigid metal or intermediate metal conduit elbows when the raceway system exits the concrete topping or earth.
- C. Electrical metallic tubing shall not be embedded in concrete or installed in earth.

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

3.2 INSTALLATION

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

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

- H. Plain Concrete: Raceways shall not be placed in plain concrete, such as cement toppings on structural floors without special instructions.
- I. Furred Spaces: Raceways installed in furred spaces shall be installed in accordance with the requirements of the National Electrical Code. Do not anchor or strap conduits to the ceiling furring channels or attach to furred ceiling hanger wires. Raceways may be attached to the suspension system (wire hangers) of drop ceilings if installed in such a manner that the ceiling panels may be removed without interference with the raceway, and the wire hangers are sized to carry the additional raceway load.
- J. Stub Ups: Extend conduit stubs at least one foot above slab or fill, before connection is made to electrical metallic tubing.
- K. Exterior Conduits: Install raceways a minimum of 42" below finished grade unless noted otherwise on the drawings.
- L. Provide marking of conduit and junction boxes to indicate which distribution system they are serving. The markings could be colored tape on conduit at or near junction boxes with different colored tapes indicating different distribution systems. Concealed junction boxes shall be legibly marked with a magic marker to indicate the panel and circuit number that junction box serves.

1. The distribution systems shall be color coded as follows:

- a. Fire Alarm - Red
- b. Paging System - Blue
- c. 120/208 Volt - Green
- d. 277/480 Volt - Orange
- e. Cable TV System - Black
- f. Telephone System – White

M. Steel Conduit (galvanized rigid steel, IMC or EMT):

- 1. Cutting: Cutting shall be done with hand or power hacksaws. All cut ends shall be reamed to remove burrs and sharp edges.
- 2. All threaded joints shall be made up wrench-tight and all compression joints shall be made up mechanically secure and snug so as to make continuous current-carrying electrical contact.
- 3. All metallic conduits buried or otherwise in contact with earth shall be painted using one heavy continuous coat of asphalt varnish after assembly of conduit and fittings.

4. Expansion joints shall be installed in steel conduit systems in structures as follows expansion joints are specified elsewhere in the specification):
 - a. Where conduit run crosses a building expansion joint.
 - b. In any conduit run exceeding 100 feet in length.
 - c. Where shown on the drawings.
- N. Threads: Clean all threads of rigid or intermediate metal conduit. Coat all male threads of all steel conduit installed in concrete with red or white lead immediately before being coupled together.
- O. Running Threads: Use "Erickson" type couplings in lieu of running threads.
- P. PVC Conduit:
 1. Joints: Conduits shall be joined by using couplings and solvent cement furnished or recommended by the raceway manufacturer. Finished joints shall be secure and watertight.
 2. Cutting: Cutting shall be done with hacksaws and ends shall be reamed to remove burrs and sharp edges.
 3. Expansion Joints: Expansion joints shall be installed:
 - a. Where conduit run crosses a building expansion joint.
 - b. As recommended by the manufacturer or as shown on the drawings.
 4. Bends for PVC conduit sizes 2" and smaller may be made "hot" in the field. Inside dimension shall be thereby undistorted. For PVC sizes larger than 2", provide only factory bends.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.2 DESCRIPTION OF WORK

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

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of panelboards and enclosures, of types, size and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

- B. Installer: A firm of at least three (3) years of successful installation experience on projects with electrical installation work similar to that required for this project.

1.4 REFERENCES

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

1.5 SUBMITTALS

- A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations for each panelboard required. Include data substantiating that units comply with specified requirements.
- B. Shop Drawings: Submit dimensioned drawings of panelboards and enclosures showing accurately scaled layouts of enclosures and required individual panelboard devices, including but not limited to circuit breakers, fusible switches, fuses, ground fault circuit interrupters, and accessories.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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

2.2 FEEDER PROTECTIVE DEVICE COORDINATION

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

system manufacturer shall fully coordinate the overcurrent protective device selection to ensure selectivity between equipment.

2.3 GENERAL

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

2.4 LIGHTING AND APPLIANCE PANELS

- A. Lighting and appliance panelboards shall be Square D type NF (or equal) for 277/480 volt or Square D type NQOB (or equal) 120/208 volt applications. All branch circuit breakers are to be quick-make, quick-break, trip indicating and common trip on all multi-pole breakers, and shall be bolt-on type. Trip indication shall be clearly shown by breaker handle located between the "ON" and the "OFF" positions. Panelboards shall have distributed phase copper bussing throughout.
- B. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.
- C. Provide fully rated main circuit breaker type panelboards, where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.
- D. Provide fully rated main lug only type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.
- E. Panelboard boxes shall be 5.75" deep, maximum and shall have 6-inch minimum gutters. Fronts are to be complete with door and cylinder lock, with all locks keyed alike. Fronts shall have adjustable trim clamps, directory frames, and shall be equipped with a typewritten directory that identifies each circuit breaker by number and the equipment that the breaker serves. One additional blank directory card for each panel shall be furnished to the Owner.
- F. Two section panels (as required by Code) shall be equipped with boxes of equal dimensions.
- G. Panelboards shall be Underwriters' Laboratory listed and shall bear the UL label. The size of the panelboard main disconnect device or main lugs, the rating and number of branch circuits, and the type of mounting shall be as shown on the drawings.
- H. All factory installed devices shall be re-torqued prior to energizing.

2.5 DISTRIBUTION PANELS

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

2.6 FEEDER PROTECTIVE DEVICES

- A. The following paragraphs list the general feeder protective device requirements. For circuit breakers that are part of the emergency distribution system electronic circuit breakers may be required to achieve selective coordination in accordance with N.E.C. 2011, 700.27.
 - 1. Feeder protective devices as shown shall be molded case air circuit breakers, built, tested and UL labeled per UL 489.
 - 2. In general 100 ampere through 400-ampere frames shall be thermal-magnetic trip with inverse time current characteristics. Breakers with 225 ampere through 400- ampere frames shall have continuously adjustable magnetic pick-ups of approximately five to ten times trip rating.
 - 3. In general breakers with 600 ampere frames and above shall be Square D Powerpact or approved equivalent with solid-state trip complete with built in current transformers, solid-state trip unit and flux transfer shunt trip. Breakers shall have easily changed trip-rating plugs with trip ratings as indicated on the drawings. Rating plugs shall be interlocked so they are not interchangeable between frames and interlocked such that breakers cannot be latched with rating plug removed. Breaker shall have built-in test points for testing long delay, instantaneous and ground fault (where shown). Functions of the breaker shall be tested by means of a 120 volt operated test kit. Provide one test kit capable of testing all breakers 600 ampere and above.
 - 4. Solid state instantaneous element shall be continuously adjustable from approximately 4 to 8 times the trip rating, with short time adjustment from instantaneous to 10-cycle delay for coordination purposes. Provide short delay override feature providing for instantaneous tripping on high magnitude faults.
 - 5. Molded case breakers shall have a minimum UL listed interrupting capacity as listed on the drawings.
 - 6. Breakers 2000 thru 3000A frame on the drawings shall be UL listed and labeled for 100 percent application per the N.E.C.

2.7 CUSTOMER METERING

- A. Where indicated on the drawings, provide a BACNET compatible digital electronic power meter with the following monitoring and metering capabilities:

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

PART 3 EXECUTION

3.1 INSTALLATION

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

END OF SECTION

SECTION 26 27 26**WIRING DEVICES****PART 1 GENERAL****1.2 DESCRIPTION OF WORK**

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

1.3 QUALITY ASSURANCE

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

1.4 REFERENCES

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

1.5 SUBMITTALS

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

PART 2 PRODUCTS**2.1 MANUFACTURERS**

- A. Subject to compliance with requirements, provide products of one of the following:
 - 1. TBD

2.2 WIRING DEVICES

- A. General: Where shown on the drawings, furnish and install wiring devices indicated by the appropriate symbols. Wiring devices shall be products of Pass and Seymour Corporation, or equal. Catalog numbers shown below are P & S hard use specification grade. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable.
- B. Switches: Branch circuit switches shall be flush tumbler type as follows:
- | | |
|---------------------------------------|----------------------------|
| 1. Single Pole | CS20AC1 Series - Gray |
| 2. Two Pole | CS20AC2 Series - Gray |
| 3. Three-Way | CS20AC3 Series - Gray |
| 4. Four-Way | CS20AC4 Series - Gray |
| 5. Single Pole SW with Lighted Toggle | PS20AC1-CSL Series – Clear |
- C. Switches located in laboratory spaces on normal power shall be the same as
1. Listed above but **GRAY** in color. Laboratory spaces include all areas indicated or referenced on Sheet LF0.12 – Lab Area Callouts
- D. Switches located in non-laboratory spaces on normal power shall be the same as listed above but **WHITE** in color.
- E. Switches fed by a generator circuit (standby or life safety) shall be the same as listed above but **RED** in color.
- F. Dimmer Switches: Provide dimmer switches according to the following (all catalog numbers are Lutron Nova T series, unless otherwise noted). At minimum, all dimmer switches shall be rated to accommodate the load shown to be switched on the Drawings.
1. Wall Mounted Line Voltage Automatic Wall Switches: Watt Stopper type DW-100-I-120/277. Provide time delay setting of 15 minutes unless directed otherwise by the University.
 2. Wall Mounted Line Voltage Digital Time Switches: Watt Stopper type TS-400-I-120/277- with adjustments set as directed by the University.
 3. Low Voltage, Dual Technology Occupancy Sensors: Watt Stopper type DT-200 complete with isolated relay for connection to HVAC control system and BZ-150 box mounted power pack. Provide sensor adjustments as directed by the University.
 4. Other occupancy sensor types: See the Electrical Abbreviations and Symbols Legend for additional occupancy sensor types and information.

2.3 RECEPTACLES

- A. All receptacles shall be side and back wired, self-grounding of the type indicated on the drawings, or as follows. Catalog numbers shown below are Pass & Seymour specification grade unless otherwise indicated. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable:
- | | |
|---|---|
| 1. Duplex Convenience Receptacles
20A-125V (Grounding Type) | CRB5362S Series |
| 2. Weatherproof Duplex Receptacles
20A-125V (Grounding Type) | CRB5362S WP Series
Weatherproof Plate |
| 3. Duplex GFI Receptacle | 2094 20A-125V |
| 4. Weatherproof Duplex
20A-125 Volt | 2094 – with GFI Receptacle
Weatherproof Wall Plate |
| 5. TVSS Duplex Receptacle | 5362ISP 20A-125V |

- B. Receptacles located in laboratory spaces on normal power shall be the same as listed above but **GRAY** in color. Laboratory spaces include all areas indicated or referenced on Sheet LF0.12 – Lab Area Callouts
- C. Receptacles located in non-laboratory spaces on normal power shall be the same as listed above but **WHITE** in color.
- D. Receptacles fed by a generator circuit (standby or life safety) shall be the same as listed above but **RED** in color.

2.4 PLATES

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

2.5 TWO PIECE SURFACE METAL RACEWAYS

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

2.6 FLOOR OUTLETS

- A. Flush Mounted Floor Boxes and Floor Outlets. See plans for types. Unless noted otherwise on the plans provide one receptacle faceplate, and one blank faceplate (to support telecom devices) for each flush mounted floor convenience outlet. When carpet is indicated on the finish schedule, supply each floor box or outlet with an appropriate carpet flange.
- B. Poke-Thru Service Fittings and Service Pedestals: See plans for types. Provide all necessary faceplate types, conduit adapters for installation on counter tops and all other accessories as noted on the drawings, or as required to meet specified project needs.

- C. Where devices are installed on exposed fittings or boxes, the plates shall be galvanized and of a type designed to fit the box. Blank covers shall be installed on all boxes without devices or fixtures, of same type as installed on devices in the room or area.
- D. Test wiring devices to ensure electrical continuity of grounding connections and proper polarity.

PART 3 EXECUTION

3.1 INSTALLATION

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

END OF SECTION

SECTION 26 50 00**LIGHTING****PART 1 GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Interior luminaires.
2. Exterior luminaires.
3. Lighting control devices.
4. Accessories.

1.2 SUBMITTALS**1. Energy Efficiency:**

- a. Submit documentation for Energy Star qualifications for equipment provided under work of this Section.
- b. Submit data indicating lumens per watt efficiency of light source.
- c. Submit data indicating color rendition index of light source.

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.**C. Documentation of manufacturer's maintenance agreement for luminaires. Include the following:**

1. Appropriate contact information.
2. Overview of procedures.

- a. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

3. Limitations and conditions, if any, applicable to the project.

1.3 QUALITY ASSURANCE**A. Energy Efficiency: Comply with National Energy Policy Act requirements for lighting products.****1.4 MAINTENANCE****A. Operational Service: Provide manufacturer's maintenance agreement service for luminaires installed in project. Service shall reclaim materials for recycling and/or reuse. Service shall not landfill or burn reclaimed materials.**

1. Indicate procedures for compliance with regulations governing disposal of Mercury.

PART 2 PRODUCTS**2.1 INTERIOR LUMINAIRES**

A. Downlight Luminaires;

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

B. Compact Fluorescent Lamps:

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

2.2 EXTERIOR LUMINAIRES

A. Luminaire:

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

2.3 LIGHTING CONTROL DEVICES

- A. Dimming Ballast Controls: Sliding-handle type with on/off control; compatible with ballast and having light output and energy input over the full dimming range.
- B. Light Level Sensor: Detect changes in ambient lighting level and provide dimming range of 20 to 100 percent in response to change. Sensor shall be capable of controlling 40 electronic dimming ballast, minimum. Adjustable Ambient Detection Range: 10 to 100 foot-candles minimum. Sensor shall have a bypass function to electrically override sensor control.
- C. Occupancy Sensors: Comply with Green Seal GC-12. Provide adjustable sensitivity and off delay time range of 5 to 15 minutes.
- D. Time Switch: Astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at predetermined time between 8:30 p.m. and 2:30 a.m. or sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise.
- E. Photocell Switch: UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell, 60 Hz with control of mechanically held contactors.

- 1. Switch shall turn on at or below 32 lux (3 footcandles) and off at 22 to 107 lux (92 to 10 footcandles).
- 2. A time delay shall prevent accidental switching from transient light sources.
- 3. Provide switch:

2.4 ACCESSORIES

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

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

- A. Resource Management:

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

END OF SECTION

DIVISION 28

ELECTRONIC SAFETY AND

SECURITY

SECTION 28 31 00
FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 SUMMARY

- A. This Section includes information on:
 - 1. Smoke Detector System

1.2 SUBMITTALS

- A. Manufacturer's product data, including manufacturer's specification summary sheet for products.
- B. Manufacturer's installation instructions, maintenance data, and warranty information.
- C. Coordination drawings, including reflected ceiling plan and smoke detector plan.

1.3 SYSTEM DESCRIPTION

- A. Fire alarm system with interconnected alarm signaling
- B. Battery operated power supply

1.3 QUALITY ASSURANCE

- A. Smoke detection units to comply with the following standards:
 - 1. NFPA 70 National Electric Code
 - 2. NFPA 72 Nation Fire Alarm Code
 - 3. NFPA 101 Life Safety Code
- B. Installer qualifications:
 - 1. Unskilled labor, no qualifications required

PART 2 PRODUCTS

2.1 SMOKE DETECTORS

- A. Manufacturer: Kidde or equal quality
 - 1. Wirelessly interconnected fire and smoke alarm
 - 2. Battery power supply

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install smoke detection units as per manufacturer's instructions and NFPA 72.

3.2 EXAMINATION

- A. All smoke detection units must be tested before and after installation on premises.
 - 1. Testing must comply with NFPA 70, NFPA 72, and NFPA 101.

DIVISION 33
UTILITIES

SECTION 33 16 20

RAINWATER HARVESTING

PART 1 GENERAL

1.1 SUMMARY

2 This Section includes engineering, fabricating, furnishing, and installing:

1. Rainwater Harvesting System.
 - a. Roof collection system.

1.2 DEFINITIONS

- A. Rainwater Harvesting System: An assembly that collects, stores, and distributes rain water for use in plant watering.

1.3 SUBMITTALS

- A. Product Data: Submit product data on all components of the rainwater harvesting system. Unless otherwise indicated, include the following for each type of product provided under work of this Section:
1. Manufacturer's brochure indicating equipment model(s).
 2. Recycled Content:
 - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
 - b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.
 - c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
 - d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
- B. Shop Drawings: For roof collection system include plans, sections, details, and attachments to other work, for the following:
1. Pumps.
 2. Storage.
 3. Connection to roofing system.
 4. Connection to irrigation system.
 5. Connection to plumbing system.
- C. Calculations: For roof collection system submit the following:
1. Maximum water capacity.
 2. Collection data: Include the following:

- a. Average rainfall rate (inches annually)
 - b. Total collection area (s.f.)
 - c. Potential collection (gallons)
 - d. Available gallons
3. Water Demand:
- a. Landscaping:
 - i. Total estimated planted area (s.f.)
 - ii. Application rate / week (high) gallons
 - iii. Application rate /week (low) gallons
 - iv. Gallons required
- D. Operation and Maintenance Manuals Submittals:
1. Operation and maintenance procedures, including variations of procedures appropriate for normal climatic conditions anticipated throughout an annual cycle of operations
 2. Water testing laboratory contact information
 3. Water testing requirements, schedule, kits, and equipment
- E. Reports for Field Quality Control: Submit test reports and inspection reports to the university.
1. System Inspections
 2. Water Quality Tests

1.4 QUALITY ASSURANCE

- A. Single-Source Responsibility: To the greatest extent possible, obtain the system components from one source and from a single manufacturer.

1.5 SEQUENCING AND SCHEDULING

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

PART 2 PRODUCTS

2.1 SYSTEM COMPONENTS

- A. Conveyance:
1. Pump(s), sized as appropriate to water demands of facility.
 - a. Roof collection system: Gravity Fed
 2. Piping. Overflow pipe shall empty into a non-flooding area. Include separate inlet for intermittent treatment as is deemed necessary on basis of regular inspection/testing.

B. Storage:

1. Tank(s), sized as appropriate to water demands of facility. Above ground design. System design shall indicate load requirements for tank foundation. Tanks shall be accessible for routine maintenance.
2. Water Tank Coatings: Coatings formulated for use in potable water storage systems. Provide minimum 59% bio-based content.

C. Lead components are not permitted.**2.2 FABRICATION**

- A. Design prefabricated components and necessary field connections required for installation to permit easy assembly, repair and maintenance, and disassembly.
- B. Design and construct to comply with applicable regulatory requirements.
 1. Non-potable system(s): Provide piping and accessories necessary to operate as a non-potable water system capable of utilizing municipal water as a supplementary source.
 - a. SD Building Code Requirements:
 - i. Rainwater harvesting and utilization may be demonstrated provided that any “collected” and “utilized” rainwater is actively diverted to bypass intentional collection systems. This may be performed via a hidden valve and diversion tee within the rainwater piping system prior to reaching a storage vessel. During tour and jury communications, the team may discuss the rainwater collection system as though it is an active and functioning system, but should disclose the diversion strategy should anyone question the team whether the site collection is in violation of local or state statute.
 - ii. The act of harvesting rainwater must be permitted within the jurisdiction where the house is intended to be permanently placed.
 - iii. The rainwater harvesting system must comply with the Solar Decathlon Building Code and its adopted International Residential Code
 - iv. Roof gutters or downspout entrances providing captured rainwater intended to be processed and used shall be provided with an effective means to prevent leaf and other roof debris from entering the collection piping. Screening providing ¼ inch (6mm) maximum openings located immediately upstream of conveyance piping including exterior downspouts shall be deemed compliant.
 - v. Rainwater harvesting systems used exclusively for irrigation or other non-potable purposes shall comply with the gray water recycling provisions contained in International Residential Code Section P3009.

PART 3 EXECUTION**3.1 EXAMINATION**

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

3.2 INSTALLATION

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

3.4 FIELD QUALITY CONTROL

- A. General: Comply with requirements of agencies having jurisdiction and as specified herein.
- B. System Inspection: System Designer/Installer shall inspect system installation and submit reports to the University. Notify resident 48 hours in advance of the date and time of inspection.
 - 1. Provide site inspection of system two weeks prior to occupancy.
 - 2. Provide site inspection of system immediately after storm event that may be severe enough to affect the system; provide inspection services for minimum 12 months after final completion.
 - 3. Provide site inspection of system seasonally, and not less than once every three months; provide inspection services for minimum 12 months after final completion.
- C. Water Quality tests: Comply with requirements of agencies having jurisdiction and as specified herein. Comply with ASTM D4840 for chain of custody of water samples.
 - 1. Provide data on the following immediately after plants are established and monthly thereafter for minimum 6 months:
 - a. Biochemical oxygen demand (BOD₅).
 - b. Total Suspended Solids (TSS).
 - c. Fecal coliform.
 - 2. Establish baseline water quality for rainwater harvesting systems for both influent and effluent.
 - 3. Provide comparison of test results with municipal water quality, and maintenance of system.

END OF SECTION

DIVISION 44
POLLUTION CONTROL
EQUIPMENT

SECTION 44 40 10 WATER REUSE SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes water reuse systems for:

1. In situ water reclamation

- a. rain water
- b. gray water
- c. black water

1.2 DEFINITIONS

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

1.3 SUBMITTALS

- A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this section:
 1. Water efficiency:
 - a. Indicate water reuse rates in gallons per day (gpd) per unit for the following:
 2. Municipal-supplied reclaimed water
 3. In situ water reclamation
 - a. Water Budget: Submit water budget statement. Indicate how approved water budget increases water efficiency over baseline; and, indicate how water reuse system(s) complies with approved water budget.

1.4 QUALITY ASSURANCE

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

1.5 MONITORING AND MAINTENANCE

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

PART 2 PRODUCTS

2.1 WATER REUSE SYSTEM

- A. General:
 - 1. Provide system design with easy access for effective monitoring program and for effective maintenance and process control program.
 - 2. Provide dual distribution systems to prevent cross-connections of reclaimed water and potable water lines and the misuse of reclaimed water.
 - a. Marking: Clearly mark distribution piping and use lavender (light purple) pipes to distinguish it from potable water. Provide piping certified and labeled “NSF-rw” in accordance with NSF Pipe Certification for Reclaimed Water End Use protocols.
 - 3. Provide backflow prevention devices on reclaimed water lines to preclude the likelihood of incidental human misuse.
- B. Municipal-supplied reclaimed water:
 - 1. Provide system design so that the pressure of reclaimed water 10 psi lower than potable water mains to prevent backflow and siphonage in case of accidental cross-connection.
 - 2. Run reclaimed water mains at least 12 inches lower in elevation than potable water mains and horizontally at least five feet away.

3. Review the quality of reclaimed water to ensure there will be no harmful effects, such as salt buildup, to piping or equipment from long-term use. Adjust design as necessary.

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

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

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

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

END OF SECTION

DIVISION 48
INDUSTRY-SPECIFIC
MANUFACTURING EQUIPMENT

SECTION 48 14 00

SOLAR ENERGY ELECTRICAL POWER GENERATION EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solar Energy System(s).

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Solar Energy Systems:

1. Photovoltaic Panels: Provide panels labeled with the PowerMark certification by PowerMark Corporation.

a. Weathering:

- i. ASTM E1038-Standard Test Method for Determining Resistance of Photovoltaic Modules to Hail by Impact with Propelled Ice Balls
- ii. ASTM E1171- Standard Test Method for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
- iii. ASTM E1597- Standard Test Method for Saltwater Pressure Immersion and Temperature Testing of Photovoltaic Modules for Marine Environments
- iv. ASTM E1802-Standard Test Methods for Wet Insulation Integrity Testing of Photovoltaic Modules
- v. ASTM E2047- Standard Test Method for Wet Insulation Integrity Testing of Photovoltaic Arrays
- vi. ASTM E1830- Standard Test Methods for Determining Mechanical Integrity of Photovoltaic Modules
- vii. ASTM E781- Standard Practice for Evaluating Absorptive Solar Receiver Materials When Exposed to Conditions Simulating Stagnation in Solar Collectors With Cover Plates
- viii. ASTM E782- Standard Practice for Exposure of Cover Materials for Solar Collectors to Natural Weathering Under Conditions Simulating Operational Mode
- ix. ASTM E823- Standard Practice for Nonoperational Exposure and Inspection of a Solar Collector

- x. ASTM E881- Standard Practice for Exposure of Solar Collector Cover Materials to Natural Weathering Under Conditions Simulating Stagnation Mode
 - b. Calibration:
 - i. ASTM E1362- Standard Test Method for Calibration of Non-Concentrator Photovoltaic Secondary Reference Cells
 - c. Energy Performance:
 - i. ASTM E948- Standard Test Method for Electrical Performance of Photovoltaic Cells Using Reference Cells Under Simulated Sunlight
 - ii. ASTM E1021- Standard Test Methods for Measuring Spectral Response of Photovoltaic Cells
 - iii. ASTM E1040- Standard Specification for Physical Characteristics of Nonconcentrator Terrestrial Photovoltaic Reference Cells
 - iv. ASTM E1462- Standard Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules
2. Solar Water Heating collectors: Submit OG 100 rating by Solar Rating and Certification Corporation for collector performance characteristics, and for rated systems submit OG 300 rating.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Photovoltaic Module with Built-In Microinverter

- 1. AC Unison PM250MA0
- 2. Power Output = 225W
- 3. Nominal Voltage = 240V
- 4. Nominal Frequency = 60 Hz
- 5. Nominal Output Current = 0.9375

PART 3 EXECUTION

3.1 SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:

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

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

END OF SECTION

APPENDIX B

Spec Sheets

APPENDIX C
STRUCTURAL CALCULATIONS