# SECTION 13 34 13 GREENHOUSE

PART 1 - GENERAL

* 1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

* 1. SUMMARY

1. Design, provide and install gutter-connected greenhouse, as shown on drawings and in accordance with these specifications. The work to be performed shall include all labor, materials, equipment and transportation for erecting the structure and components. The Greenhouse Contractor shall provide and mount or assemble the greenhouse including, but not limited to, the following:
   1. Entire greenhouse structure.
   2. Glass roof and wall glazing and associated hardware.
   3. Glass partition walls separating zones.
   4. Interior doors and all associated framing.
   5. Architectural panels as indicated on drawings.
   6. Complete automatic heat curtain systems, including motors and hardware.
   7. South wall vent window with rack and pinion drive system, including motors and hardware.
   8. Evaporative cooling fog system.
   9. Complete automated environmental control system for four (4) greenhouse climate zones.
   10. Greenhouse HID supplemental lighting fixtures and controls.
   11. Horizontal Air Flow (HAF) fans.
   12. Overhead and below bench hydronic heating systems.
   13. Complete irrigation system.
   14. Continuous insect screening for all vents.
   15. Greenhouse benches.
2. Supply flashing to connect pre-engineered greenhouse systems to other new construction, including all materials required to accommodate differential movement.
3. It is not the intent of this portion of the specifications to cover concrete, grouting, masonry work, plumbing (other than the components of the irrigation system), electrical work (power and control wiring), utility connections, final cleaning of glazing, nor counter-flashing. This portion shall be the responsibility of the General Contractor or his selected Subcontractors other than the Greenhouse Manufacturer.
4. No masonry or foundation installation supporting the greenhouse structure shall be made prior to approval of greenhouse drawings. Approved greenhouse drawings shall be used to make all masonry and foundation installations. Dimensions may vary slightly from contract drawings to accommodate manufacturer's standard, but total area shall not be less than 98% of that shown.
5. These specifications are intended to supplement the drawings. Any items required by the specifications which are not shown on drawings shall be supplied and installed by the Greenhouse Contractor.
   1. RELATED SECTIONS
      1. Division 03 – Concrete
      2. Division 04 - Masonry
      3. Division 05 – Metals
      4. Division 7 – Thermal and Moisture Protection
      5. Division 21 – Fire Suppression
      6. Division 22 – Plumbing
      7. Division 23 – Heating, Ventilating and Air Conditioning
      8. Division 26 - Electrical
   2. SUBMITTALS
      1. Greenhouse Contractor shall submit six (4) complete sets of approval drawings.
      2. Approval submittals shall include engineered stamped drawings and a full set of engineering calculations, signed and sealed by a structural engineer licensed to practice in the State of -------------.
      3. Submit engineering drawings of the greenhouse structure and footings, including drawings showing alloys and properties of all structural members used in greenhouse frame. Show type, size, material, finish, design values, location of all connectors and bearing and anchorage details.
      4. Submit design analysis and test reports indicating loading, section modulus, assumed allowable stress, stress calculations and any other information required for analysis and to ensure that the building complies with requirements. Greenhouse design shall conform to current NGMA design guidelines, and all applicable codes.
      5. Submit fabricator's technical data covering metal components, hardware, fabrication process, handling and erection.
      6. Submit a full warranty as specified herein.
      7. Provide submittals for all equipment.
      8. Approval drawings shall detail the following:
         1. Floor/Post Plan.
         2. Post feet details.
         3. Detail section of typical framing members.
         4. Roof framing plan.
         5. Roof Glazing plan, including details of all hardware required for glazing.
         6. Sidewall elevations.
         7. Endwall elevations.
         8. Partition elevations.
         9. Trusses and other roof framing.
         10. Foundation Outline and Greenhouse Structural Loads.
         11. Typical sidewall section.
         12. Roof to Gable section.
         13. Closure Details (Greenhouse to adjacent structures).
         14. Door and door hardware.
         15. Equipment plan and section, showing placement of components.
         16. Heating plans and details, showing placement of all piping, pumps, mixing valves, fittings and other accessories.
         17. HID lighting plan including light rack plan and all details, and a plan of the light distribution in μmol • m-2 • sec-2. Show the light uniformity in each zone and indicate the basis for the calculation of uniformity.
         18. Ridge vent & Sidewall vent section and installation details, including drive mechanism and rack and pinions.
         19. Fog system plan and details, including all components.
         20. Shade curtain plan and details.
         21. Benching details and irrigation plan.
      9. Environmental Controls supplier shall submit for approval complete details of the environmental controls system, including the following:
         1. Location and sizes of all components.
         2. Schematic plan of the control system network.
         3. Details of all control panels.
         4. Details of relay control panels.
         5. A complete list of control points.
         6. A sequence of operation consistent with these specifications.
   3. DESIGN CRITERIA
6. Design greenhouse structure to withstand the following loads:
   1. Dead Load – structure and equipment
   2. Wind:
      1. Basic wind speed:115 mph
      2. Exposure B
      3. Importance Factor: 1.15 (Occupancy III)
   3. Snow
      1. Ground snow load: Pg = 20 psf
      2. Importance Factor: 1.10 (Occupancy III)
   4. Roof Live loads: 15 psf
   5. Roof Bars shall be designed to carry a 100 lb. concentrated load at the center of the span.
   6. Seismic requirements Seismic Category B
7. Structural design shall consider all load combinations dictated by ASCE-07 and applicable codes.
8. Maximum allowable deflection shall be L/120 of the span.
9. Comply with the following codes and standards:
   1. State & code required ----------- Administrative Code.
   2. ASTM B-308 - Standard Specification for Aluminum-Alloy 6061-TS Standard Structural Shapes.
   3. ASCE 7-10 – Minimum Design Loads for Buildings and other Structures.
   4. NGMA Standards for Design Loads in Greenhouse Structures, Ventilating and Cooling Greenhouses and Greenhouse Heat Loss Standards.
   5. Aluminum Association Design Manual – Specification for Aluminum Structures.
   6. QUALITY ASSURANCE
      1. The entire greenhouse structure shall be the product of a single manufacturer. The greenhouse shall be manufactured by a firm with a record of successfully fabricating greenhouses similar to the type indicated which have performed satisfactorily for a period of no less than five (5) years.
      2. Greenhouse Installer shall be a company regularly engaged in installation of pre- engineered greenhouses and with at least five (5) years’ experience building greenhouses of the type specified. Installer shall be approved or licensed by manufacturer of greenhouse systems.
      3. Environmental controls supplier shall have as a principal activity the supply of specialized greenhouse computer control systems. The supplier's software should be proven in existing greenhouses for all the mechanical systems specified.
      4. Upgrades and modifications of the environmental control software shall be supplied for a period of 1 year from the date of installation.
      5. All environmental control hardware and software components shall be warranted for a period of one year from the date of final acceptance of work.
      6. Environmental controls supplier/manufacturer shall offer toll-free telephone support for the system, including applications support for a period of one year.
   7. STORAGE AND HANDLING
      1. Handle and store all greenhouse materials with care, in accordance with manufacturer's instructions. Time delivery and erection of materials to avoid extended on-site storage. Store materials on skids or platforms; do not store directly on ground.

PART 2 - PRODUCTS

* 1. MATERIALS
     1. The structure shall be designed and detailed according to good engineering practice by a structural engineer licensed in the State of -----------. All aluminum framing shall be 6005 or 6061-T6 and 6063-T6 alloys. Aluminum shall be mill finish with appropriate heat treatment. All aluminum flashing shall be 5005-H14 alloy.
     2. Sidewall columns shall be attached to top of kneewall with epoxy set plated anchor bolts, Grade A36 or A307, or Stainless Steel All-Thread Rods, ASTM A304. Drilling for anchors and setting of plated anchor bolts to be by the Greenhouse Contractor. Columns shall be properly punched or drilled to receive fitting for attaching sills, purlins, gutters, rafters and other components as applicable.
     3. Provide a system of integral gutters in roof framing and glazing bars designed to collect condensation and weep moisture to the exterior. Under gutter drip channels shall collect condensation on gutters.
     4. Provide extruded aluminum glazing bars, spaced 30 3/4 inches on centers and sized to provide sufficient strength for design loads specified. Typical glass length will be from roof purlin to roof purlin. Provide shoulders to receive roof glass and grooves to conduct condensation to suitable disposal points. Roof bars shall extend in one piece from eave to ridge and be supported by purlins. Raise glazing bars a minimum of ¼ inch above the top of the purlin using aluminum straps or clips to allow condensation to pass to suitable collection points.
     5. Provide aluminum sills at kneewalls, vents and wherever required. Sills shall be capable of receiving side vents or fixed glazing.
     6. Provide and install an extruded aluminum ridge at the peak of the structure.
     7. Provide all other structural components; such as bracing, clips, and fasteners not mentioned above but required to complete the framework of the greenhouse.
  2. GREENHOUSE STRUCTURE
     1. Greenhouse structure shall be a metal frame gutter connected house. Structures shall conform to all conditions of these specifications, and overall dimensions and configuration shall conform to those shown on Drawings. The greenhouse elevation shown on drawings is illustrative in nature – the greenhouse roof and other structural components shall be manufacturer’s standard styles and profiles.
     2. Greenhouse columns shall be spaced and sized to provide a single span across the width of the greenhouse. Trusses between columns shall be adequate to support design dead, wind and snow loads as well as live loads indicated. Columns shall be a minimum of

8 feet apart along the length of the greenhouse. Factory punch or drill columns to attach required members.

* + 1. Connections shall be made with galvanized steel bolts. Bolts ¼ inch to ½ inch diameter shall be A307. Larger bolts shall be Grade 5.
    2. Aluminum plates used for connections shall be pre-punched. Prefabricate all purlins for attachment of glazing bars and connecting lugs.
    3. Self Tapping Screws: AISI C 1018SS
    4. Self Drill Screws: AISI C 1022
  1. EXPANSION CONTROL
     1. Suitable expansion joints shall be provided in all longitudinal members to take care of the longitudinal expansion in framing members. No longitudinal members shall exceed 21’-0”. All members shall be so joined as to require each joint to handle the expansion in the individual member and to prevent an accumulation of expansion in several members in one direction.
  2. KNEEWALL SILL FLASHING
     1. Aluminum sill flashing shall be placed on the outside of the perimeter kneewall. Sill flashing shall be placed under the glazing sill and to the outside of the greenhouse column. Aluminum sill flashing shall extend no less than 2 inch down the vertical face of the kneewall. All sill corner flashing shall be shop welded. All sill flashing to be laid end to end with a 4 inch long splice cap matching the profile of the flashing. Set splice cap in sealant and hold in place with pop-rivets.
  3. GUTTERS
     1. Connections for gutter downspouts shall be provided where indicated on drawing. Final connection and downspout materials are covered in other sections of these specifications.
  4. INSULATED PANELS
     1. Insulated panels for partition walls shall be metal faced modular tongue and groove metal faced panels, minimum of 2 inch thick, EPS Energy-Lok Insulated Panels by Energy Panel Structures, Inc. or approved equal.
     2. Panels must be labeled by a code approved testing agency.
     3. Panel facing shall be prepainted aluminum, minimum 0.032 inch thick.
  5. RIDGE & SIDE VENT
     1. Automatic sidewall vents to be 36 inches high with a continuous socket hinge arranged to open out. Vents for each compartment shall be continuous from one end to the other. Vent shall be made up of a top rail, bottom rail and mullions of extruded aluminum. Bolt vent assembly together in accordance with the manufacturer’s instructions.
     2. Design vents with weather tight hinges and weather tight fit between sash and vent headers.
     3. All vents shall have provisions at the hinge point to prevent creeping of the vents.
  6. VENT OPERATORS
     1. All vents shall be operated with aluminum rack arms with zinc pinions.
     2. Provide minimum 14 gauge 1.315-inch diameter galvanized drive shaft.
     3. Provide rack and pinion arms with aluminum rack, zinc pinion gear and extruded aluminum housing assembly to keep rack and pinions in proper mesh and alignment. Racks attach to bottom rail of vents with aluminum clips and stainless steel cotter pins. No fewer than two sets of rack and pinion arms shall be provided for each bay per run of vents.
     4. Provide vent motors to operate motorized wall vents, with integral line voltage limit switches, Lock EWA series or approved equal.
  7. VENT SCREENS
     1. Screens shall be provided at all vent openings. Screen rails shall be 5/16 inch by 7/8 mill finish extruded aluminum with a groove to receive a vinyl insert to hold 16 by 18 aluminum mesh in place.
     2. Screen frames shall be assembled with die cast aluminum corners and designed to allow for re-screening of units in the field.
     3. Brush seals shall be provided at ends of screen frames where vent operator arms penetrate.
  8. GLAZING
     1. All glass shall be B or Greenhouse quality, 1/8-inch double strength, clear annealed glass.
        1. Interior and exterior wall glazing: All standard rectangle sized glass to be 1/8-inch clear tempered glass. All odd sized or sloped cut glass to be 1/8-inch double strength, clear annealed glass.
        2. All roof glazing to be laminated glass consisting of (2) 1/8-inch clear annealed glass pieces with .030-inch PVB inner layer. Nominal thickness to be ¼ inch.
     2. All glass shall be laid with 3/8-inch lapped joints and held in place with aluminum bar caps to cover the glazing, and prevent the glass from slipping.
     3. Aluminum extruded bar caps shall be applied to the bar covering the entire length of each lite of glass and made to conform to the laps in the glass and provide a uniform 3/8-inch lap. These caps shall be fabricated from extruded aluminum, so fabricated to exert a uniform, but not excessive pressure, along the entire length of the glass lite. Each cap shall be held with a minimum of two ½-inch by #10 stainless steel hex head self-tapping screws. Screws which hold bar caps shall be spaced not over 15 inches apart, nor shall any screw be placed closer than 1-1/2 inches from the end of the caps.
     4. At each truss top chord and end rafters, scaffold screws, 1-inch by #12 round head stainless steel screws shall be used to hold the caps in place, yet provide sufficient shank protruding above the caps for support of scaffolding.
  9. GLAZING SEALS
     1. Lay Butyl rope in the corners of the glazing bar shoulders before placing the glass.
     2. After placing the glass apply a bead of clear silicone top seal to the side edges of the roof glass only. Top seal is not required on vertical lapped glass.
  10. FASTENERS
      1. Non-load bearing screws and bolts shall be 18-8 stainless steel or 2024-T4 aluminum. All structure fasteners shall be A325 high strength, hot-dipped galvanized bolts.
  11. DOORS
      1. Provide doors as indicated on drawings.
      2. Doors shall be 1 ¾-inch by 3'0" by 6'-8” anodized with 5-inch extruded tube rails and

4-inch extruded aluminum tube frame with wool pile seals. Hardware shall include (1 ½

pr.) Hager or approved equal 4 ½-inch by 4 ½-inch stainless steel hinges with non- removable pins, lever handles, aluminum threshold and door sweep. Door shall be glazed with ¼-inch clear safety glazing and bottom panel shall be an aluminum faced panel. Equip doors with door closers as specified in Division 08 of these specifications.

* + 1. All rails and frame shall have a .125 inch minimum wall thickness.
  1. METAL BENCHES
     1. Provide stationary galvanized steel benches of the size and quantity shown on the Drawings. Bench supports shall be spaced at 6'-0" intervals maximum unless otherwise indicated on Drawings. Bench tops shall be single piece expanded metal. Provide leg bases that can be anchored to the floor.
     2. Side and end rails shall be extruded aluminum, 2 3/4 inches tall. Install safety plastic corner connectors at end rails on all bench top corners.
     3. Inset legs and top support rails a minimum of 3 inches on each side and 6 inches on the ends to facilitate movement in the aisles. Provide metal tubing to support bench tops above the support system. Provide metal bracing as required to stabilize the bench system.
  2. EVAPORATIVE COOLING SYSTEM
     1. Evaporative cooling system shall be the product of a single supplier and shall include all components for a complete, operational installation.
     2. The evaporative cooling system shall consist of a high pressure fog system including pump(s), filters, controls, gauges, all necessary piping and valves, fog nozzles, solenoid valves, and any other equipment and components required for a complete installation, including any necessary water treatment equipment. The fog system shall generate 10 micron average droplets. Motors shall be installed with variable frequency drive (VFD) controls to provide soft-start, optimum operating speed and to minimize noise.
     3. Fog nozzles shall be 316 stainless steel, equipped with easily removed 5-micron polypropylene or Knar filter. Nozzles to be unconditionally guaranteed for a minimum 10 years against orifice wear.
     4. Nozzle manifolds and main piping shall be stainless steel tube (ASTM A269) capable of withstanding pressures up to 3,000 psi.
     5. Solenoid valves shall be designed to operate at pressures up to 3,000 psi, with anti-drip and unloading functions, Danfoss VDHT 15EC or approved equal.
     6. Provide insulation on all lines where condensation could form. Fog system control panel shall include:
        1. Provisions for manual and automatic operation
        2. Hour meter
        3. Pump dry-run shut off for low water pressure or inadequate water supply.
        4. Provisions to automatically shut off the motor in the event of motor overloads, phase-loss, low voltage or short circuit.
        5. Motor thermal protection.
        6. 24 VAC interface for external controls.
        7. Emergency stop.
     7. The high pressure fog system shall be designed as an evaporative cooling system to maintain 85o F air temperature at no more than 85% relative humidity within the greenhouse, based on an outside temperature of 92oF and relative humidity of 45%.
     8. The evaporative cooling system shall include all valves and other necessary controls to provide independent operation in each of the four zones of the greenhouse.
     9. High pressure fog equipment shall be installed in strict accordance with manufacturer’s instructions.
     10. High pressure fog system shall be as manufactured and supplied by ColdFog or approved equal.
  3. UNDER BENCH HEATING SYSTEM
     1. The overhead heating equipment shall comprise a complete system including all necessary fittings and components, including but not limited to valves, check valves, motorized actuators, pumps and air-bleed valves.
     2. Under bench piping shall be TrueLeaf DuoFin aluminum tubing or approved equal. Piping shall be capable of providing at least 90 Btu/hr-ft. with a water temperature of 140oF and a greenhouse temperature of 65oF.
     3. The heat distribution piping shall not include the use of chokes or other restrictions to balance flow.
     4. Provide air bleeds at all high spots in the overhead heating system and as required to ensure the elimination of air from the piping.
     5. Temperature drop in under bench pipe loop shall not exceed 20oF, based on entering water temperature of 140oF and greenhouse air temperature of 65oF.
     6. Water temperature shall be capable of modulation by ways of three-way valves, Belimo LF24 Actuators or approved equal.
     7. Circulator pumps shall be in-line, single stage, capable of operating continuously at temperatures from 30oF to 230oF, by Taco, Grundfos or approved equal.
     8. Under bench heating system design may differ from system shown on drawings provided the system meets these specifications and provides uniform temperatures below the benches, subject to approval of detailed heating system drawings.
  4. UNIT HEATERS
     1. Provide and install unit heaters as shown on drawings (Modine or approved equal).
  5. GREENHOUSE LIGHTING
     1. Greenhouse lighting fixtures shall be designed and supplied by a manufacturer engaged in the manufacture of high pressure sodium fixtures designed specifically for greenhouse use. Assembly and parts shall be U.L. or CSA approved. Ballast shall be 60 Hz, designed to withstand greenhouse environmental conditions. The lighting manufacturer shall have a minimum of 8 years experience in the manufacture of lighting fixtures for greenhouses.
     2. Lighting fixtures shall be by P.L. Light Systems, Inc., Kavita Canada, Inc., or approved equal.
  6. HORIZONTAL AIR FLOW FANS
     1. Horizontal air flow (HAF) fans shall have totally enclosed motors, minimum of 1,250 CFM capacity in free air, Schaffer VK12 or approved equal.
  7. RETRACTABLE SHADE/HEAT RETENTION CURTAIN SYSTEMS
     1. Provide independently operated curtain systems in each compartment, one horizontal and one vertical, at locations shown on drawings.
     2. Curtain systems shall be sealed to minimize air transmission at edges using fixed fabric skirts. Fixed fabric panels shall be wrapped and stapled around 1x7 coated cable. Upper wrapped wire of sidewall seals to be capped with a smooth plastic wire guard to reduce wear between the shade/heat retention curtain and the seal. Wire guard shall travel the length of the greenhouse.
     3. All curtains are to be precut with ends serged to prevent material from unraveling.
     4. Support curtains with clear, low friction polyester lines spaced 16 inches O.C.
     5. Prevent billowing with clear polyester lines on 32-inch centers.
     6. Shade/Heat retention fabric to be Ludvig Svensson Tempa 5555 FR or approved equal.
     7. Curtain Drive motors to be U.L. or CSA approved, with integral primary and backup limit switches for each travel direction, Lock EWA series or approved equal.
     8. Drive cable to be 3/32-inch diameter 7 x 19 stainless steel, continuous length with no splices.
     9. All rotating components such as brackets and pulleys shall have pre-greased double sealed ball bearings.
     10. All hardware shall be galvanized or plated to protect against corrosion.
  8. LOW PRESSURE BENCH MOUNT IRRIGATION SYSTEM
     1. The main line water supply system should maintain no greater than 50psi. If the existing system does maintain a higher pressure than 50psi supply and install a regulator (by others).
     2. Install a riser system to provide full coverage on benches, complete with connectors, hangers, riser stands, polypipe and punch tool.
     3. Each bench will be equipped with two ¾-inch single union ball valves. Greenhouse Contractor manufacturer will supply and install in each compartment a 1-inch cartridge filter 100 micron with 150 screen mesh that is rated for 25gpm.
     4. Solenoid valves shall be fast acting, Globe type Body, cover to be nylon reinforced construction rated for 10-150 psi operating pressure (ANSI: Class 125) and stainless steel valve plunger and seats.
     5. Nozzles will be alternating low pressure ADV at 3’ on center
     6. The water source and distribution piping to the solenoid valve for each compartment is by others.
  9. ENVIRONMENTAL CONTROLS
     1. The automated control system shall be the integrated product of a single manufacturer.
     2. The control system supplier shall provide all necessary equipment for a complete installation, including but not limited to all required sensors and signal conditioning equipment, relays, relay control panels, transformers and control software. Provide and mount a pre-wired NEMA contactor cabinet for control of all items noted in these specifications. The contactor panel shall control relays and/or magnetic contactors for control of the equipment. Control and power (line voltage and low voltage) wiring and conduit by electrical contractor.
     3. Electrical contractor to mount provided greenhouse environmental control panels at locations shown on drawings. Greenhouse Contractor to provide and installed 1/8-inch mill finished aluminum panel for any panels mounted to the greenhouse structure. Aluminum mounting panels to be fastened directly to structural posts. Control panel mounting location to be coordinated with greenhouse manufacturer.
     4. The control system shall be capable of remote operation and monitoring via a broadband connection.
     5. The environmental control system will include the capability of alerting supervisory personnel of alarm conditions via a phone connection and by text messaging and electronic mail via a broadband connection.
     6. The control system supplier will assume responsibility for ensure a complete and functional installation in accordance with these specifications and other construction documents.
     7. Automated environmental system will consist of Titan Controllers, Input/Output modules and contactor panels as manufactured and supplied by Argus Controls or approved equal. Manufacturer’s personnel will supervise the installation and provide 8 hours of training.
     8. Environmental control system shall include complete control components for the following equipment and systems in each of the four zones:
        1. Modulating valve for overhead heating (Tri-State Floating).
        2. Circulating pump for overhead heating (On/Off).
        3. Reversing motor for thermal curtains (Tri-State Floating).
        4. Reversing motor for vent windows (Tri-State Floating).
        5. One control for Variable Frequency Drive controller for exhaust fan
        6. Two solenoids for fog cooling (On/Off).
        7. HAF fans (one circuit) (On/Off).
        8. Two solenoids for misting/watering (On/Off)
        9. Two lighting circuits (On/Off)
     9. The control system shall provide one (1) On/Off output for a single exhaust fan to remove air from above the shade curtains in all zones.
     10. The control system shall include the capacity for installation of a minimum of four additional On/Off digital outputs in each zone.
     11. The environmental control system shall be configured to monitor the following conditions in each of the four zones:
         1. Temperature at top of crop canopy
         2. Temperature above shade curtains
         3. Relative humidity
         4. PAR
     12. The control system shall include the capacity to add a minimum of three additional sensors in each zone without the installation of additional input boards or control panels.
     13. The environmental control system shall include sensors and equipment to monitor the following within the greenhouse:
         1. Hot water main supply temperature
         2. Hot water main return temperature
         3. Outside temperature
         4. Outside relative humidity
         5. Outside PAR
         6. Outside solar radiation
         7. Wind velocity
         8. A minimum of 4 additional environmental conditions without installing additional input boards or control panels.
     14. Sensor wiring is by the electrical contractor.
     15. The environmental control system shall be installed with complete controls for two fog pumps.
     16. The environmental control contractor shall supply and install relay control panels as required to provide a complete installation of all output devices listed in this section. All relays within the panel shall have 24VAC coils.
     17. The environmental control system shall be capable of communication with the Building Automation System specified in Division 23 of these Specifications and should be installed with all software and hardware necessary to provide environmental conditions and equipment status to the Building Automation System in real time.
     18. Sequence of operation:
         1. Daytime cooling: Provide proportional venting to attain the desired setpoint by opening the intake vent and activating the exhaust fan at the corresponding speed after a five second delay. The intake vent shall be opened to maintain a 750 fpm air velocity.
         2. Evaporative Cooling: Activate fog nozzles at the vent window when the exhaust fan is operating at full speed and the intake window is fully open and the greenhouse air temperature is above the setpoint. Activate fog nozzles within the greenhouse if the vent window nozzles have been operating for 10 minutes and the air temperature remains above the setpoint.
         3. Nighttime cooling: Provide proportional venting to maintain higher of the desired setpoint or a temperature 3oF above the outside temperature\
         4. Provide one hour ramp between daytime and nighttime settings.
         5. Bench heating: Temperature of water in under bench piping shall not exceed 120oF.
         6. Overhead heating: Control unit heaters to achieve daytime and nighttime setpoints. Provide one hour ramp an hour before sunrise and an hour before sunset.
         7. Close shade curtains 15 minutes before sunset.
         8. Open shade curtains 5% 15 minutes after sunrise, wait 15 minutes, then open curtains 100%.
         9. Close curtains whenever the temperature is 3oF above the cooling setpoint and all stages of cooling are active and the outside light level is above 600 μE. Curtains

shall remain closed for a minimum of 60 minutes.

* + - 1. HAF Fans: Operate HAF Fans in the daytime when shade curtains are open.
      2. Supplemental lighting: Turn lights on at 11:00pm and off at 5:00am.
      3. Activate attic exhaust fan when the temperature above the shade curtain in any of the four zones exceeds 90oF.

PART 3 - EXECUTION

* 1. PREPARATION
     1. Examine areas and conditions under which greenhouse work is to be installed. Notify Contractor in writing of conditions detrimental to proper and timely installation of work.
     2. Coordinate and furnish anchorages, setting diagrams, templates and directions for installation of anchorages. Coordinated delivery of such items to project site.
  2. GREENHOUSE ERECTION
     1. Comply with manufacturers’ instructions, except where more stringent requirements are shown or specified, and except where project conditions require extra precautions or provisions to ensure satisfactory performance of the work.
     2. Drilling and setting of anchor bolts is to be by Greenhouse Manufacturer.
     3. Greenhouse Contractor is responsible for all unloading of greenhouse materials, systems, equipment and to provide any lift or installation equipment required.
  3. ENCLOSURE INSTALLATION
     1. Install equipment in accordance with Manufacturer’s installation instructions and recognized industry practices to insure intended function.
     2. Secondary Structure: Install framing and glazing system for roof, exterior walls and interior partitions taking care to align members correctly for proper engagement of attachment system. Anchor framing securely in place with provisions for thermal and structural movement. The entire structure shall be constructed to prevent water incursion and air infiltration consistent with typical greenhouse standards.
     3. Install gaskets, sealants, closures, and trim as the work progresses to minimize water and air infiltration into the completed installation.
     4. Provide supplemental framing for door openings. Anchor door frames securely and install flashing, trim, sealants, and the like to minimize air and water infiltration.
  4. GLAZING PANELS
     1. Handle and install panels in strict accordance with the manufacturer's instructions and recommendations.
     2. Replace any damaged panels.
     3. Install glazing panel system so it is watertight and to allow for thermal movement considerations.
  5. GREENHOUSE EQUIPMENT
     1. Install mechanical, electrical and other equipment specified in this section in strict accordance with manufacturer's recommendations.
  6. ENVIRONMENTAL CONTROL SYSTEM
     1. The environmental controls supplier shall provide all control panels, sensors and communication and sensor wire.
     2. The electrical contractor shall be responsible for installing the control panels, communication and sensor wires and wiring all sensors to the control panels.
     3. The greenhouse contractor of the environmental controls contractor shall be responsible for the final connections for the controls and sensor wiring in the control panels.
     4. The electrical contractor shall furnish and install all associated conduits, power wiring , control wiring from the contactor panel to the control panels (where required).
     5. The electrical contractor shall furnish and install all conduits and wiring required to connect all equipment (both line voltage and low voltage) to the load terminations in contactor panels. as well as limit switch wiring for vent and curtain motors.
  7. ADJUSTING
     1. Final Adjustments: Upon achieving substantial completion of the work, adjust all operable components to ensure that they are properly installed and functioning smoothly. Replace any component which cannot be adjusted for proper operation.
  8. DISSIMILAR MATERIALS
     1. Separate aluminum from cementitious material with polyurethane or asphaltic coating.
  9. GROUTING
     1. After the Greenhouse Manufacturer has placed the wall sills, the Masonry Contractor shall provide the necessary materials and labor to grout between the wall and the sill to eliminate any discrepancies between the two and produce a finished joint, if required.
  10. FLASHING
      1. All counter-flashing shall be furnished and placed by the sheet metal contractor. Drawings establishing flashing line shall be furnished by the Greenhouse Contractor. All flashing and counter-flashing shall be minimum 1/16-inch aluminum.
  11. INSTRUCTION
      1. In addition to a minimum of (2) two site visits by Greenhouse Manufacturer project management, Greenhouse Manufacturer personnel in combination with greenhouse environmental controls personnel shall instruct owner, on site, on the use and operation of the greenhouse, including greenhouse systems and equipment.
      2. Greenhouse Contractor shall supply the project with complete sets of Operation & Maintenance manuals both in three ring binders (4) and in CD format. Maintenance manuals shall include all equipment data and product literature including all periodic maintenance requirements.
  12. WARRANTY
      1. Greenhouse Manufacturer shall provide a one (1) year warranty on materials and workmanship from date of substantial completion. Any greenhouse warranty item within the warranty period shall be directed to and be the direct responsibility of the Greenhouse Manufacturer, including that of its material suppliers, vendors and subcontractors.
      2. Written warranty conforming to the above paragraph to be submitted as a part of the approval drawing submittal package.
      3. All supplied coverings and equipment will carry their manufacturer’s respective warranties.
  13. COORDINATION
      1. All equipment, piping, conduit, and other devices and fittings shall be installed without interfering with any other greenhouse equipment or systems. Specifically, no installed materials shall obstruct doorways, vent windows, exhaust fan openings, thermal curtains or other greenhouse systems.
      2. Equipment and other components of greenhouse shall be located and installed in a way that minimizes shading of the greenhouse interior.
      3. High pressure fog nozzles shall be located and oriented so as to minimize the accumulation of spray drift on greenhouse components, equipment, fixtures and plants.
  14. CLEANING
      1. During progress of the work, remove from project site all discarded materials, rubbish, and debris resulting from the work.
      2. Upon completion, clean all surfaces which have become soiled or coated as a result of work of this section, using proper methods which will not scratch or otherwise damage finished surfaces. Use only products and techniques acceptable to manufacturer of products being cleaned.
      3. Final cleaning of glazing shall be the responsibility of the General Contractors, or selected Subcontractors other than the Greenhouse Contractor.
  15. PROTECTION

A. Institute protective procedures and install protective materials as required to ensure that work of this section will be without damage or deterioration at substantial completion.

# END OF SECTION 13 34 13