Chapter 18
MECHANICAL (HVAC) DRAWINGS AND DESIGN

SECTION 1801 - CONTENTS

1801.1 Definitions. Mechanical drawings delineate equipment, materials, components, ductwork, piping and accessories to convey liquids, gases, air and control data for Heating, Cooling, Ventilation and Air Conditioning systems (HVAC). The drawings shall indicate complete design. Prior written acceptance is required for any design-build component.

1801.2 These drawings establish the requirements for construction of the facility design, including pertinent services, equipment, and other features required for the performance of the mechanical equipment. These drawings incorporate dimensions, symbols, reference to codes, conventions, schedules, diagrams, etc., in describing the size and routing of pipes, the kind of material to be used, equipment criteria, duct sizes and shapes, amount of flow and the temperature of material in pipes and ducts, valve types and location, floor and wall penetrations, tank construction, equipment, piping insulation, and other facets of mechanical design as are required.

SECTION 1802 - SEQUENCE

1802.1 Mechanical Drawings are divided into specific groups. Drawings within a group are numbered consecutively, i.e. M2.01, M2.02, etc. The group designation shall always remain the same, regardless of the size or scope of the individual project. If specific projects do not include work related to a group, that group shall be eliminated from the drawings. When appropriate, the Consultant shall obtain written permission from the Project Manager to vary the sequence.

<table>
<thead>
<tr>
<th>M0.XX</th>
<th>Mechanical Symbols/Abbreviations/Notes/Table of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1.XX</td>
<td>Site Plan/Demo (if applicable)</td>
</tr>
<tr>
<td>M2.XX</td>
<td>Mechanical HVAC Duct Floor/Roof Plans</td>
</tr>
<tr>
<td>M3.XX</td>
<td>Mechanical HVAC Piping Floor/Roof Plans</td>
</tr>
<tr>
<td>M4.XX</td>
<td>Mechanical Zoning/Pressure Plans</td>
</tr>
<tr>
<td>M5.XX</td>
<td>Control System Diagrams (Mechanical Flow Diagrams, SOO, BAS Control Matrix)</td>
</tr>
<tr>
<td>M6.XX</td>
<td>Mechanical Details</td>
</tr>
<tr>
<td>M7.XX</td>
<td>System Schematic Riser Diagrams (Air and Water)</td>
</tr>
<tr>
<td>M8.XX</td>
<td>Mechanical Schedules</td>
</tr>
</tbody>
</table>


SECTION 1803 – MECHANICAL FLOW DIAGRAMS

1803.1 Schematic Illustrations: Flow diagrams are schematic illustrations of piping or duct circuits including equipment, components, sensors and control devices involved in the mechanical system. The purpose of flow diagrams shall be to define a mechanical system with respect to flow directions, component sizes, control functions, sequence of operation and flow balances. Flow diagrams form a basis for detail design drawings, construction and installation.

1803.2 Early Submittal: Flow diagrams shall be submitted with the Schematic Design phase submittal or as a separate submittal before the halfway point of Design Development.

1803.3 Mechanical flow diagrams shall be required to illustrate the following:

A. All HVAC Systems
B. HVAC air flow
C. Hydronic Piping Systems
D. Building Automation Systems
The need for additional flow diagrams shall be determined on a project by project basis by the Design Engineer (supervisory) or Project Manager. The need for additional flow diagrams shall be based on the complexity of piping the mechanical system.

SECTION 1804 - FLOW DIAGRAM REQUIREMENTS

1804.1 General Requirements: All piping, ductwork, and equipment shall be represented on flow diagrams in schematic form. Accurate depiction of physical relationships is essential for clarity, e.g., a vessel with connections located on top, bottom, and sides should appear on the flow diagram with connections shown in approximately the same relationship. Piping specialties and special features shall bear a reasonable resemblance to the actual items or installations.

1804.2 Flow Direction: A flow direction arrow shall appear at each line junction or change of direction in order to illustrate the flow direction clearly.

1804.3 Limits of Construction: Purchased equipment packages, which are pre-assembled or pre-piped, shall be so designated with a dashed line to indicate the limits of the vendor-supplied portion.

1804.4 Instruments and Controls: Symbols used to represent instruments and control loops shall be defined in a legend on the drawings.

1804.5 Set Points: Set points for relief valves, limit switches, control valves, dampers and operating temperatures shall be indicated. Failure positions shall be called out for control valves and dampers (fail open, fail closed). Other instrument set points or operating control points shall be called out as appropriate to aid design and construction.

1804.6 Sequence of Operation: For complex systems or those systems controlled by Direct Digital Control (DDC), a written logic description shall be added to the flow diagrams and included in the project Technical Provisions of the Specifications.

1804.7 Operating Controls: Consideration shall be given to all anticipated operating conditions, including start-up and shutdown. Flow diagrams shall show bypasses, and any valves, controls, etc., required for any anticipated operating condition.

1804.8 Identification Tags: The type of point shall be shown on the control instrument in the mechanical flow diagrams.

1804.9 System Points List: A matrix showing the Point Description (e.g. Discharge Air Temperature), Point Name (e.g. DA-T) Point Type (e.g. AI) and Remarks shall be on the same page as the mechanical flow diagram. The point name will be provided by the CSU Building Automation Services group.

1804.10 Existing System Tie-in: When new mechanical systems are to be tied into existing systems or systems being designed by others, each tie-in shall be identified on the drawings by a hexagon symbol bearing a unique tie-in number. The designer shall include a list of tie-ins on the drawings as required for a project. The tie-in schedule shall note the tie-in number, piping, ductwork or other service, and the extent of interruption required to affect each tie-in. This schedule shall be used to help coordinate construction with normal operations in order to minimize unscheduled down time.

1804.11 Symbols: Symbols used on flow diagrams for valves, instruments, and accessories shall conform to standards established by the legend.

1804.12 Gravity Drainage: When a specific service requires positive gravity drainage, arrows and notes on the flow diagram shall illustrate the slope required.
1804.13 Service Diagrams: On all systems requiring natural gas service, compressed air or other types of pressured systems, provide as part of the construction documents flow diagrams indicating demand loads. An example may be a flow diagram indicating gas service with regulator size, and inches of water demand calculations for each element or devices to be served by the gas service. Include identification at each device the range of pressures acceptable for start-up, testing and operation of the device.

SECTION 1805 - DRAWINGS FOR PIPING

1805.1 General: Piping drawings shall delineate the components required to convey the fluids. Drawings shall be completely coordinated with other disciplines and existing systems to ensure no conflicts occur in the documents. Piping drawings, or a set of piping drawings, delineate the kind, size, and routing of pipe, hose and tubing, the associated vessels and equipment, and other facets of mechanical design by incorporating dimensions, symbols, codes, conventions, schedules and diagrams.

1805.2 Flow Diagram Precedence: When flow diagrams are required they shall be completed prior to commencement of detail piping drawings.

1805.3 Drawing Delineation: The following rules shall be followed in the delineation of piping drawings:

A. Exposed pipe shall be shown as a single thick line and hidden, or buried pipe shall be shown as a thick dashed (hidden) line; however, in order to delineate clearances and special conditions, 6" and larger pipe shall be shown using a double line, drawn to scale, and showing the actual pipe dimensions.

B. When new and existing pipe and/or equipment is shown on the same drawing, existing pipe and equipment shall be shown using a hidden line.

C. Pipe shall be identified as to size and service code (fluid in pipe).

D. Valve stems, hand wheels, etc., even though shown symbolically, shall be drawn to scale where a clearance problem may exist or where removal or operation may be critical.

E. The scale used for piping drawings shall be as follows:
   General site routing plans - 1/10" to 1/20" = 1'-0"
   Piping plans (including double line piping) 1/8" to 1/4" = 1'-0"
   Sections and details - 1/4" to 3/4" = 1'-0"

F. Pipe mains and branches shall be dimensionally located from the facilities structure, such as column lines, walls, ceiling, equipment, supports, etc., or from recognized bench marks; as required or justified by complexity or space constraints.

G. Pipe(s) shown in elevation or section shall have their centerline or bottom of pipe elevations given above or below grade or floor elevation to a reference datum plane. All pipe elevations shall be identified on the drawings and piping coordinated with other items vertically.

H. When draining of horizontal lines is required or drip stations are called for, the slope in lines shall be called out by an arrow placed adjacent to the applicable line.

I. Indicate slope in fraction of an inch per foot or the elevation given at both ends of the slope.

J. Use line designations when more than one system or service is delineated on the drawing.

K. Call out line designations when pipe or tubing runs are grouped close together.

L. Guides, anchors and expansion compensators shall be located and described.
SECTION 1806 – DRAWINGS FOR AIR HANDLING

1806.1 General: Heating, ventilating, and air-conditioning drawings delineate the components required to supply, move air by natural or mechanical means. Such air may or may not be conditioned, i.e., filtered, tempered and/or humidified. The delineation for these drawings shall incorporate dimensions, symbols, codes, conventions, schedules, diagrams, etc., in describing the ducts, blowers, filters, heating or cooling coils, roof exhausts, grilles, dampers, air-conditioning units, pumps, and controls, ducts and equipment. The drawings shall be completely coordinated with all other design disciplines to assure that there are no design or physical conflicts and that the systems can be installed as delineated.

1806.2 Combined Drawings: HVAC Systems and piping systems for HVAC systems may be combined on the same set of drawings where practical and prior written acceptance form the Project Manager has been issued. Section 1804 Flow Diagram Requirements and Section 1805 Drawings for Piping shall apply to the HVAC drawings as needed.

1806.3 Drawing Delineation: The following rules shall apply when detailing these drawings:

A. Drawings shall be prepared showing routing of ducts and piping and location of ducts, grilles, and required ventilation, exhaust, and/or air-conditioning equipment. The preferred scale for arrangements is 1/4" = 1'-0". (To aid in checking drawings and resolving potential interferences among other components, such as piping, electrical, architectural, etc., the heating, ventilation, and air-conditioning drawing shall be prepared to the same scale as these other drawings, where feasible).

B. Duct layouts shall include grille sizes, CFM, splitters, outlet control dampers, elbows, access doors, branches, volume control dampers, louver openings, booster heating equipment, test holes, and other miscellaneous components equipment and controls.

C. When duct sizes are given, the first dimension is the side shown, for example, 20" x 12". The 20" dimension is the width and the 12" dimension is the depth where the duct is shown in plan.

D. Material for ducts, gauge of metal, type and spacing of joints and reinforcements, type and spacing of hangers, angle or change in size transitions, and cross bracing shall be covered in the specifications.

E. Direction of flow shall be indicated by an arrow.

F. All parts such as coils, fans, dampers, filters, housings, compressors, and miscellaneous items shall be called out on the drawing. A schedule may be employed for this purpose. A schedule lists the type, size, capacity, speed, pressure, type enclosure, fins per inch and rows, and other pertinent components in tabular form.

G. Direct Digital control diagrams for heating, ventilation, and air-conditioning systems shall show:
   1. All controllers, sensors, thermistors, valves and damper actuators, relays, and accessories necessary to illustrate the functions and sequence of operation of all principal components in the system.
   2. The set point of all control points.
   3. The normally open or closed position of all valves and dampers.
   4. The sequence of operation of the system through a complete winter-summer cycle, including the off and fire alarm conditions.

SECTION 1807 – MECHANICAL (HVAC) DESIGN
1807.1 **General:** Prior to commencing design, the Consultant shall study and be familiar with the CSU Construction Standards, Part III, Divisions 20 General Mechanical and 23 HVAC, along with all other parts of the CSU Construction Standards (Administrative, Design and Construction Standards), current edition, as posted on the Facilities Management website.

1807.2 **Vibration Standards:** Sources of vibration include machinery and mass movement of fluids.

The Mechanical Engineer shall study and be familiar with the standards regarding vibration of rotating machinery, fan design criteria and mounting details. See Part III Technical Standards, Sections 23 05 48 – VIBRATION CONTROL and 23 34 00 – HVAC FANS. Fans and other rotating machinery shall be designed with rigid frames mounted directly to structure. Spring-mounts are prohibited.

Building vibration performance criteria are presented in Part II Design Standards, Section 1707 Structural Design. The Mechanical Engineer and Structural Engineer shall collaborate to assure the vibration performance criteria are met. Performance to the more stringent criteria may require designs to control, isolate and transfer vibration forces from mechanical systems or mass fluid movements independent of the building structure.

1807.3 **Field Investigation:** CSU maintains an archive of project drawings from past projects. However, CSU has not compiled projects over time to maintain current, conformed building drawings. In addition, correspondence of the record documents to the actual construction performed is not assured, and subsequent modifications may not have been recorded. The Mechanical Engineer shall study the available drawings and be responsible for adequate field investigation to identify and verify critical dimensions, clearances and connections to existing systems, especially where concealed to casual inspection during the limited time available to prospective bidders during a pre-bid site visit.

1807.4 **Design Overview:** The Mechanical Engineer shall be responsible for facility program analysis to determine the intent and objectives for heating, cooling, relative humidity, pressure gradient, etc. required by those programs that are applicable to the project, such as LEED, BSL-3, FDA 21 part 11, etc.

1807.4 **Specific Sequencing:** The Mechanical Engineer shall design the specific sequencing required to assure controlled environments are stable, can be monitored and controlled.

END OF CHAPTER 18