COMMERCIAL HVAC SYSTEMS

System Selection

Technical Development Program
Technical Development Programs (TDP) are modules of technical training on HVAC theory, system design, equipment selection and application topics. They are targeted at engineers and designers who wish to develop their knowledge in this field to effectively design, specify, sell or apply HVAC equipment in commercial applications.

Although TDP topics have been developed as stand-alone modules, there are logical groupings of topics. The modules within each group begin at an introductory level and progress to advanced levels. The breadth of this offering allows for customization into a complete HVAC curriculum – from a complete HVAC design course at an introductory-level or to an advanced-level design course. Advanced-level modules assume prerequisite knowledge and do not review basic concepts.

System selection can be a simpler, more understandable, process if the designer and owner follow a step-by-step procedure. This TDP on System Selection presents one method that can be used by designers on most commercial projects. We will begin by assembling and documenting all available project data at the earlier phases of the design process. After determining the delivery method, budgets and schedules, and running rough heating and cooling loads for our zoned project, an initial list of potential HVAC systems will be assembled. This list will be reviewed against various design criteria that were determined for the project. The final two or three HVAC systems will be evaluated against a prioritized list of design criteria using a rating method called the Systems Scoresheet. The system with the highest numerical rating, once approved, will then be designed and built. Throughout the selection and design processes, job requirements and system parameters are documented on the Design Record form presented in the TDP.
Table of Contents

Introduction........................................................................................................................... 1
HVAC System Selection and Design .................................................................................. 1
HVAC System Design Process ......................................................................................... 1
  Programming ................................................................................................................... 2
  Schematics ..................................................................................................................... 2
  Design Development (DD) ............................................................................................ 2
  Construction Documents (CD) ...................................................................................... 3
  Bidding ......................................................................................................................... 3
  Construction Administration ......................................................................................... 3
  Commissioning ............................................................................................................ 3
  Closeout ....................................................................................................................... 3
HVAC System Selection Flow Chart ............................................................................... 4
  Step 1: Assemble Initial Project Data ................................................................. 4
  Step 2: Rough First Pass Selections ................................................................. 5
  Step 3: Initial Criteria and Constraints ............................................................ 5
  Step 4: Refine Selection Criteria ........................................................................... 5
  Step 5: Evaluate Using the Systems Scoresheet ................................................ 5
  Step 6: Implementation and Follow-Through .................................................. 6
Step 1: Assemble Initial Project Data ........................................................................ 6
  Project Type ............................................................................................................... 6
    New Building or Addition ......................................................................................... 6
    Remodeling, Renovation or Retrofit .................................................................... 7
  Building Occupancy and Construction .................................................................. 8
    Building Usage (Code Occupancy) ....................................................................... 8
    Building Fire-Resistance Rating (Code Construction Type) ...................... 9
  Project Particulars .................................................................................................... 10
    Key Design Factors ............................................................................................... 11
    Process Delivery Methods ..................................................................................... 12
Step 2: Rough First Pass Selections ........................................................................... 15
  Zoning and Rough Loads ......................................................................................... 15
    Zoning for Equipment Selection ....................................................................... 16
    Zoning for IAQ ...................................................................................................... 16
  Load Components for System Selection ................................................................ 17
    Space Loads .......................................................................................................... 17
    System Loads ........................................................................................................ 17
    Total Load (Coil Load) ......................................................................................... 18
    Load-Related Building Data .............................................................................. 19
HVAC Design Check Figures ....................................................................................... 20
  Cooling Check Figures ........................................................................................... 20
  Heating Check Figures ........................................................................................... 21
  Ventilation Check Figures ....................................................................................... 21
  Comfort Conditions ................................................................................................. 21
Practical Design Targets and Formulas ....................................................................... 22
  Load Profiles .......................................................................................................... 22
  Review the HVAC Systems List ............................................................................ 22
List of Potential Systems ............................................................................................. 23
<table>
<thead>
<tr>
<th>Appendix A –</th>
<th>HVAC System Selection Process Flow Chart</th>
<th>49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix B –</td>
<td>Building Occupancy Classifications</td>
<td>50</td>
</tr>
<tr>
<td>Appendix C –</td>
<td>International Building Code Fire Resistance Rating Tables</td>
<td>51</td>
</tr>
<tr>
<td>Appendix D –</td>
<td>HVAC System Selection and Design Documentation Form</td>
<td>52</td>
</tr>
<tr>
<td>Appendix E –</td>
<td>Load Components Terms List</td>
<td>56</td>
</tr>
<tr>
<td>Appendix F –</td>
<td>HVAC Design Check Figures</td>
<td>57</td>
</tr>
<tr>
<td>Appendix G –</td>
<td>Manufacturing Offices Block and Zone Loads</td>
<td>59</td>
</tr>
<tr>
<td>Appendix H –</td>
<td>Table of Design Conditions</td>
<td>69</td>
</tr>
<tr>
<td>Appendix I –</td>
<td>HVAC Systems List</td>
<td>70</td>
</tr>
<tr>
<td>Appendix J –</td>
<td>HVAC System Elements</td>
<td>71</td>
</tr>
<tr>
<td>Appendix K –</td>
<td>Relative Installed Cost Multipliers for HVAC Systems</td>
<td>72</td>
</tr>
<tr>
<td>Appendix L –</td>
<td>Heating Fuel Equivalents</td>
<td>73</td>
</tr>
<tr>
<td>Appendix M –</td>
<td>Average Heating Energy Consumption</td>
<td>73</td>
</tr>
<tr>
<td>Appendix N –</td>
<td>Cooling and Other Electric Energy Consumers</td>
<td>74</td>
</tr>
<tr>
<td>Appendix O –</td>
<td>ASHRAE Standards</td>
<td>76</td>
</tr>
<tr>
<td>Appendix P –</td>
<td>CSQR System Descriptions</td>
<td>78</td>
</tr>
<tr>
<td>Appendix Q –</td>
<td>System Strengths and Weaknesses, Design Layouts, and Comments</td>
<td>100</td>
</tr>
<tr>
<td>Appendix R –</td>
<td>System Component Spreadsheets</td>
<td>106</td>
</tr>
<tr>
<td>Appendix S –</td>
<td>System and Terminal Control Schematics with Operational Mode Sequences</td>
<td>109</td>
</tr>
<tr>
<td>Appendix T –</td>
<td>Systems Scoresheet</td>
<td>115</td>
</tr>
<tr>
<td>Appendix U –</td>
<td>Manufacturing Offices Systems Scoresheet</td>
<td>117</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>119</td>
</tr>
</tbody>
</table>
Introduction

The HVAC (Heating, Ventilating, and Air-Conditioning) system maintains desired environmental conditions within building spaces. As with many design tasks, getting started correctly is key to successful system selection. This Technical Development Program (TDP) addresses the many, often conflicting, needs that must be weighed during the process of selecting between two or more HVAC systems for a building construction project.

This TDP will explore:

- The four main delivery methods for achieving HVAC system design and construction: plan and specification-bid-build (plan and spec), design-build, construction management, and performance contracting
- The sequential steps for design, approvals, and implementation of HVAC systems
- Determining project criteria that will allow selection of potential HVAC systems for evaluation
- Evaluation of potential systems using a mathematical score-sheet
- Developing project documentation of the selection process, system construction and commissioning before delivery to the client.

HVAC System Selection and Design

No matter what size the project is or how the HVAC system design is implemented, there is a series of design phases that should guide the HVAC designer’s efforts. After the design phases are explained, we will develop a step-by-step process that will begin the HVAC system selection efforts. This will guide the designer through the iterative process of selection, approval, design, and implementation.

HVAC System Design Process

Many times an experienced designer will quickly determine the HVAC needs of a project and will develop an outline of the HVAC system solution. Regardless of how compressed the selection process has been, each task will have been considered and addressed in the final results. We will not go over each task in detail, because task details are covered in related industry publications, such as the Air-Conditioning Systems Design Manual available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Figure 1 shows a breakdown of the process phases for system selection, design, and implementation. Shown next to each phase is the essence of the key tasks and percentage of total project design effort (either hours or dollars) required. The line slopes down over time to represent diminishing ability to affect the design (of any building system).
Programming

When a building project begins, the design team is established and work begins to determine the needs of the client (e.g., owner, developer, tenant, or occupant). This process is usually led by an architect and includes engineering members, special systems consultants, and representatives of the client and occupants. Overall budgets and schedules are established to guide the design and construction process that will last until the final punch list items are resolved, the occupants have moved in, and the building systems are performing as required. Initial systems selection, proposal, and approval make up the bulk of the HVAC designer’s efforts in this phase.

Schematics

When working on schematic drawings, initial layouts of HVAC equipment and distribution systems are not final but are representative of the final product. Detailed confirmation of initial system selections, budgets and schedules are where the greatest efforts are directed.

Design Development (DD)

Design development involves reviewing the equipment selections and fitting the selections into the building. This detail work requires coordination between the design team disciplines (architectural, structural, HVAC, plumbing, fire protection, and electrical) and a thorough knowledge of the building’s enclosed spaces (above suspended ceilings, inside chases, and within walls) for locating equipment and distribution systems. Mechanical equipment rooms (MER), chases, plenums, and approved equipment locations on the roof or site are usually not numerous or spacious, so this is when we lobby for good maintenance and service spaces for the HVAC equipment and distribution/utility mains. Here too, final approvals of the system selections are obtained from the design team members, especially the client.