DESIGN GUIDELINE 230900
MECHANICAL SYSTEMS CONTROLS

Scope

Mechanical system control requirements, including direct digital controls (DDC) and other types. Also applies to laboratory controls in labs that do not include VAV or combination sash hoods.

Related Sections

U-M Design Guideline Sections:
SBA 5.11 - Fire Command Center
DG230030 - Laboratory Ventilation Design
DG230930 - Refrigerant Monitoring Systems

U-M Master Specification Sections:
MS230900 - Mechanical Systems Controls
MS230901 - Mechanical Systems Controls-Turnkey
MS230910 - Lab Air Flow Controls-DDC
MS230920 - Lab Terminal Air Flow Units & Controls

U-M Standard Details:
MD 230900 001 Differential Pressure Transmitter Liquid
MD 230900 002 DDC Panel Assembly
MD 230900 003 Mechanical Controls Symbols
MD 230900 004 Mechanical Controls Blocks
MD 230930 001 Refrigerant Monitor Control

General

Direct Digital Controls are the standard for control at U-M. Pneumatic or other non-DDC controls are limited to small systems and shall only be specified with the Design Manager's permission.

U-M's master specification (MS) for mechanical systems controls shall be used as the controls specification on all projects, generally MS 230900. In some cases U-M MS 230901 "Turnkey" shall be used instead of or in addition to MS 230900, see additional info below. The A/E shall edit the U-M master specification to make it project specific. Turn on hidden text and read all spec. editor's notes when editing the specification.

> Note that generally the U-M controls specification should only have items *added to it* to make it project specific (e.g. a meter which is peculiar to the project and not already

covered in the spec.), otherwise it is recommended that the A/E *not* delete materials or devices from the specification.

U-M has an extensive Building Automation System (BAS) that networks to localized DDC controls. This system utilizes propriety Siemens components (Siemens Apogee Building Automation System) as well as non proprietary generic controls. UM has negotiated pricing for the proprietary components and purchases these direct from Siemens for projects. U-M also self performs a portion of the DDC control work. Project budgets must (also) include the cost of the proprietary components and U-M's self performed work. During budget planning, the U-M Design Manager will provide information regarding how these costs are to be accounted for in the budget.

For central campus projects, the Area Level Network shall be a BACnet/IP Ethernet network and the Field Level Network shall be BACnet MS/TP (not BACnet/IP). These requirements are described in U-M's master specifications.

Note that the controls contractor in the U-M master spec.s is referred to as the Mechanical Systems Control Contractor or "MSCC".

U-M vs MSCC Work Scope- 230900

230900 Mechanical Systems Controls shall normally be used as the control specification for a project. The A/E should consult Part 1 of 230900 for detailed information regarding the split of control work, University versus MSCC. Under 230900, the university's DDC shop performs a significant amount of the control work. By utilizing U-M's control specification, proper work scope split occurs automatically and is essentially transparent to the A/E design effort. Note that non General Fund auxiliary units may handle controls differently; always consult the Design Manager. In general, the split is as follows:

University of Michigan: Provides proprietary DDC controllers and programs and starts-up the controllers. This includes proprietary terminal equipment controllers (e.g. DDC VAV box controllers) and proprietary room sensors for the terminal equipment, when they are required.

MSCC: Supplies and installs: all field devices (transmitters, actuators, control valves, control dampers, transducers, etc.), all control wiring and tubing, all auxiliary control panels, and prepares a complete controls submittal. Installs U-M supplied DDC controllers, including proprietary terminal unit controllers and room sensors.

The detail MD 230900 002 DDC Panel Assembly provides a graphical representation of the work split.

U-M vs MSCC Work Scope- 230901 "Turnkey"

In some cases when directed by the U-M Design Manager, U-M 230901 Mechanical Systems Controls-Turnkey shall be used instead of (rare) or in addition to (less rare) 230900. MS 230901 is a duplicate of MS 230900 except for the work split between the MSCC and the university. Under 230901 the MSCC does most of the control work. The university's self

performed work is minimal and limited to essentially BAS head-end server work. Under 230901, the MSCC supplies all of the proprietary Siemens parts.

When used, 230901 is typically used as an Alternate, with both 230900 and 230901 included in the Project Manual. Both shall be updated by the A/E as required to make them project specific, however the scope of work split between U-M and the MSCC (in either spec.) should normally **not** be edited.

After bids are received the U-M Project manager will determine if the Alternate is accepted.

Using U-M Master Specification 230900/230901

As previously described, the U-M master spec are designed to require minimal editing for use by the A/E. In particular the scope of work split between the University and the MSCC described in Part 1 should not be edited unless specific changes are directed by the U-M Design Manager.

Special attention should be paid to the following articles:

- Article 1.10: The list of acceptable controls contractors shall not be edited unless directed by the Design Manager.
- Article 2.11 (Flow Meters): U-M normally uses magnetic flow meters for hydronic and steam condensate applications. For steam, multiple types are specified; obtain direction from the U-M Design Manager regarding type to be used. In all cases meter type shall be indicated on the control drawings.
- Article 2.17: If electrical actuators are used, power for these actuators must be accounted for on drawings. Read the spec editor's note in this article for further direction.

The U-M master specification includes specifications for most types of control components. In some cases the A/E will need to add supplemental specifications for atypical components.

Control or automatic dampers (actuated dampers) are specified in Master Specification 230900. The A/E's specification should include no other control damper specifications, and specification sections requiring factory provided control dampers, e.g. air handler specifications, shall reference Master Specification 230900 for the control damper spec.

230900 includes the specifications for laboratory controls (including fume hood monitors) when conventional (blade damper) VAV/CAV boxes are used to serve the labs. For labs with VAV or combination sash hoods, venturi style terminal units must be used on all the terminal units serving the lab. Refer to DG230030 - Laboratory Ventilation Design for more information.

Control Drawings

The required scope of a project's controls shall be indicated by the use of control drawings. Each control drawing shall include a detailed sequence of operation.

Each control diagram shall be labeled with a unique identification number, similar to how multiple details are typically numbered on a drawing. This unique number shall be used to identify the control drawing that applies to a particular piece of equipment or system, e.g. in a terminal equipment schedule.

Control drawings and sequences shall appear on the mechanical drawings; they shall not appear in project specifications.

Control drawings shall utilize U-M's standard controls symbology and acronyms, refer to MD 230900 003 Mechanical Controls Symbols and be sure to include these symbols on a key sheet as part of the mechanical drawings. Each control device on the drawing shall be tagged and labeled with a unique identification number, as indicated by the # symbol on MD 230900 003.

Normally, U-M will provide sample control drawings in electronic format for A/E use, which will include sequences of operation. In some cases, these are available on the U-M AEC website; refer MD 230900 004 Mechanical Control Blocks. Revise these drawings to make them project specific. Revise sequences of operation to include strategies specific to the project (example: change-over to free cooling). Provide similar control drawings for systems not available from U-M's samples.

"Point Lists" are not required and shall not be used.

Sequence of Operation Requirements:

- Each paragraph in a sequence shall be numbered.
- The control device tag numbers shall be included when describing the sequence of operation, e.g. "The leaving air temperature set point shall be maintained at 55°F +/- 2°F, as measured at TTR-12"
- Include all project specific set points, including the allowable variation from set point, and any special alarms with alarm setpoints. Note that 230900 requires certain standard alarms be set up in the DDC/BAS; see the scope of work description in Part 1 of the specification for standard alarms.
- Where specific tuning requirements are required, e.g. for high precision temperature control, they shall be described in the sequence of operation. Note that 230900 includes default tuning requirements in Part 3.

Siemens Part Numbers for Proprietary Parts:

- The A/E must obtain the Siemens proprietary part numbers from U-M and include them on the control drawings.

DDC Panel Locations, Clearances, and Communication Wiring

The control drawings shall include system network architecture diagrams specific to the project. These diagrams indicate the location and quantity of DDC and auxiliary panels. U-M will normally provide this information to the A/E, for inclusion on the project drawings, just prior to completion of CD documents.

The controls contractor will run all communication wiring between DDC panels and terminal equipment controllers. Communication wiring is to be indicated on the system architecture diagram, including wiring back to a data closet.

Each DDC panel will have one or more auxiliary panels. See MD 230900 002 DDC Panel Assembly. The A/E shall indicate the location of these panels on the plan views. For a typical assembly allow 7'of wall space; note that some panel assemblies require more space, consult with U-M. Locate panels to provide a minimum of 36" clearance in front of each panel, and designate this clearance on the drawings.

Power for Controls

DDC Panel Assemblies: Each assembly (not each panel in an assembly) shall be provided with (2) 20 amp dedicated circuits (separate circuit breakers). Indicate these circuits on the electrical drawings, home-runned to the panel assembly location.

Terminal Equipment Controller Power (DDC VAV box controllers, etc.): Designate circuits in receptacle panels on each floor for terminal equipment control power transformers. Provide one 20 amp circuit for every (50) terminal unit controllers.

Actuator Power: See Master Specification 230900, Article 2.17.F.

Power for meters and other control accessories that are provided by the controls contractor: This is provided through a fused disconnect located in the DDC auxiliary panel and is part of the controls contractor's scope of work per U-M Master Specification 230900. Therefore the A/E does not need to typically indicate power for such items on the design drawings.

Life Safety Control

U-M's DDC system is not listed for life safety use and therefore shall not be used for initiating or alarming life safety applications. Two common examples are as follows:

> Stair Pressurization Control: The building fire alarm system will initiate operation of the stair pressurization fans. Any controls required for stair pressurization shall be stand-alone from (and independent of) the DDC system.
>
> Atrium Smoke Purge: The building fire alarm system will initiate atrium smoke purge. Any controls required for smoke purge shall be stand-alone from (and independent of) the DDC system.

However, the controls contractor will provide the stand alone components (dampers, end-switches, pressure transmitters, etc.) and therefore these components shall be indicated on the control drawings and include complete sequences of operation.

Fire Command Centers

The building code requires status indicators and controls for air distribution systems in Fire Command Centers (FCC). These devices shall be provided as a separate DDC control panel

in the FCC. The DDC system (as opposed to the fire alarm control system) shall output status to the panel and provide air distribution system control from the panel. Refer to Design Guideline SBA 5.11 Fire Command Center for additional information.

Manufacturer Provided (Packaged) Controls

Chillers and boilers shall be equipped with manufacturer provided controls. Manufacturer provided controls shall typically be limited to control of the chiller (boiler) itself. Control of the chiller (boiler) plant (chiller (boiler) sequencing, etc.) shall be by U-M's DDC system.

Packaged controls should also be specified for equipment normally equipped that way, such as storm/sanitary pumps, RO/DI systems, vacuum pumps, air compressors, pollution control (air and water treatment) systems, refrigerant leak detection, fuel oil systems, DX systems, condensate pumps, etc. See the respective design guideline for these systems for any specific requirements for the packaged controls.

Packaged controls shall not be specified for air handlers, unless specific permission is given by the U-M Design Manager.

Control Air

For central campus projects, 90 PSIG compressed air is available from the campus steam tunnel system. This air shall be utilized for control air use, however a desiccant dryer must be indicated if any control air line or pneumatic component (e.g. actuators) will be exposed to outside air conditions. Otherwise, the tunnel air is dry enough for indoor control air use.

For other campus locations, a control air compressor and dryer will normally be required. U-M Master Specification 230900 specifies control air compressors and accessories (PRV stations, refrigerated air dryers, etc.).

In either case, A/E drawings shall indicate the source of control air.

Electric vs. Pneumatic Actuators

Damper actuators and large control valves shall be pneumatically actuated, except for special conditions as approved by the U-M Design Manager. Small dampers and valves controlled by terminal equipment controllers shall utilize electric actuators, as indicated in U-M Master Specification 230900.

Typical Alarms to be Monitored by DDC

In addition to the typical status alarms associated with DDC control, the DDC shall be indicated as monitoring the following equipment. Equipment should be specified with a common alarm contact for DDC monitoring, not separate alarm contacts for each alarm condition, except as noted:

- Sanitary and Storm Pumps (common alarm: high level, seal failure, etc)
- Cold/Warm/Environmental Rooms

- Walk-in Freezers
- Heat Trace
- Emergency Generator (generator running, generator trouble)
- Automatic Transfer Switch Transferred to Generator Power (Connect in series each "on generator power" auxiliary contact in each ATS to a single point in a DDC panel to notify BAS if any ATS transfers to generator power.)
- Critical Unitary A/C units (for example, computer rooms)
- RO/DI Systems
- Pollution Control Systems
- Fuel Oil Systems
- Refrigerant Leak Detection Systems (refer to DG230930 Refrigerant Monitoring Systems)
- Chiller Relief Valve Status
- Domestic Water Booster Pump Systems
- Glycol Make-up Systems (separate low pressure and low glycol level alarms)
- Substation Room Temperature

The above list is not exhaustive. The design team shall carefully consider and include alarm monitoring appropriate for the project.

Miscellaneous

For air handlers that are shut down by smoke detectors, a detail must be included with the control diagrams that describes the interface wiring between the air handler controls and the fire alarm system. U-M coins this the "red/blue box detail". Use the detail that is appropriate for the project specific fire alarm system from the electrical standard details on the U-M AEC website. Consult with the U-M Design Manager to determine which detail is appropriate. Typically an addressable fire alarm system is used, in which case U-M standard electrical detail 28310006 is appropriate.

Fan coils, unit heaters, cabinet unit heaters, small sections of fin tube, and similar terminal equipment including, in some cases, chilled beams, should be controlled by application specific controllers designated RTC or RTC-F in 230900. Consult the U-M Design Manager for permissible applications specific to your project.

For central campus buildings a U-M Utilities Data Acquisition Panel is required whenever steam, steam condensate, or chilled water will be billed to a building. Consult with the U-M Design Manager regarding when required. When required, show and label the panel on a control drawing with the appropriate control points connected to the panel:

- Steam: steam flow meter output
- Steam Condensate: Condensate flow meter output
- Chilled Water: BTU meter output.

The DDC points associated with the data acquisition panel must also be shown looped to the DDC system.

U-M central campus has traditionally used Loop Powered Indicators (LPIs) to display analog point data local to the DDC panels. LPIs are being phased out in favor of flat panel displays (referred to as "Human Machine Interface" in 230900). Consult the U-M Design Manager regarding which to use for a particular project.

Exterior lighting associated with new buildings shall be controlled by DDC. DDC shall turn the lights on and off, and status the lighting contactor (via a current sensing relay). The contract drawings shall indicate a contactor for exterior lighting control by DDC.

U-M utilizes a central weather station that transmits outside temperature and humidity conditions across the BAS network. Therefore local outside temperature and humidity transmitters should normally not be indicated.

Fan systems capable of developing static pressures in excess of the duct system's (air handler casing, plenums, ducts) static pressure rating (positive or negative) shall be equipped with static pressure safeties to turn off the fans prior to damage occurring from excessive pressure. The AE should not indiscriminately specify these devices but shall include them based on an evaluation of the maximum pressure the fan can develop, the pressure class of the duct system, damper pressure ratings, and the degree of risk.

In general, for air handlers, heating coils shall be designated as fail open, and cooling coils shall be designated as fail closed.

For reheat coils in zones serving animal rooms, reheat coil control valves shall be **normally closed** type. This avoids a wild coil condition from severely over-heating the animal room.

Include MD 230900 001 Differential Pressure Transmitter Liquid on any project utilizing liquid DP transmitters.

For all air and liquid flow measuring devices, the AE shall indicate their location on the plan views as well as on the control drawings. Design the duct or piping at the meter location to provide the manufacturer's required up and downstream straight and unobstructed lengths, and indicate these requirements on the drawings. When in doubt as to specific manufacturer's requirements, provide 10 straight diameters upstream and 5 straight diameters downstream.

For information regarding controls related to refrigerant leakage monitoring, see DG230930 Refrigerant Monitoring Systems.