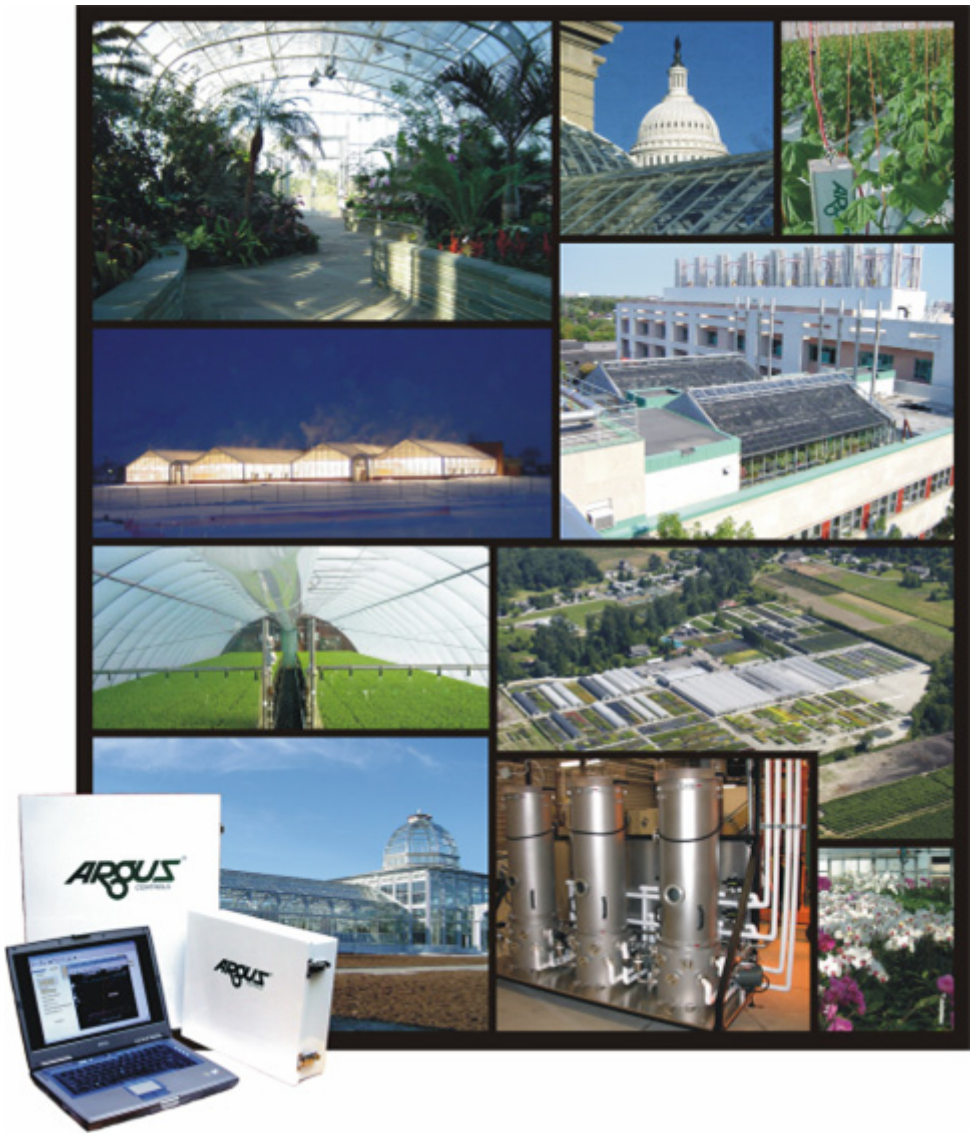
ARGUS CONTROLS

A CONVIRON COMPANY

Greenhouse Control Specifications

Guide



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Greenhouse Control Specifications

Argus Control Systems Ltd.

Telephone: (604) 538-3531 or (604) 536-9100
Toll Free Sales: (800) 667-2090 (North America)
Toll Free Service: (888) 667-2091 (North America)
Fax: (604) 538-4728
E-mail: argus@arguscontrols.com
Web Site: www.arguscontrols.com

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Developing a Greenhouse Control Specification

Argus Control Systems Ltd. recognizes the need to develop comprehensive greenhouse controls specifications and the positive benefits for all concerned when these specifications are complete, accurate, and clear.

The following information has been developed as a guide for developing greenhouse control specifications. It is not intended to be a complete specification nor is it intended to focus exclusively on Argus products. Rather, it is intended to reflect the current capabilities of state-of-the-art greenhouse control systems and the expectations of end users.

General Information

Greenhouse controls typically feature specialized programs for the maintenance and management of horticultural crops. They are optimized for the control of highly dynamic horticultural environments and specialized equipment control strategies employed to enhance plant growth processes.

This may include:

- Assimilation and photoperiodic lighting;
- Complex irrigation and nutrient control;
- Mist, fog, or pad & fan evaporative cooling;
- Precision humidity management;
- Shade and thermal curtain systems;
- CO2 supplementation;
- Diurnal or multi day climate settings;
- Heat storage;
- Tank management;
- A range of other crop specific control requirements.

In most situations, it is the growers or greenhouse managers rather than the building maintenance personnel who are operating these control systems. Therefore, we strongly recommend that the end-user(s) of the horticultural facility be consulted when developing control specifications and the control points list.

Wherever possible, and particularly where technical specifications may be lacking, it is important to specify the ***performance specifications*** that are required for each climate and equipment system.

Developing a Greenhouse Control Specification

There are a number of similarities between computerized greenhouse control systems and building control systems, and occasionally some confusion arises as to the suitability of each system for various applications. While conventional building controls and greenhouse controls are both very good at what they are designed to do, they are seldom interchangeable, due to the significant differences in the types of structures and equipment controlled, and the fundamentally different objectives of each application.

The most important distinction between conventional building controls and greenhouse control systems is that building controls are primarily designed to manage air temperatures and ventilation rates for human habitation, while **integrated** greenhouse control systems are designed as production tools for facilitating horticultural **growth processes**.

The capabilities of greenhouse control systems extend far beyond air temperature management and ventilation, to the **direct process control of biological growth parameters**. The control emphasis therefore, is to manipulate the environment from the point of view of the crop.

The requirements are usually very specific and highly variable from crop to crop. This includes precision management of humidity, air and root zone temperatures, irrigation, nutrients, and specific programming for the safe, integrated, and efficient operation of specialized equipment such as reversing motors, modulating roof and side-wall vents, HID Lighting, CO2 systems, fog/mist propagation, pad & fan cooling, etc.

Definitions

Control Groups

Most horticultural control problems can be broken down into control groups that, for the most part, mirrors the physical design and layout of the operation. Control groups are usually comprised of **related equipment, sensors, and other components that work together to produce a common result.**

Some examples of control groups include:

- A **greenhouse climate** is produced within a compartment when it is physically isolated from other compartments and it has it's own control equipment that is operated independently of any other climate.
- An **irrigation system** starting at the water source, passing through distribution piping to individual zone control valves, and into the final water application equipment.
- A **nutrient system** that includes all sensors and equipment to add and mix water, fertilizer salts, and pH buffering agents to produce feed solutions.
- A **central heating plant** that might include all boilers, piping, and headers, pumps and control valves, water expansion tanks, heat storage tanks, transport loops, and other equipment that together are used to produce hot water for heating purposes.

In each of the above examples, the control group is essentially self-contained; it does not depend on outside control, nor does outside control interfere with it.

Output Control Points

A control point is **any piece of equipment or grouping of equipment that is operated as a single entity**. There are several ways that equipment can be operated:

- **Digital (on/off)** – this type of control method is used for equipment that has only two states – **ON** or **OFF**. An example of this would be a light switch or a single speed fan.
- **Tri-State Floating (Open/Close/Stop)** – this type of equipment control is commonly used for equipment such as reversing vent motors and mixing valves. Two signals are required – one to 'open' and one to 'close'. The equipment is in a stopped state when it is neither opening nor closing. Using movement timing or position sensors, the greenhouse control system calculates the position of a device as it operates. This type of equipment control is generally less expensive and more reliable than analog controls for modulating equipment.

Proportional (analog) – this type of equipment can be operated somewhere between fully ON (Opened) and fully OFF (Closed) based on the strength of the signal it receives. An example of this would be a 4-20 mA control for motor speeds or air intake louver positioning. This type of equipment is normally used with VFD (variable speed) electric motors, and it tends to be much more expensive than tri-state floating.

Sequence of Operations

Most control systems designed for horticultural facilities are supplied with sophisticated sequence of operation strategies specifically designed for the safe efficient operation of greenhouse equipment. These strategies have been developed through years of experience with the standard types of equipment and building designs that are commonly used in horticultural enclosures.

This part of the specification typically addresses the order in which related equipment or equipment groupings must work together to achieve a common control objective, usually over time or

in response to changing external conditions. One way to look at this is to determine the strategy that the greenhouse operator would use to operate the equipment if they were controlling it manually (for example, if they were standing in front of a control panel of switches and displays, reacting to changing conditions in the greenhouse). This provides a good idea of what the end user expects from a control system.

For example (how evaporative cooling pads & fans are operated):

1) Upon a rise in compartment temperature above the operator-defined cooling set point the inlet louvers open and exhaust fans #2 and #4 turns on.
2) Upon a further rise in compartment temperature, fans #1, 3 & 5 are also turned on.
3) Upon a further rise in compartment temperature, the pad pumps are turned on (with all 5 fans running).
4) Whenever one or more of these cooling levels have been employed, and the compartment temperature has subsequently started to decline, they are deactivated in reverse order that they occurred.

The physical sequence of operation that each piece of equipment has been designed for is also important. One way to provide this is to list as sequence of operation for each specific condition (or emergency condition) that the equipment is exposed to. This list should also included how the equipment should react why it should react this way when it should stop reacting what happens if the system fails to react to this condition.

For example (how the shade curtain operates during snowfall events):

1) If the shade curtain were to remain closed during a snowfall event, there is a risk of structural damage since there might not be enough heat to melt the accumulating snow load.
2) When snow is detected (using a reliable snow sensor), the shade curtain fully opens, no matter what it's present position is
3) This is to a void the snow buildup on the roof structure by allowing unrestricted heated air to melt the snow as it falls
4) This override should only be released when the snowfall has ended. Under no conditions should the shade curtain move to any other position while the snow sensor still indicates that areas snow

By providing not only the desired sequence of operation but also the reasons for it, it is easier for the environmental controls supplier to safe y coordinate the control of the environment and proper operation of the equipment.

CONTROL SPECIFICATIONS

General Requirements

- The control system should be designed in accordance with the latest advancements in greenhouse control, with the objective of regulating the environmental plant growth factors, collecting and processing data in view of the intended purpose (plant production, conservatory maintenance, or scientific research).
- All functions should be accessible through central, satellite, and remote computers.
- The control system should take all control parameters into consideration to determine the appropriate operating conditions and the sequence of operation of the different mechanical systems to best maintain the desired setpoints.
- The system should allow for variable setpoints as a function of the control parameters as commonly found in industry practice and in accordance with the latest research in greenhouse control.
- The control system should consist of a dedicated, distributed, and networked control system.
- Control must be independent of all PC (personal computer) operator interfaces and terminals (failure of one part must not affect the rest).

Vendor Requirements

- The supplier should have as a principal activity the supply of specialized greenhouse computer control systems. The supplier should supply proof of prior installations in greenhouse facilities of comparable size, nature, and complexity. The supplier's software should be proven in existing greenhouses for all the mechanical systems specified.
- Upgrades and modifications of the software should be supplied for a period of 1 year from the date of installation.
- The manufacturer/supplier should offer toll-free telephone support for the system, including applications support.
- All hardware and software components should be warranted for a period of one year following the date of final acceptance of work.

Functional Features

- The control software must be capable of maintaining the desired setpoints while operating all mechanical systems so that conditions remain optimal for plant growth, within the limits of the equipment capabilities.
- Setpoints are required for (select all that apply and add others as needed): air temperature, air-moisture content, light levels, carbon dioxide concentration, nutrient control, and irrigation, and others.
- The control system should be accessible using the Internet for factory service, troubleshooting, support, and remote access by the greenhouse operator(s).
- Manual overrides for testing and emergency operation of machinery and equipment should be located in the control panels where they are protected from the environment and lockable.
- Each controller is to operate independent from other controllers and each controlled climate and irrigation zone is to operate independent of other zones.
- The control system should be capable of automatic synchronization of client server files across computer networks and telephone access lines.
- The control system should support simultaneous access by multiple PC's
- The system should scan all sensors at least once every second.
- The control system should be capable of automatically transferring data to the local PC hard disk for long-term data storage.
- All settings are to be stored in controller-resident memory capable of maintaining settings for at least one month without power to the module.
- Automatic backup of settings and data should be compiled at least once per day for all changed parameters. Restoration of settings (for example, after board replacement) or prolonged out-of-service periods should be manually initiated but otherwise fully automatic and complete.

Installation and Configuration

- All **line voltage** electrical equipment and components should be CSA or UL approved. All panels containing **line voltage** components must bear a CSA or UL stamp or approval.
- The control system should be configured with a minimum 10% additional capacity for future programs, sensor inputs, and control outputs.
- Where applicable, the risk of lightning damage to the control system should be minimized by the use of optical isolation and surge suppression techniques.
- All components must meet the applicable standards for radio interference suppression (e.g. FCC part 15 in the US, or Class A in Canada).
- The power source for the control system must be on a dedicated circuit(s) that does not share power with other equipment loads.
- Climate temperature/humidity sensors should be provided in aspirated modules with backup temperature sensor protection.
- All sensors and control components should be selected & designed to withstand greenhouse and horticultural production environments.
- Special sensor requirements and preferences should be specified (e.g. accuracy, resolution, range, & type)

Complete System

The complete system should include:

- A complete software package adapted for research and production greenhouse control (includes all equipment control program modules).
- Event recording for logging equipment cycles, motor starts etc.
- Comprehensive programmable alarms and alarm display. The system should differentiate between critical and non-critical alarms. The system should monitor outside and inside climate and equipment conditions with visual, audible, and signal output capabilities.
- Graphic display of all logged data in up to 4 user-selectable parameter combinations. Data should be displayable in daily, weekly, monthly, or yearly graphic and tabular intervals.
- Long term archival data storage.

- Data export capability for all recorded data files for use in general programs such as Microsoft Excel.
- Multi-level password protection (e.g. 16 levels of password protection down to the individual compartment level).
- User-programmable menus and graphical display options.
- Comprehensive display on a control group basis of measured environmental conditions, setpoints, control parameters, and outputs.
- User-configurable display of current measured environmental conditions, setpoints, and control parameters.
- On-screen help files for all functions should be available at all times.
- A programmable start-up sequence to permit sequential starting of each piece of greenhouse equipment. The sequence is initiated at each power up and after a power failure during the time the greenhouses are powered by the emergency generator. This is to minimize overloading the generator on starting.
- A weather station to monitor global radiation, air temperature, rain detection, wind speed, and wind direction.
- Reference to absolute or relative time values, for example, before/after solar dawn/dusk vs. absolute time of day.
- Up to 4 diurnal climate temperature/humidity setpoint periods.
- Humidity and light-based modifiers for climate equipment control and irrigation management.
- Automatic ramping between set-point periods.
- Hysteresis control (deadband control).
- Snow melt overrides.
- Wind/rain lockout ventilation capabilities.
- Integrated equipment override capabilities.
- Minimum/maximum pipe temperature setpoints by heating period with maximum temperature control for heating system components.

Scope of Work

- Greenhouses do not always fit well into the standard specification categories for building projects. Due to the need for high light transparency and extremely high air exchange, the structural design of greenhouses does not lend itself to conventional mechanical or electrical equipment and installation methods. Therefore, many jobs that are normally performed by the mechanical trades on other types of buildings are typically performed by the greenhouse contractor, since the work is specialized, and the components are often designed as integral parts of 'turnkey' greenhouse structures. This may include ventilation, shading, hot water heating, etc.
- The scope of work should clearly indicate the boundaries of each section and the division of responsibilities between sections. This avoids omissions and overlaps.
- Normally the greenhouse control supplier provides all hardware and software for controlling all specified devices within the greenhouse, and any specified devices and systems outside the greenhouse such as header houses, boiler & mechanical rooms, miscellaneous storage, field irrigation, perimeter lighting, etc.
- It is not normal for the greenhouse control supplier to supply the actuators, motors, transformers, lamp ballasts, valves, pumps, and other equipment devices. These are normally designed as integral parts of the mechanical and electrical systems, and they are best supplied by the contractors selected to design and install these systems. It should be noted, that in the case of modulating control, it is usually preferable to specify tri-state floating rather than expensive analog signal equipment control, and that all reversing motors should be instant acting. This eliminates the need for intermediate reversing motor controller time delays.
- All line voltage electrical loads under computer control should be activated through motor starters, contactors, and relays. No line voltage loads should be directly under computer control or controlled through the computer interface cabinet. All starters, contactors, and relays should have 24 VAC coils. This clearly separates the control section from dangerous electrical potentials, allowing the operator to safely access the control cabinets to add sensors, troubleshoot, etc.
- All required information for control wiring must be supplied on shop drawings.

- All power wiring, control wiring, and conduit should be supplied and installed by the greenhouse electrical contractor per the detailed shop drawings provided by the greenhouse controls supplier. Integrating all the electrical work under one contractor usually results in a neater, more coordinated installation, and should result in lower costs to the customer.
- The greenhouse controls contractor sometimes supplies relay control panels (RCPs). They may also be provided by Electrical. Some special items such as VFD (variable frequency drive) controls for variable speed motors are often supplied as part of the motor package or with the equipment that contains the motor. The specification should clearly indicate who is to provide the relay interfaces for each control point. Alternately, the relay control panels specification may be moved to it's own section for separate bids.

Control Points List

The Control Points list should contain all of the intended control points in a detailed list complete with drawings.

For the greenhouse control points each point should have the following attributes:

An Example Control Point Specification*:

1) **Component Name (control point):** East Roof Vent Motor
2) **Component Location:** Climate 3, Support Pillar #6
3) **Relay Control Panel Location:** RCP # C3
4) **Control Group:** Compartment 3 Climate
5) **Identification:** VM104 (the item tag or identification number on the drawings)
6) **Type of Output:** Tri-state Floating
7) **Supplied by:** Greenhouse Structural Contractor
8) **Mounted by:** Greenhouse Electrical Contractor
9) **Wired by:** Greenhouse Electrical Contractor
10) **Notes:** Motor is instant reversing.

* If several pieces of equipment are to be operated or controlled together (e.g. horizontal air flow (HAF) fans, exhaust fans, HPS lights etc.), then indicate the intended groupings or "stages" if any, that the items are to be grouped into for control purposes. If you have no opinion, request that the greenhouse controls bidder make the decision or recommendation.

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