# CHAPTER 1: BASIC REQUIREMENTS

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## 1.1 INTRODUCTION

This HVAC Design Manual is revised to incorporate numerous changes due to:

- Energy Conservation (EPACT 2005 and DOE – Final Rule)
- Energy Conservation (Executive Order No. 13423 Dated January 24 2007: Strengthening Federal Environmental, Energy, and Transportation Management)
- Memorandum of Understanding (MOU): Federal Leadership In High Performance and Sustainable Buildings
- Physical Security Requirements
- Sustainable Design Considerations
- Commissioning

Use of this manual is meant for the Architect/Engineer (henceforth referred to as the A/E) and others engaged in the design and renovation of the VA facilities. These facilities are:

- New Hospitals
- Replacement Hospitals
- Ambulatory Care
- Clinical Additions
- Energy Centers
- Outpatient Clinics
- Animal Research Facilities
- Laboratory Buildings

It is expected that HVAC systems designed with the use of this manual will meet their primary objective of providing environmental comfort to the veterans, employees, and visitors. The HVAC system design package shall be complete, coordinated, and technically correct. In addition, the HVAC systems shall be safe, easily accessible for repairs and maintenance, energy efficient, and in compliance with the prescribed noise and vibration levels.

Deviations can be made from the stipulations of this manual to accommodate new concepts and design enhancements. However, such deviations shall be subject to review and approval by the VA Project Manager in consultation with the VA Facilities Quality Service (Office of Construction & Facilities Management) and shall not conflict with any Federal Regulations, Public Laws, Executive Orders, and the needs of the end-users.

Throughout this manual, the statement is made: to obtain approval from the “VA Authorities.”The “VA Authorities” is defined as the VA Project Manager. If approval is required by the local VA Medical Center, it is so noted in this manual.

## 1.2 ENERGY CONSERVATION

The need to conserve energy is mandated by the Federal Government by both Executive Order and Federal Law. In addition, 19 Federal Agencies have signed a Memorandum of Understanding (MOU) outlining specific goals and targets for energy conservation and sustainable design. The VA is one of the signatory agencies. In the following paragraphs, references and details of various requirements are given.

### 1.2.1 DOE FINAL RULE

In the Federal Register (Volume 72, No. 245), dated December 21, 2007, the Department of Energy (DOE) issued mandatory energy conservation guidelines as the final rule for implementing provisions in the Energy Policy Act (EPACT 2005). Provisions of the final rule are as follows:

#### 1.2.1.1 ASHRAE Standard 90.1

**(a) ASHRAE Standard 90.1 – 2004**
ASHRAE Standard 90.1 – 2004 is a component of the DOE final rule. Provisions of this standard shall be used as a baseline for computing energy savings. By reference, DOE has incorporated Standard 90.1 – 2004 into 10 CFR Part 433. Also, the U.S. Congress has prescribed this standard in section 109 of the Energy Policy Act of 2005 (EPACT).

**(b) ASHRAE Standard 90.1 – 2007**
Recently, ASHRAE has published the revised Standard 90.1 – 2007. HVAC systems shall be designed to comply with the ANSI/ASHRAE/IESNA Standard 90.1 – 2004 for Buildings except Low-Rise Residential Buildings. The A/E is expected to fully comprehend and implement the practices dictated in ASHRAE 90.1 – 2004.

#### 1.2.1.2 Additional Mandated Energy Conservation Measures

In addition to complying with the ASHRAE Standard, DOE has mandated that a new federal building must be designed to achieve an energy consumption level that is at least 30% below the level achieved under Standard 90.1-2004, ***if life-cycle cost-effective.*** Use the Performance Rating Method – Appendix G of ASHRAE Standard 90.1 – 2004 to document the energy savings.

**(a) Life-Cycle Cost (LCC) Analysis (Requirements**): If the 30% reduction in energy consumption is not life-cycle cost-effective, the A/E must evaluate alternate designs at successive decrements (for example, 25%, 20%, or lower) in order to identify the most energy-efficient design that is life-cycle cost-effective. To do so, the A/E will consider and evaluate readily available energy conservation measures with which the industry is generally familiar.

DOE further stipulates that the "agencies must estimate the life-cycle costs and energy consumption of the planned building as designed and an otherwise building just meeting the minimum criteria set forth in the baseline ASHRAE Standard." This measure is meant to demonstrate and record the extent to which the mandated compliance is achieved.

**(b) Life-Cycle Cost Analysis (Methodology):** To comply with the Public Law 95-619, an engineering economic analysis shall be performed in accordance with the procedure outlined by the Department of Energy (DOE) in the National Institute of Standards and Technology (NIST) Handbook 135 dated February 1996 (or the latest version) – Life Cycle Costing Manual for the Federal Energy Management Program.

Use the following parameters when performing the analysis:

- 20 year life-cycle period for system comparison
- Public domain programs such as TRACE, E-CUBE, and Carrier E20-II, etc.
- Other features are:
  - 7% discount factor
  - No taxes or insurance while computing cost

### 1.2.2 EXECUTIVE ORDER 13423 DATED JANUARY 26, 2007

Mandatory energy conservation requirements are also published in the above Executive Order. The MOU is mentioned in Section 2, paragraph f of the Executive Order. The MOU was signed under the Federal Leadership in High Performance and Sustainable Buildings.

The stated goals and objectives of the MOU are as follows:

#### 1.2.2.1 New Construction

For new construction, reduce the energy cost budget by 30% compared to the baseline performance rating of ASHRAE Standard 90.1 - 2004. This requirement is identical to the DOE Final Rule published in the Federal Register.

#### 1.2.2.2 Major Renovations

For major renovations, reduce the energy cost budget by 20% below pre-renovations 2003 baseline. In the event pre-renovation 2003 baseline data is not available, the A/E shall calculate the energy consumption before renovation, compare it with the energy consumption after renovation, and document the mandated savings. It is assumed that the use of the facility shall remain similar before and after the renovation. A project classified as “major renovation” shall meet the following two criteria:

**(a)** For a facility selected for renovation, the area of renovation is greater than 50% of the total area.

**(b)** A project is planned that significantly extends the building’s useful life through alterations or repairs and totals more than 30% of the replacement value of the facility.

#### 1.2.2.3 VA Policy

Reduction in the energy cost budget shall be implemented as the reduction in energy consumption measured as BTU (British Thermal Units) or Joules (J).

#### 1.2.2.4 Additional Measures (MOU)

MOU also addresses related issues such as commissioning, measurement, and verification, and protection and conservation of indoor and outdoor water. These issues are described below.

## 1.3 COMMISSIONING

While the VA guidelines for commissioning are under preparation to be issued soon, employ total building commissioning practices tailored to the size and complexity of the building and its system components in order to verify performance of building components and systems and help ensure that design requirements are met. This shall include a VA-designated commissioning authority to perform the following:

- Include commissioning requirements in construction documents
- Provide commissioning plan
- Verify the installation and performance of systems to be commissioned
- Provide commissioning report

## 1.4 MEASUREMENTS AND VERIFICATION

Per DOE Guidelines issued under Section 103 of EPACT, install building-level utility meters in new major construction and renovation projects to track and continuously optimize performance. MOU mandates that the actual performance data from the first year of operation shall be compared with the energy design target. After one year of occupancy, measure all new major installations using the ENERGY STAR® Benchmarking Tool for building and space types covered by ENERGY STAR® or FEMP designated equipment.

## 1.5 COMPLIANCE

See Section 1.9 for a list of abbreviations, applicable codes, and standards. These references are also given in the text of this manual where appropriate.

## 1.6 VA HOSPITAL BUILDING SYSTEM

The VA Hospital Building System (VAHBS) is a methodology based on a modular concept for planning, designing, and constructing hospitals.

The methodology has been used nationwide successfully for capital and operating cost containment, shortened delivery schedules, and improved space utilization flexibility. All new and replacement VA hospital buildings shall use the VAHBS system. This system is also recommended for major additions to existing hospitals where future adaptability is an important factor.

See VHA Program Guide PG-18-3, Design and Construction Procedures, Topic 3, VA Hospital Building System for further guidance. The complete reference for the VAHBS is contained in the 1976 Development Study (called the Redbook) and the 2006 Supplement. Additional details are included in Appendix 1-A.

### 1.6.1 DESIGN IMPLICATION

Due to the modular concept, the A/E will find that mechanical schematic/design development decisions occur much earlier in the overall planning/design process. Equipment selection and main distribution sizing should be evaluated as soon as the size and number of modules is determined.

## 1.7 PERTINENT STANDARDS

**Note:** The A/E shall submit to the VA a list of all applicable documents, posted in the TIL, listed below along with the datesthat were in effect on date of contract award.

Major standards are described in this section.

### 1.7.1 DESIGN MANUALS (PG-18-10)

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/manuals_hosp.asp**

**Purpose**
Conveys the general and specific VA design philosophy for medical and support facilities.

The manuals accomplish this by:

- Explaining specific design methodologies.
- Listing acceptable system types.
- Codifying certain code interpretations.
- Listing values for design parameters.
- Referencing certain sections of the Master Specification and Standard Details.
- Containing examples of certain design elements.

### 1.7.2 DESIGN SUBMISSION REQUIREMENTS (PG-18-15)

Located in Architect/Engineer Information
**http://www.va.gov/facmgt/ae/des_sub.asp**

The submission requirements shall be implemented in conjunction with Appendix 1-C.

**Purpose**
Provides a staged list of tasks in various design categories to define the A/E scope and assure thorough and timely completion of the final design package and bid documents.

The instructions accomplish this by:

- Progressively listing tasks at Schematic, Design Development, and Construction Documents stages.
- Requiring task completion and submission for each stage according to a Critical Path Method (CPM) calendar.
- Requiring implementation of a QA/QC process to assure a quality design product.
- Requiring life-cycle analysis of alternatives in order to optimize the design/cost tradeoff.
- Listing and detailing all the drawings, calculations, and specifications required for a complete design package.
- Indicating the final distribution of bid documents.

**Note:** The A/E shall submit specifications at the Construction Documents (CD1) submittal to include an electronic version of the VA Master Specifications with tracked changes or modifications displayed.

### 1.7.3 MASTER SPECIFICATIONS (PG-18-1)

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/spec_idx.asp**

**Purpose**
Defines a standardized method for the A/E to assure that the contractors provide equipment and systems that meet the design intent in terms of performance, quality, and cost.

The specifications accomplish this by:

- Providing specific narrative descriptions of required equipment, salient elements, and system construction.
- Listing applicable standards and codes and references.
- Requiring individual submittal of equipment and systems for review and approval prior to contractor purchase.
- Defining specific installation methods to be used.

### 1.7.4 ARCHITECT ENGINEER REVIEW CHECKLIST

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/ae_checklist.asp**

**Purpose**
Provides the VA Peer Reviewer with a minimum list of critical items which must be included in each A/E submission.

The checklist accomplishes this by:

- Referring to all VA design tools which pertain to the specific project.
- Detailing certain life safety and coordination requirements.

### 1.7.5 DESIGN ALERTS

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/d_alert.asp**

**Purpose**
Communicates current design issues and solutions.

The design alerts accomplish this by:

- Publishing periodic alert memos.
- Summarizing design solutions.

### 1.7.6 QUALITY ALERTS

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/q_alerts.asp**

**Purpose**
Communicates quality deficiencies from recent A/E design submissions.

The quality alerts accomplish this by:

- Publishing checklists of design details often missed.
- Including references to technical resources.

### 1.7.7 DESIGN GUIDES (PG-18-12)

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/dg_idx.asp**

**Purpose**
Provides the designer with specific layout templates and medical equipment lists for all types of spaces/uses and specific design parameters for structural, electrical and mechanical service.

The design guides accomplish this by:

- Publishing design information.
- Including functional diagrams and layout plates.
- Listing standards.

### 1.7.8 DESIGN AND CONSTRUCTION PROCEDURES (PG-18-3)

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/proc_idx.asp**

**Purpose**
Establishes minimum consistent design/construction practices.

The procedures section accomplishes this by:

- Referencing applicable codes and policies.
- Describing standard drawing formats.
- Listing security strategies.
- Including miscellaneous design details.

### 1.7.9 NATIONAL CAD STANDARDS (NCS) AND DETAILS (PG-18-4) AND CAD DELIVERABLES GUIDELINES (PG-18-4)

Located in Technical Information Library (TIL)
**http://www.va.gov/facmgt/standard/details.asp**

**Purpose**
Promotes standardization of CAD documents submitted to the VA Authorities.

The standards section accomplishes this by:

- Providing downloadable equipment schedules.
- Listing symbols and abbreviations.
- Providing downloadable standard details in .dwg or .dwf format.
- Providing guidelines for preparing CAD drawings.

**NOTE:** The A/E shall utilize the VA Standard Details to the fullest extent possible. A modification to a Standard Detail requires the approval of the VA Authorities.

### 1.7.10 PHYSICAL SECURITY DESIGN MANUAL FOR VA FACILITIES – MISSION CRITICAL FACILITIES AND LIFE SAFETY PROTECTED FACILITIES (FORMERLY CD-54)

**http://www.va.gov/facmgt/standard/physecurity.asp**

**Purpose**
Sets physical security standards required for facilities to continue operation during a natural or man-made extreme event and for facilities that are required to protect the life safety of patients and staff in an emergency.

The manuals accomplish this by:

- Setting objectives for physical security.
- Providing strategies for use in design and construction to provide protection to VA facilities.
- Providing cost-effective design criteria.

### 1.7.11 COST ESTIMATING MANUAL

Located in Cost Estimating
**http://www.va.gov/facmgt/cost-estimating/**

**Purpose**
Conveys the general and specific VA cost estimating philosophy for medical facilities.

The manual accomplishes this by:

- Explaining specific estimating methodologies.
- Providing examples of certain design elements.

### 1.7.12 SUSTAINABLE DESIGN FOR DESIGN AND CONSTRUCTION OF VHA FACILITIES, VBA FACILITIES, AND NCA FACILITIES

**Purpose**
Incorporates sustainable design practices to improve the building environment and to provide cost savings for long-term building operations and maintenance.

The manual accomplishes this by:

- Prescribing the use of integrated design practices.
- Providing strategies for optimization of energy performance.
- Providing strategies for protection and conservation of water resources.
- Providing strategies for enhancement of indoor environmental quality.
- Providing strategies for reduction of environmental impact of materials.

### 1.7.13 SEISMIC DESIGN REQUIREMENTS (H-18-8)

Located in Technical Information Library (TIL)
**http://www.VA.gov/facmgt/standard/etc/seismic.pdf**

**Purpose**
Sets the requirements for seismic design in new facilities and for rehabilitation of existing facilities.

The manual accomplishes this by:

- Defining critical and essential facilities.
- Prescribing code compliance with modifications.
- Prescribing occupancy categories.

### 1.7.14 FIRE PROTECTION DESIGN MANUAL

Located in Technical Information Library (TIL)
**http://www.VA.gov/facmgt/standard/dmnual/dmfpfire.doc**

**Purpose**
Provides the fire protection engineering design criteria for all categories of VA construction and renovation projects.

The manual accomplishes this by:

- Mandating code and standard compliance.
- Defining water supply requirements.
- Defining fire extinguishing and fire alarm system requirements.

## 1.8 COMPUTER AIDED FACILITIES MANAGEMENT REQUIREMENTS (CAFM)

The VA intends to implement Computer Aided Facility Management (CAFM) systems in all new and replacement hospital construction, and as feasible in all existing hospitals. The CAFM concept requires that all pertinent data regarding a facility be contained in a master digital database, accessible by facilities personnel at their workstations for use in operations, energy/cost management, and maintenance and for planning modifications in facility infrastructure due to space utilization changes.

In Appendix 1-B, additional information about format, utilization, and calculations is given.

## 1.9 ABBREVIATIONS AND REFERENCES

### 1.9.1 ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| A/E | Architects and Engineers |
| AB | Air Blender |
| AC | Air-Conditioning Section |
| AF | After-Filters |
| AFCV | Air Flow Control Valve |
| AHU | Air-Handling Units |
| BHP | Brake Horse Power |
| BMT | Bone Marrow Transplant |
| BSC | Biological Safety Cabinets |
| BTU | British Thermal Units |
| BTUH | British Thermal Units per Hour |
| CC | Cooling Coil |
| CD-1 | Conceptual Design (Submission1) |
| CD-2 | Conceptual Design (Submission2) |
| CFM | Cubic Feet Per Minute |
| CH | Chiller |
| CHW | Chilled Water |
| CT | Cooling Tower |
| CV | Constant Volume |
| D-1 | Outdoor Air Damper |
| D-2 | Return Air Damper |
| D-3 | Relief Air Damper |
| DD-1 | Design Development (Submission1) |
| DD-2 | Design Development (Submission2) |
| DDC | Direct Digital Controls |
| DPA | Differential Pressure Assembly |
| DP | Diffuser Plate |
| DPS | Differential Pressure Switch |
| DX | Direct-Expansion |
| ECC | Engineering Control Center |
| EER | Energy Efficiency Ratio |
| ETO | Ethylene Oxide |
| FF | Final Filters |
| FM | Flowmeter |
| FPM | Feet Per Minute |
| FPS | Feet Per Second |
| GPM | Gallons Per Minute |
| H | Humidifier |
| HAC | Housekeeping Aide’s Closet |
| HRD | Heat Recovery Device |
| HW | Hot Water |
| ICU | Intensive Care Unit |
| JC | Janitor’s Closet |
| KPA | 1000 Pascal |
| LAFW | Laminar Air Flow Workbench |
| MB | Mixing Box |
| MERV | Minimum Efficiency Reporting Valve |

| Abbreviation | Description |
|---|---|
| MRI | Magnetic Resonance Imaging |
| NC | Noise Level |
| OA | Outside Air |
| P | Pump |
| PF | Pre-Filter |
| PHC | Preheat Coil |
| PPM | Parts Per Million |
| PSI | Pounds per Square Inch |
| PSIG | Pounds per Square Gage |
| PSS | Primary Secondary System |
| RA | Return Air |
| RAF | Return Air Fan |
| RDS | Room Data Sheets |
| REA | Relief Air |
| RF | Radio-Frequency |
| RHC | Reheat Coil |
| SCI | Spinal Code Injury |
| SA | Supply Air |
| SAF | Supply Air Fan |
| SD | Smoke Detector |
| SD-1 | SA Duct Smoke Damper |
| SD-2 | RA Duct Smoke Damper |
| SDB | Branch Return Air Duct Detercor |
| SDR | Smoke Damper (Return) |
| SDS | Smoke Damper (Supply) |
| SP | Static Pressure |
| SPD | Supply Process and Distribution |
| TAB | Testing Adjusting and Balancing |
| VAV | Variable Air Volume |
| VHA | Veterans Health Administration |
| VPS | Variable Primary System |
| VSD | Variable Speed Drive |
| WG | Water Gage |

### 1.9.2 REFERENCES

| Abbreviation | Full Description of Reference |
|---|---|
| AMCA | Air Movement and Control Association International |
| ANSI | American National Standards Institute |
| ARI | Air-Conditioning and Refrigeration Institute |
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| DOE | Department of Energy |
| IMC | International Mechanical Code |
| IPC | International Plumbing Code |
| ISO | International Organization for Standardization |
| NEC | National Electric Code |
| NEMA | National Electrical Manufacturers Association |
| NFPA | National Fire Protection Association |
| NSF | National Science Foundation |
| OSHA | Operational Safety and Health Administration |
| SMACNA | Sheet Metal and Air-Conditioning Contractors' National Association |
| UBC | Uniform Building Code |
| UL | Underwriters Laboratories |

# APPENDIX 1-A :VA HOSPITAL BUILDING SYSTEM

## 1-A.1 DESCRIPTION OF MODULES

### 1-A.1.1 INTRODUCTION

The Redbook proposes a systematic or modular approach to the design of new hospital buildings. The building system approach requires integration of service modules starting with the initial stages of the design process. Service modulesare defined as one-story units of building volumes with a foot print of 10,000 Square Feet [3,048 Meters] to 20,000 Square Feet [6,096 Meters]. Each module is comprised of structural bays, a service zone, and a functional zone (often subdivided into space modules). Each service module is completely contained in a fire compartment, either alone or with one or more other modules.

### 1-A.1.2 STRUCTURAL BAYS

The structural bay  is the basic unit of which all other modules are composed. The dimensions of the structural bay are influenced by the functional layout, service zone clearances, and the type of structural system selected.

### 1-A.1.3 THE SERVICE ZONE

A service zone includes a full height service bay (with independent mechanical, electrical, and telecommunications rooms) and an independent service distribution network that includes an interstitial space above the functional zone.

### 1-A.1.4 THE FUNCTIONAL ZONE

The functional zoneis the occupied floor area within a service module. Space modules are subdivisions of the functional zone.

### 1-A.1.5 FIRE COMPARTMENT

A fire compartment  is a unit of area enclosed by a two-hour rated fire resistive construction with at least two different exits.

### 1-A.1.6 UTILITIES

Individual HVAC, plumbing, electrical power, telecommunications, and fire protection (sprinkler systems) are all fully integrated into the service module.

## 1-A.2 ZONING OF AIR-HANDLING UNITS

### 1-A.2.1 ZONING CONSIDERATIONS

As far as possible, selection of the air-handling unit shall follow the modular concept and match the boundary of the service zone. To achieve this, the space planners must ensure that only a single functional department is fitted in the space below the service zone.

During the conceptual design development, the following issues should be raised and resolved with the space planners:

**(a)** A single air-handling unit is meant to serve one medical function such as surgery, the patient wing, or a clinic. The same air-handling unit cannot service multiple functional areas due to their substantially differing HVAC needs.

**(b)** Should the boundary of the single air-handling unit extend beyond the service zone, the air-handling unit shall cross the service zone to serve the spaces located beyond the zone. Conversely, if two functional areas share the space below the same service zone, multiple air-handling units may be required for the same service zone. Multiple air-handling units may also be required if the capacity requirement of the functional space exceeds the limiting parameter of 40,000 CFM [18,868 Liters/Second].

## 1-A.3 REFERENCES

### 1-A.3.1 DEVELOPMENT STUDY-VAHBS (REDBOOK – REVISED 1976)

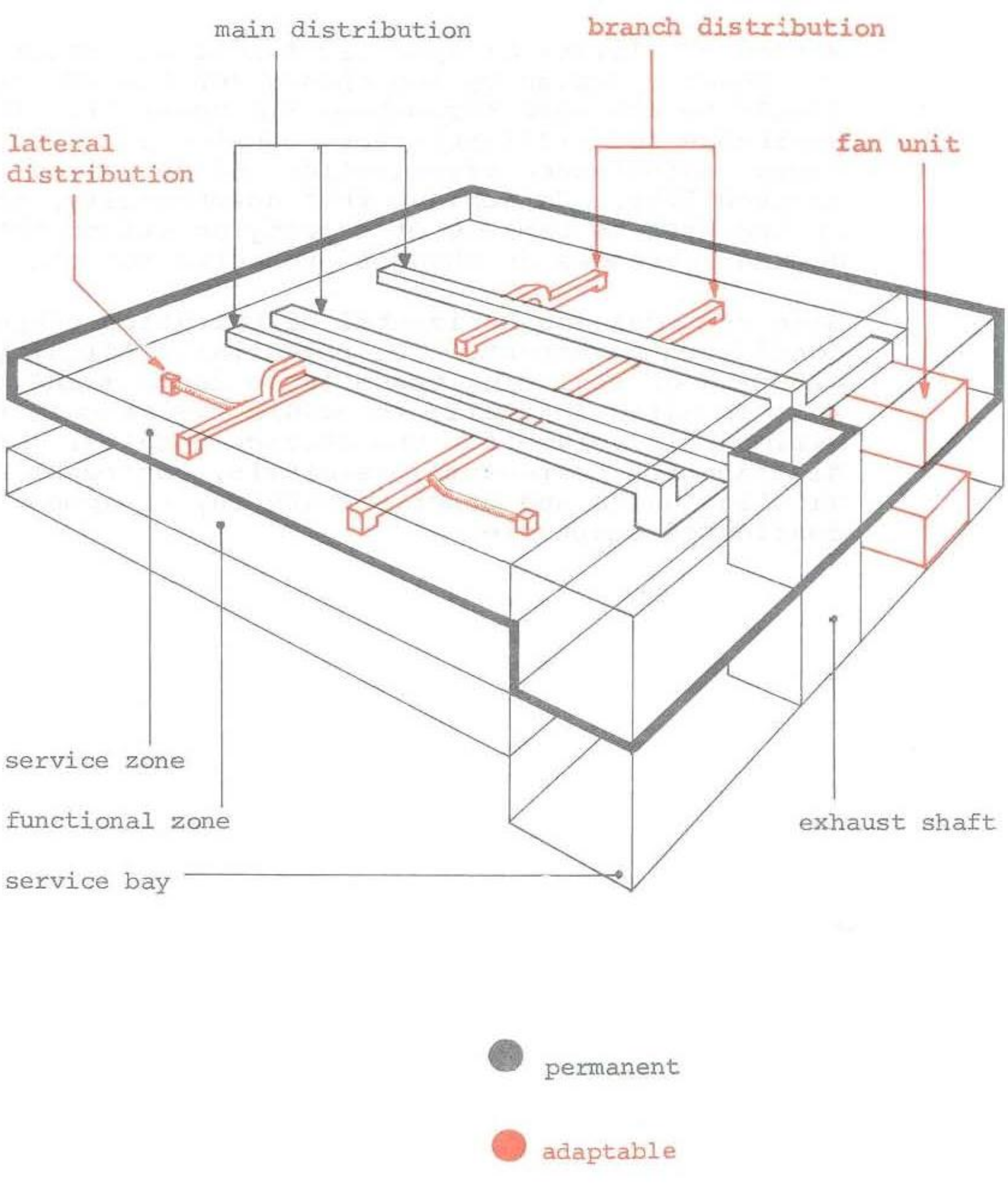
### 1-A.3.2 SUPPLEMENT TO DEVELOPMENT STUDY (2006)

## 1-A.4 BASIC DESIGN OF A SERVICE ZONE

Figure 1-A shows a typical service zone.

Appendix 1-A

**HVAC DESIGN MANUAL**
**Chapter 1 - Basic Requirements**
**May 2004**




**Basic Design of a Service Zone**
Not to Scale

# APPENDIX 1-B: COMPUTER AIDED FACILITIES MANAGEMENT

## 1-B.1 CAFM AND EQUIPMENT SCHEDULE UTILIZATION

### 1-B.1.1 INTRODUCTION

The requirement for access to a master digital database necessitates the compilation all architectural/engineering design data (plans, specifications, calculations, equipment selections, equipment submittal, commissioning/balance reports, and both hard copy and electronic job-related communications) in a digital, electronic format throughout the project. This need for digital data will affect the requirements for submission (see Design Submission Requirements).

### 1-B.1.2 SUBMISSION REQUIREMENTS

Although the VA is still finalizing software requirements for the ultimate CAFM configuration, the A/E shall begin the digital submission process now.

### 1-B.1.3 SCHEDULES

**(a)** The equipment and other schedules, which previously appeared in the VA TIL under the National CAD Standards as either .dwf or .dwg files, have been converted into Excel spreadsheet files (.xls), and are still located in the CAD section of the TIL. The schedules shall be downloaded for use.

**(b)** The schedules are similarly arranged to promote consistent data presentation. Notes for special requirements are listed below the schedules. Roll the cursor over column headings to display pop-up notes containing recommended methodologies for determining how to populate the columns. Several columns are intially hidden for use later in the design/construction and maintenance process.

**(c)** Use the schedules initially for equipment selection and listing. Completed schedules can then be inserted into project CAD drawings. Copies of the Excel files will be given to the successful contractor to fill in data from approved submittals, equipment suppliers, or bills of material. These modified schedules will then be inserted into the final as-built CAD drawings, to become part of the ultimate CAFM database. The facilities management group can then reveal the hidden columns for their purposes.

**(d)** The A/E Submission Requirements include full calculation sets for equipment selections. These calculations will also appear in the pop-up data boxes to provide easy access when used later in the CAFM system.

# APPENDIX 1-C: A/E SUBMISSION REQUIREMENTS AND HVAC DESIGN MANUAL COORDINATION

## 1-C.1 GENERAL

### 1-C.1.1 INTRODUCTION

In this appendix, specific tasks outlined in the A/E Submission Requirements for Major New Facilities, Additions, and Renovations (Program Guide, PG-18-15, Volume B, May 2006) at various submittal stages of the design process are presented and related to the contents of this Design Manual. This effort substantiates and supplements the Submission Requirements, while providing in-depth insight into the submission needs.

### 1-C.1.2 COORDINATION

Coordination between the Submission Requirements and the Design Manual is mandatory. Variations and deviations from the prescribed submission task may be permitted on a case-by-case basis, if and where deemed necessary, to meet the project-specific scope of work. Such variations and deviations must be submitted in writing for the prior approval by the VA Authorities.

### 1-C.1.3 COMPLIANCE REQUIREMENTS

For each submittal, the A/E shall forward to the VA a detailed list of the submission required with a notation of full or partial compliance.

### 1-C.1.4 SPECIFIC DRAWING REQUIREMENTS

**(a)** The contract drawings shall include those listed below. For uniformity, drawings shall be arranged in the order listed. See NCS for more organizational detail:

- MH – 0xxx General Notes, Abbreviations, and Symbols (use only VA NCS).
- MD – 1xxx Demolition of existing HVAC work, floor plans, if applicable. Minor demolition may be shown on new construction drawings. Extensive demolition requires drawings for demolition only.
- MS – 1xxx Site Plan, Chilled Water. Heating Water as applicable, Steam Distribution.
- MH – 1xxx Floor Plans 1/8” = 1’-0” (1:100) for Equipment and Ductwork.
- MP – 1xxx Floor Plans 1/8” = 1’-0” (1:100) for Equipment and Piping.
- MH – 3xxx Sections shall be shown at large scale as required to clarify installation, especially through areas of possible conflict. At least 2 full building sections shall also be provided. Show all the equipment, including plumbing and electrical.
- MH – 4xxx Large Scale Floor Plans and Sections ¼” = 1’0” (1:50) for Mechanical Equipment Rooms (MERs). This includes central chillers and boiler plants.
- MH – 4xxx Large Scale Plans ¼” = 1’0” (1:5) for Mechanical Chases at each floor, showing all ducts, dampers, piping, and plumbing. All sizes shall be indicated at each level.
- MH – 5xxx VA Standard Details and all other necessary details.
- MH – 6xxx VA Standard Equipment Schedules. Include schedules for existing air-handling units, fans, pumps, etc. that will require alteration or rebalancing. See listing for the order of Equipment Schedules.
- MH – 6xxx Flow Diagrams for Chilled Water and Hot Water Systems. Flow diagrams shall show entire system on a single drawing.
- MH – 6xxx Flow and Control Diagrams for Steam and Condensate Piping Systems.
- MP – 7xxx Piping Riser Diagrams for chilled water, hot water, steam and condensate systems, where applicable. Piping Diagrams shall show all sizes, valves, gages, unions, vibration isolation, expansion devices, control devices, etc.
- MH – 8xxx Temperature Control Diagrams and Sequence of Operation for all HVAC Systems, including “Sequence of Operation” written on the drawings alongside the control diagrams.

**(b)** Walk-in refrigerators/freezers in dietetic areas and in laboratories shall be shown on “MH” drawings.

**(c)** Room numbers and names shall be shown on HVAC plans at every review stage including schematic submissions. Where there is insufficient room on the HVAC floor plans to show room names, room numbers only may be shown on the floor plan, with the room number and name tabulated on the drawing.

### 1-C.1.5 EQUIPMENT SCHEDULES

#### 1-C.1.5.1 Order of Presentation

Equipment schedules shall be listed in the following order, vertically, from left to right, to facilitate checking and future reference. Refer to Appendix 1-B for equipment schedule utilization. For each item in a schedule, show the Basis of Design, including the manufacturer and model number selected.

**(a)** Air Conditioning Design Data (Outdoor and Indoor Design Conditions for the various occupancies)
**(b)** Air Flow Control Valves
**(c)** Air Flow Measuring Devices
**(d)** Air Handling Equipment
**(e)** Air Separators
**(f)** Chillers, Condensing Units, Air-Cooled Condensers
**(g)** Heat Exchangers
**(h)** Cooling Towers
**(i)** Engineering Control Center
**(j)** Expansion Tanks
**(k)** Fans
**(l)** Fan-Coil Units, Air Terminal Units (Boxes)
**(m)** Filters for Closed Loop Water Systems (chilled water and hot water)
**(n)** Finned Tube Radiation
**(o)** Heat Recovery Equipment
**(p)** Humidifiers
**(q)** Pre-Filters, After-Filters, Final-Filters, and Terminal-Filters
**(r)** Preheat Coils, Cooling Coils, Reheat Coils
**(s)** Pressure Reducing Valves, Safety Valves
**(t)** Pumps
**(u)** Radiant Heating Panels
**(v)** Room By Room Air Balance
**(w)** Sound Attenuators
**(x)** Supply, Return, and Exhaust Air Diffusers and Registers
**(y)** Unit Heaters
**(z)** Vibration Isolators
**(aa)** Water Flow Measuring Devices
**(bb)** Control Valves

#### 1-C.1.5.2 Equipment Capacity and Performance Data Requirements

Equipment performance and capacity data shall correspond to that shown in the calculations, not a particular manufacturer's catalog data, but rather the data shall be in the range of available manufactured products.

#### 1-C.1.5.3 Equipment Schedules – Glycol Data

Heat exchangers, coils, pumps, and chillers in a glycol-water system shall be identified on the equipment schedule showing the percent glycol by volume of the circulating fluid for equipment de-rating purposes.

## 1-C.2 SCHEMATICS 1 (S1)

| **Task Description (Item 9a – Page 8)**<br>Provide estimated heating and cooling requirements of the existing and/or new buildings based on the gross square footage of area of each unique function space, such as patient bedrooms wing, animal research area, laboratories, offices, etc. Coordinate the estimated preliminary steam demand with the A/E submission requirements of the Steam Generation Section. |
|---|
| **Design Manual Coordination**<br>Provide basis for selecting the gross square footage for heating and cooling of each unique function. |

| **Task Description (Item 9b – Page 9)**<br>Investigate the condition and availability of the spare capacity of the existing systems such as chilled water, hot water, and steam, if any, and provide specific recommendations for meeting the needs of the project |
|---|
| **Design Manual Coordination**<br>Refer to Chapter 2 for the field survey requirements and the need to interview the technical personnel at the project site. |

| **Task Description (Item 9c – Page 9)**<br>Investigate the availability of utilities such as natural or propane gas, electricity, etc. for the HVAC equipment and provide their status. |
|---|
| **Design Manual Coordination**<br>Refer to Chapter 2 for the field survey requirements and the need to interview the technical personnel at the project site. Obtain the utility rate structure from the VA Facility and establish the division in the scope of work between the utility company and VA. |

| **Task Description (Item 9d – Page 9)**<br>Provide description of the tentative zoning of the spaces for proposing dedicated HVAC systems. State clearly the engineering criteria and rationale used for selecting three different types of systems for the life-cycle cost analysis for each functional space. State clearly all assumptions and parameters to be used in the analysis. If the analysis is scheduled to be performed on a computer, provide the name of the program. |
|---|
| **Design Manual Coordination**<br><br>**(a) Zoning Requirements:** HVAC zoning requirements are given in Chapter 6 and Appendix 6-A, where a list of the spaces that are grouped together with each dedicated air-handling unit is given. Depending upon the size and scope of the projects, the dedicated air-handling units may not be required, if approved by VA Authorities.<br><br>Refer to Chapter 2 for the systems generally not permitted in the VA facilities.<br><br>**Examples:**<br>Radiant ceiling panels for cooling<br>Fan coil units for new construction<br><br>**(b) Life-Cycle Cost Analysis (System Comparison):** Where an all-air system is mandated in the design manual, life-cycle cost analysis comparing three systems is not required on airside. |

| **Task Description (Item e – Page 9)**<br>Provide a list of the energy conservation measures proposed to be used in the HVAC system design and the life-cycle cost analysis. State clearly the logic and criteria used in selecting each conservation measure. |
| --- |
| **Design Manual Coordination**<br><br>**(a)** In Chapter 1, Executive Order and MOU (Memorandum of Understanding) mandates 30% additional energy conservation over the ASHRAE Standard 90.1 – 2004 baseline. To meet this goal, wholly or partially, several measures are outlined in this manual. In Chapter 2, building thermal envelope study and energy recovery systems are described. In Chapter 4, a major study requiring optimization of the chilled water plant and piping/pumping arrangement is described. In Appendix 6-A and Appendix 6-B, numerous control sequences promoting energy conservation are mentioned.<br><br>**(b)** The A/E should generate a list of the project-specific energy conservation measures to attain the goal of energy conservation and provide life-cycle cost analysis back-up data for each measure. |

## 1-C.3 SCHEMATICS 2 (S2)

| **Task Description (Item 9a – Page 18)**<br>Provide a description of the heating, ventilating, and air-conditioning (HVAC) systems and equipment for each functional space. |
|---|
| **Design Manual Coordination**<br>Chapter 2 and Chapter 3 describe the HVAC systems and their configurations. |

| **Task Description (Item 9b – Page 18)**<br>Provide complete life-cycle cost analysis with specific recommendations and full back-up data. State the heating and cooling capacities of each functional area used in the life-cycle cost analysis. State the block cooling and heating loads for each new and/or existing building. |
|---|
| **Design Manual Coordination**<br>The life-cycle cost analysis procedure and results for the central plant shall be in compliance with the methodology outlined in Chapter 1. While performing the life-cycle cost analysis, the A/E shall use block loads provided in 9a of S1. |

| **Task Description (Item 9c – Page 18)**<br>Indicate tentative locations and sizes of all mechanical equipment rooms and principal vertical shafts. Show a block layout of major pieces of equipment in each mechanical equipment room. Show outside air, exhaust air, and relief air louvers. Resolve various items affecting louver location, while considering other factors such as visibility, historical considerations, wind direction, nuisance and health hazard odors caused by short circuiting of air from exhaust from emergency generators, truck waiting areas, etc. to intake. |
|---|
| **Design Manual Coordination**<br><br>**(a)** Coordinate with the equipment and louver locations with the physical security requirements. Note the special considerations imposed by facilities that are in the vicinity of hurricanes and major storms.<br><br>**(b)** Provide dedicated shafts for the contaminated exhaust per NFPA 90A. |

## 1-C.4 DESIGN DEVELOPMENT 1 (DD1)

| **Task Description (Item 9a – Page 28)**<br>Provide the first version of the detailed zone heating and cooling load calculations. Accompany these calculations with the architectural drawings 1:200 (1/16 inch) scale showing correlation between each zone boundary and the floor area and abbreviated/coded room numbers used with computer input data sheets. Provide input manuals for the software programs with clear indications of the capabilities and limitations of the programs. Provide a level of detail of the calculations consistent with the development of the architectural drawings. |
|---|
| **Design Manual Coordination**<br>**(a)** Chapter 2 requires computerized calculations and computerized psychrometric analysis. Specify the software program used for performing calculations and analyses. Provide an input manual and a matrix showing the co-relationship between the room numbers used and architectural drawings.<br><br>**(b)** Submit first version of additional mandated energy conservation measures with calculations in accordance with Chapter 1. |

| **Task Description (Item 9b – Page 28)**<br>For air handling units, heating and ventilating units, and exhaust air systems, estimate the capacities in cubic feet [cubic meters] per minute, static pressure, and required fan motor horse power. |
|---|
| **Design Manual Coordination**<br>Express the supply air volume in the Inch-Pound (IP) units followed by SI (Metric Units) CFM (Cubic Feet per Minute) followed by Liters per Second (Liters/Second) in metric units. Provide an air balance for each air-handling unit with the level of detail consistent with the progress of project. |

| **Task Description (Item 9c – Page 28)**<br>For the proposed chilled water plant, indicate the quantity and type of chillers, capacity in tons of refrigeration, and the electrical requirements. Provide pertinent data for the chilled water plant accessories, that is, the chilled water and condenser water pumps, and cooling tower. Coordinate the cooling tower location with other disciplines. Perform a sound/acoustic analysis to ensure that the noise generated by the chillers, condensers and condensing units, cooling tower, etc. is in compliance with the acceptable limits stipulated in the VA HVAC Design Manual. |
|---|
| **Design Manual Coordination**<br>The A/E shall carefully study the two requirements outlined in Chapter 2 and include them in DD1 submission with specific recommendations.<br><br>These requirements are:<br><br>• Acoustic Analysis<br>• Dispersion Analysis |

| **Task Description (Item 9d – Page 28)**<br>For the heating system, compile the total heating load based on the available information of the space heating requirements, domestic hot water load, humidification loads, and the equipment steam demand. Provide a written description of the proposed zoning of the heating system indicating such features as distribution of ventilation load, perimeter heat load, and reheat load associated with air terminal units. |
|---|
| **Design Manual Coordination**<br><br>**(a)** Coordination with the Steam Generation, Outside Utility Distribution, Architectural Service, and the Medical Center is essential before the preparation of the construction drawings.<br><br>**(b)** Submit dispersion analyses for the boilers. |

| **Task Description (Item 9e – Page 28)**<br>Assemble and provide available preliminary electrical power (normal and emergency) data to the electrical discipline. |
|---|
| **Design Manual Coordination**<br>Emergency power requirements are given throughout this manual. Mission critical facilities may require more emergency power than the minimum specified here.<br><br>Coordinate with the electrical discipline the extent of emergency power, generator room size, number of generators, and the type of generators (with integral radiators or remote radiators), fuel requirements, and fuel storage needs. |

| **Task Description (Item 9f – Page 28)**<br>Provide a description of the interaction between the existing HVAC systems (if any) and the new requirements. State clearly the impact on the existing HVAC systems. |
|---|
| **Design Manual Coordination**<br>The design team shall coordinate the hidden costs associated with the existing HVAC systems and correctly estimate the impact on the project cost. These costs are:<br><br>• Testing, Adjusting, and Balancing (TAB) of the existing systems<br>• Replacing components such as electric motors, starters, drives of the existing systems<br>• Impact on the architectural and interior design, such as demolition of the suspended ceiling and light fixtures, new suspended ceiling, fixtures, painting, shutdown, etc. |

| **Task Description (Item 9g – Page 28)**<br>Provide a written description of the seismic criteria (if applicable) on the HVAC systems. |
|---|
| **Design Manual Coordination**<br>See Chapter 2 for the seismic criteria and the reference of the applicable manuals and standards. Ensure coordination with these documents. |

| **Task Description (Item 9h – Page 28)**<br>Provide a list of edited VA standard symbols and abbreviations. |
|---|
| **Design Manual Coordination**<br>See TIL for the National CAD Standards. |

| **Task Description (Item 9i – Page 28)**<br>Provide 1:100 (1/8 inch) scale HVAC floor plans for typical areas showing the proposed routing of the main air distribution and piping layouts. Ductwork and piping may be shown in single line. |
|---|
| **Design Manual Coordination**<br><br>**(a)** Use of the single line ductwork is permitted only through DD1 submission.<br><br>**(b)** Refer to Chapter 2 for the double line ductwork and piping for the DD2 documents.<br><br>**(c)** Submit HVAC floor plan for each functional area such as a nursing unit, radiology, surgery, SPD, etc. |

| **Task Description (Item 9j – Pages 28 and 29)**<br>Show fire and smoke partitions on HVAC floor plans. Show necessary smoke and fire dampers and smoke detectors, etc. on floor plans. For buildings that are not equipped with quick response sprinklers, describe each designated smoke zone interaction with the HVAC systems for the building. |
|---|
| **Design Manual Coordination**<br>Ensure coordination with the VA Standard Detail for the duct crossing of the designated barrier for control sequence and division in the scope of work. |

| **Task Description (Item 9k – Page 29)**<br>Provide equipment schedule for each major equipment. |
|---|
| **Design Manual Coordination**<br>Provide all anticipated equipment schedule information in the VA standard format arranged as in section 1-C.1.5 Equipment Schedules, this appendix. Provide data for major equipment, leaving remaining schedules blank. |

| **Task Description (Item 9l – Page 29)**<br>Submit 1:50 (¼ inch) scale floor plans of the typical mechanical equipment rooms (MERs) with at least two cross-sections showing all floor and ceiling mounted equipment, major ductwork, and piping. Show all ductwork and piping, 6 inches [150 mm] and larger, in double line. On the cross-sections, generally taken at right angles to each other, show actual elevations of each HVAC component, rise and drop as required to coexist with other interfering items of equipment and other building elements such as beams, lights, plumbing pipes, cable trays, etc. On the MERs, show all miscellaneous equipment and systems such as heating and ventilating systems for the MERs and locations of the temperature control panels. Clearly demonstrate clearances for access and maintenance with coil and tube pull spaces on the equipment layouts. |
|---|
| **Design Manual Coordination**<br>Ensure that the equipment room includes space and related requirements of the sub-systems, such as:<br><br>• Mechanical Room Ventilation and Heating<br>• Emergency Exhaust System Refrigerant Spill Removal<br>• Make-Up Air System<br>• Cooling Tower Make-Up Water System |

| |
|---|
| **Task Description (Item 9m – Page 29)**<br>Provide schematic flow and riser diagrams for each type of the typical air handling systems and all hydronic systems such as chilled water system, hot water system, steam system, glycol heat recovery system, etc. Provide existing capacities of these systems and new estimated loads with pumping arrangement, and control valves for complete understanding of existing systems to be utilized or interfaced with the new systems. |
| **Design Manual Coordination**<br><br>**(a)** Include general and special exhaust systems, dedicated exhaust shafts where required, floor isolating valves for the piping risers, flowmeters, automatic flow control and balancing devices, motorized dampers, fire dampers, smoke dampers, etc.<br><br>**(b)** Submit each type of the typical air handling system for each functional area, including nursing unit, surgery, radiology, SPD, etc. |

| |
|---|
| **Task Description (Item 9n – Page 29)**<br>Develop schematic control diagrams for each type of typical air and hydronic systems. Show control devices such as thermostats, humidistats, flow control valves, dampers, freeze stats, operating and hi-limit sensors for all air systems and fluids, smoke dampers, duct detectors, etc. |
| **Design Manual Coordination**<br>Provide a DDC controls system architectural layout as specified in the design criteria. Show all DDC control points (analog and binary). |

| |
|---|
| **Task Description (Item 9o – Page 29)**<br>Investigate the possibility of using the existing (if any) central Engineering Control Center (ECC) for the automatic temperature control requirements of the new project. Address the key issues of available spare capacity, compatibility, proprietary expansion, and any other information available from the medical center. |
| **Design Manual Coordination**<br>Coordinate with the requirements given in Chapter 5 of this manual. |

## 1-C.5 DESIGN DEVELOPMENT 2 (DD2)

**Task Description (Item 9a – Page 37)**
Provide the first version of the room-by-room heating and cooling load calculations. These calculations shall be accompanied by the architectural drawings showing correlation between each HVAC zone boundary and the floor area, and a room schedule showing correlation between the architectural room numbers and abbreviated/coded room numbers used with computer input data sheets.

Provide input manuals (if not provided earlier during DD1) for the software programs with clear indications of the capabilities and limitations of the programs. Show the derivation of all "U" factors for building elements based on the actual building construction and published window data. The accuracy and the level of detail of the calculations shall be consistent with the development of the architectural drawings. Update these calculations during subsequent design phases to reflect all changes and availability of additional information. Include the following calculations:

**(1)** Peak zone-by-zone heating and cooling loads.

**(2)** Building block heating and cooling loads.

**(3)** Estimated steam consumption from all sources.

**(4)** Psychrometric chart for each air-handling unit showing cooling and heating coil conditions and computation of humidification loads. Show coil entering and leaving conditions and fan motor heat gains for supply and return air fans.

**(5)** Room-by-room air balance charts for each air handling unit showing supply, return, exhaust, make-up, and transfer air quantities with the intended pressure relationship with respect to adjoining spaces : positive, negative, or zero,.

**Design Manual Coordination**
In Chapter 2, the above requirements are substantiated.

- While calculating heat gain and loss, use the building thermal parameters selected and approved per the Building Thermal Envelope analysis.
- Submit an updated version of additional mandated energy conservation measures with calculations in accordance with Chapter 1. Provide life-cycle cost analysis data and identify the most energy-efficient design.
- Use a software program while performing the psychrometric analysis.
- Include the above room-by-room air balance schedule on the drawings, preferably on the applicable floor plans.

See VA Standard Details for room unit balance schedule.

| **Task Description (Item 9b – Pages 37 and 38)**<br>Submit complete engineering calculations and selection criteria of major HVAC equipment such as chillers, cooling tower, air handling units, heating and ventilating units, return and exhaust fans, circulating pumps, and energy recovery equipment. Provide catalogue cuts for all selected equipment. |
|---|
| **Design Manual Coordination**<br>See Chapter 2. In addition to the above, provide equipment schedules, selection calculations, product data information for heat exchangers, PRV stations, and humidification equipment. All equipment schedule engineering data shall be backed up by submitted calculation. |

| **Task Description (Item 9c – Page 38)**<br>Ensure coordination with electrical, plumbing, and steam generation disciplines by compiling the pertinent information that they require. Distribute information, such as normal and emergency power requirements, steam consumption for all HVAC and kitchen/sterilizer equipment, and make-up water requirements, to the respective trades. |
|---|
| **Design Manual Coordination**<br>Provide a checklist, or any other supporting documents, showing the details of the coordination effort. |

| **Task Description (Item 9d – Page 38)**<br>Submit 1:100 (1/8 inch) scale HVAC floor plans for typical areas showing at least the main supply, return, and exhaust air ductwork with sizes based on the updated calculations. Illustrate duct and ceiling clearances, where ductwork cross, with 1:50 (¼ inch) scale local sections. Indicate ductwork, regardless of sizes and/or complexity of layout and show 6 inch [150 mm] and larger piping in double line. Indicate individual room air distribution and temperature control arrangement for a representative sample of typical spaces, such as patient bedrooms, operating suite, laboratory areas, conference rooms, etc., on duct and piping layouts. Provide separate floor plan drawings for layouts of air distribution and piping systems. |
|---|
| **Design Manual Coordination**<br>Use the duct and piping criteria prescribed in this manual. Deviations, if any, shall be permitted only if backed by acoustic or economic analysis. |

| **Task Description (item 9e – Page 38)**<br>Provide updated 1:50 (¼  inch) scale typical mechanical equipment room plans with resolution of review comments made during previous submission. |
|---|
| **Design Manual Coordination**<br>Typical mechanical equipment rooms shall include an AHU room per each functional area, central plant, and heating room. |

| **Task Description (Item 9f – Page 38)**<br>Update the typical schematic and riser diagrams for air-handling systems and hydronic systems by providing quantities and sizes to reflect the latest engineering calculations. Show locations of all exhaust fans. Also show the locations of all major components with respect to the building floor and each other. |
|---|
| **Design Manual Coordination**<br>Refer to section 1-C.1.4 Specific Drawing Requirements, this appendix, for a list of diagrams and risers. |

| |
|---|
| **Task Description (Item 9g – Page 38)**<br>Perform a sound/acoustic analysis to ensure that the noise generated by the air-handling units and the fans is in compliance with the VA HVAC Design Manual. |
| **Design Manual Coordination**<br>In Chapter 2, minimum requirements and suggested measures are described. |

| |
|---|
| **Task Description (Item 9h – Page 38)**<br>Provide demolition drawings indicating scope of work for demolition. |
| **Design Manual Coordination**<br>None. |

| |
|---|
| **Task Description (Item 9i – Page 38)**<br>Show HVAC work associated with phasing plan. |
| **Design Manual Coordination**<br>The phasing plan shall be coordinated with the medical center in consultation with the VA resident engineer and the required shutdown of the affected facilities and utilities. The phasing plan shall address such issues as swing space, parking interruptions, and re-routing of pedestrian/vehicular traffic. |

| |
|---|
| **Task Description (Item 9j – Page 38)**<br>Show the extent of the outside chilled water and condenser water piping. Clearly show how the piping shall be laid in the tunnels, trenches, or by direct burial. |
| **Design Manual Coordination**<br><br>**(a)** Show piping profile with direct burial system. Provide manholes as required. Piping shall be laid below the frost line. Provide expansion loop and guides for the high-pressure steamlines.<br><br>**(b)** Provide a cross-section of the trenches and tunnel layouts. Trench covers shall be removable. Provide lighting and ventilation with the tunnel installation. Show access to tunnels. |

| |
|---|
| **Task Description (Item 9k – Page 38)**<br>Update the schematic control diagrams for each type of typical air and hydronic system used for development in previous submission by providing a written description of the sequence of operation on the floor plans. Explain clearly the function and role of each control device and describe the safety/alarms and normal operating controls of each system. Provide a schedule showing electrical control interlock of each component. |
| **Design Manual Coordination**<br>See Chapter 5 for additional details. Include DDC architecture on drawings. |

| **Task Description (Item 9l – Pages 38 and 39)**<br>Detail the scope of work involved with the central Engineering Control Center (ECC). Indicate the planned capabilities including features of energy management and conservation. Provide a point schedule for analog/digital input and output to be included in ECC. |
|---|
| **Design Manual Coordination**<br><br>**(a)** See Chapter 5 for the sample of the point schedule.<br><br>**(b)** Ensure coordination with the disciplines other than mechanical. |

| **Task Description (Item 9m – Pages 39)**<br>Specifications. |
|---|
| **Design Manual Coordination**<br>Coordination with the actual scope of work and editing of the specifications is essential. |

## 1-C.6 CONSTRUCTION DOCUMENTS 1 (CD1)

| **Task Description (Item 9a – Page 47)**<br>Provide complete and final engineering calculations of all systems. In addition to the updated room-by-room heating and cooling calculations, perform and submit the following calculations:<br><br>**(1)** Final selection of all pumps with the pump head calculations based on the actual piping layout and takeoffs and pressure drop through the equipment selected for the systems.<br><br>**(2)** Final selection of all fans with the fan static pressure calculations based on the actual duct layouts and takeoffs and static pressure drop through the equipment for the systems.<br><br>**(3)** Sizing and selection of all expansion tanks based on the actual piping layout and volume computation. |
|---|
| **Design Manual Coordination**<br>All selections shall be based on the actual takeoffs using a public domain software program. All engineering parameters indicated on equipment schedules shall be backed up by detailed engineering calculations, submitted in electronic format, and not based on "rule of thumb" and/or "office policies." Variable speed drives shall not be used as a justification for not providing detailed engineering calculations. |

| **Task Description (Item 9a – Page 47)**<br>**(4)** Sizing and selection of all steam to hot water converters and heat exchangers based on the flow requirement of each terminal unit, that is, duct-mounted reheat coil, box (air terminal unit) mounted reheat coil, unit heaters, convectors, finned tube radiation, radiant ceiling panels, etc. |
|---|
| **Design Manual Coordination**<br><br>**(a)** Do not assume water flow rate based on the block load or the fixed and assumed water temperature differential. Flow thus established is likely to fall short of meeting the needs of all terminal units, specifically the miscellaneous terminal units, which are generally not considered.<br><br>**(b)** Submit final version of additional mandated energy conservation measures with calculations in accordance with Chapter 1.<br><br>**(c)** Submit detailed calculations for each PRV station and safety relief valve. |

| **Task Description (Item 9a – Page 47)**<br>**(5)** Sound analysis of various systems and steps shall be taken to ensure compliance with the specified noise levels. |
|---|
| **Design Manual Coordination**<br>See Chapter 2. Acoustic analysis is required for ***all*** HVAC systems, not just for a few typical systems. |

| **Task Description (Items 9b – 9c – 9d) Pages 47 and 48)**<br>**(b)** Provide complete selection data including catalogue cuts and calculations for all HVAC equipment and drawings showing all equipment schedules.<br><br>**(c)** Complete the coordination requirements with electrical, plumbing, and steam generation by providing revised information (if any) developed since the last submission. In addition, complete coordination with the architectural drawings (louvers, ceiling access panels, reflected ceiling plans, etc.) and structural drawings (operating weights of ceiling and floor mounted equipment, concrete and steel supports, roof and floor openings, etc.).<br><br>**(d)** Submit 100% complete HVAC floor plans for all areas showing all ductwork and piping at 1:100 (1/8 inch) scales. Indicate ductwork and piping on separate drawings unless this requirement is waived by VA. Show all duct/pipe sizes and air/fluid quantities. Show air quantities for each room and each air inlet/outlet, expressed in cubic meters (feet) per minute, and fluid quantity, where required, in liters per second (gallons per minute). Show all volume dampers, fire dampers, smoke dampers, automatic control dampers, and rise and drop in ductwork, air inlet/outlets, etc. on the air distribution floor plans. Show all piping specialties, such as expansion loops, anchors, valves, drip assemblies, balancing fittings, etc., on the piping floor plans. Indicate all architectural room names and numbers along with designated smoke and smoke/fire barriers. |
|---|
| **Design Manual Coordination**<br>Express quantities first in IP (Inch-Pound) units followed by SI (Metric) units.<br><br>• CFM (Liters/Second)<br>• GPM (Liters/Second) |

| **Task Description (Item 9e - 9f - 9g – 9h – 9i – 9j – 9k – Pages 48 and 49)** |
|---|
| **(e)** Submit 100% complete HVAC floor plans for all mechanical equipment rooms with at least two cross-sections taken at right angles to each other at 1:50 (1/4 inch) scale. Show all equipment located on roof and/or grade.<br><br>**(f)** Update smoke and fire partitions in HVAC floor plans as described under DD1.<br><br>**(g)** Provide 100% complete drawings of the outside chilled water and condenser water distribution showing pipe sizes and insulation with plans, profile, sections, details, and all accessories such as anchors, expansion loops/joints, valves, manholes, capped and flanged connections, and interfaces between the new and existing work (if any). Clearly indicate any interferences with the existing utilities and/or landscape elements on outside piping layout drawings. Show rerouting of any utilities, cutting of roads, pavements, trees, etc. and the extent of new and demolition work. Base outside utility drawings on the study of the latest site drawings, discussions with engineering personnel, and the actual site inspection of the existing utility.<br><br>**(h)** Provide 100% complete automatic temperature control drawings. Clearly show all duct detectors, control valves/dampers, static pressure sensors, differential pressure control assemblies, etc. whose actual physical location is critical for the intended sequence of operation on floor plans. For projects involving a central Engineering Control Center (ECC), provide a point schedule with intended analog/digital input and output, graphics capabilities, and requirements of the other trades to be included in the ECC. Provide a riser diagram showing locations of all field data gathering panels and their interfaces with the ECC. Show the actual location of the ECC and peripherals on floor plans.<br><br>**(i)** Submit 100% complete standard detail drawings. Edit VA details to suit the project. Include any special details deemed useful and necessary for the project.<br><br>**(j)** Provide 100% complete HVAC demolition drawings showing clearly the extent of demolition work. Indicate sizes of ductwork and piping to be dismantled. Show capacities and sizes of the existing equipment to be removed. Clearly show points of connection, disconnection, blank-offs, and dead-end flanges with isolating valves. Coordinate demolition and restoration work with other disciplines. Clearly state the revised capacities of the existing systems affected by the demolition work together with additional efforts, if any, involved in testing, balancing, and adjusting them.<br><br>**(k)** Submit HVAC specifications in the format provided in CD1, paragraph 16, SPECIFICATIONS. |
| **Design Manual Coordination**<br>Ensure coordination and provide supporting documentation such as a checklist showing the extent of coordination. Provide 100% complete riser and air flow diagrams. |

# CHAPTER 2: HVAC DESIGN PARAMETERS AND SELECTION CRITERIA

## Table Of Contents

## 2.1 INTRODUCTION

The HVAC systems shall be designed and selected in accordance with the parameters and criteria given in this chapter. Unless a change from these parameters is approved by VA Authorities, the logic and methodology outlined here shall govern. This chapter details the selection criteria for the air-handling units (AHU), as they are the prime HVAC delivery systems.

### 2.1.1 DEFINITION – HIGH HUMIDITY AREAS

High humidity areas are defined as locations where the dew-point is greater than or equal to 60 F [15.6 C] for 4,000 hours per year or more. See Chapter 7 for the VA Facilities that meet this requirement.

### 2.1.2 DEFINITION – LOW HUMIDITY AREA

Low humidity areas are defined as locations where the-dew point is less than 35 F [1.7 C] for 4,000 hours per year or more. See Chapter 7 for the VA Facilities that meet this requirement.

## 2.2 SPECIAL REQUIREMENTS

### 2.2.1 DX – TERMINAL UNITS

Through-the-wall air-conditioners, window air-conditioners, packaged terminal air-conditioners (PTAC), or heat pumps are ***not*** permitted, unless specifically approved by VA Authorities. See Chapter 4 for permitted applications.

### 2.2.2 ROOF-MOUNTED EQUIPMENT

Do not use roof-mounted air-handling equipment unless specifically approved by the VA Authorities.

**Exceptions:**

- Cooling Towers
- Exhaust Fans
- Air-Cooled Chillers
- Pre-Fabricated Air Intakes
- Relief Hoods

For ***all*** roof-mounted equipment, including the above exempted equipment, the A/E shall coordinate the structural integrity, access, screening needs, and walking pads with other disciplines and the facility personal. Structural integrity must be evaluated and certified by a registered professional structural engineer.

All AHUs shall be housed in adequately sized, enclosed spaces.

### 2.2.3 REFRIGERANT HCFC-22

Do not design air-conditioning or refrigeration equipment using HCFC-22 refrigerant. The design shall include only EPA-approved refrigerants.

### 2.2.4 ACOUSTIC LINING

#### 2.2.4.1 Ducts – Positive Air Pressure

Use of the acoustic, sound lining is ***not*** permitted on the inside surface of the supply air ducts or other ducts under positive air pressure.

**Exceptions:**

- Supply air terminal units (CV/VAV boxes)
- Integral supply air plenums serving linear diffusers

#### 2.2.4.2 Ducts – Negative Air Pressure

Acoustic lining may be used in the return and exhaust air ducts under negative air pressure.

#### 2.2.4.3 Lining Characteristics

Acoustic lining shall be anti-microbial and non-friable. Thickness of the lining shall not be less than 1 inch [25 mm].

### 2.2.5 HUMIDIFIERS

Direct use of steam from the central boiler plant is not permitted for the unit-mounted and terminal humidifiers. Use boiler steam on the upstream side of the non-fired, steam-to-steam generator(s) to produce low or medium pressure steam on the downstream side for use in the humidification equipment.

### 2.2.6 GLYCOL

Use of ethylene glycol solution is not permitted as an anti-freeze agent for closed-loop hydronic systems. Use propylene glycol for its lower toxicity and higher heat transfer efficiency compared to ethylene glycol. See Chapter 4 for the VA position on the use of glycol for chiller and hot water systems and Appendix 4-A for further technical details.

### 2.2.7 AIR SYSTEMS

See Chapter 3 for the special requirements of the supply air systems (air-handling units and fan coil units) and distribution systems (ductwork and air terminal units).

## 2.3 SPECIAL STUDIES

Perform the following special studies and analyses to verify and substantiate the system design and its ability to meet design goals and objectives. The submittal for review and approval by the VA Authorities shall include a certified copy of each study and analysis, including recommendations and cost implications. See Appendix 1-C.

### 2.3.1 ACOUSTIC CONSIDERATIONS

#### 2.3.1.1 General

Perform detailed acoustic analysis to demonstrate that the specified room noise levels are achieved in all octave bands for all air handling units, heating and ventilating units, fans, chillers, boilers, generators, and outdoor noise producing equipment such as cooling towers and chillers. See Chapter 6 (Room Data Sheets) for the maximum permissible room noise criteria (NC) levels. Follow ASHRAE recommendations for spaces not included in the Room Data Sheets.

Listed below are suggested acoustic measures to be evaluated and implemented, if feasible:

**(a)** Select equipment with lower sound power levels.

**(b)** Locate equipment away from noise-sensitive areas such as conference rooms and patient bedrooms.

**(c)** Provide factory-fabricated sound attenuators in the main ducts, AHU casings, or on the downstream side of the air terminal units as needed to achieve the required noise levels.

**(d)** Provide acoustic sound lining in return or exhaust ducts under negative air pressure. Show the full extent of the acoustic lining on the floor plans and cross-sections. Specify expected attenuation in each octave band with the selected lining.

**(e)** Radiated or breakout noise in the low frequency range (humming noise) is often ignored and is hard to attenuate. Evaluate and include in the design measures such as the use of thicker gage ducts and recommended duct configurations (see 2007 ASHRAE Handbook of Applications).

**(f)** If recommended by the acoustic analysis, select duct velocities lower than those shown in the duct sizing criteria provided in Table 2-1.

**(g)** Select louvers with sound baffles, where practical. Select transfer grilles with acoustic treatment.

#### 2.3.1.2 Cooling Towers

Attenuation treatment of cooling towers depends upon factors such as local ordinance and functions of the surrounding spaces. The measures suggested below should be included as necessary to meet the design requirements.

**(a)** Locate cooling towers away from sensitive areas.

**(b)** Select cooling towers with low noise generating fans.

**(c)** Include acoustic screening (fencing) around cooling towers to contain the radiated noise. Coordinate this measure with the architects, VA Authorities, and local authorities.

**(d)** Use acoustically-lined louvers, where required.

**(e)** Install sound attenuators on the intake and/or discharge sides.

**(f)** Include maximum permissible sound power levels measured at 5 Feet [1.5 Meters] and 55 Feet [17 Meters] from the cooling tower in the equipment schedule.

#### 2.3.1.3 Fan Coil Units (Where Permitted)

It is recognized that spaces served by the unitary equipment (such as fan coil units) experience higher NC levels than those specified for similar spaces without fan coil units. Select fan coil units at mid-speed to deliver the required output. Provide acoustic lining in the return air ducts for ducted fan coil units.

### 2.3.2 DISPERSION ANALYSIS

The A/E shall perform a computerized dispersion analysis to ensure odors and hazardous exhaust do not enter the outside air intakes and open windows of VA facilities and adjoining properties. The analysis shall be self-certified with back-up data and itemized recommendations.

***Contamination is a serious safety and health issue. It is critical to evaluate and implement the recommendations of the analysis. All recommendations must be implemented even if they exceed OSHA and ASHRAE requirements.***

The dispersion analyses that shall be conducted include, but not limited to, the following:

- Exhaust from laboratories
- ETO exhaust
- Infectious disease ward
- Animal research department
- Emergency generators
- Vehicular exhaust
- Kitchen exhaust
- Boiler stacks
- Cooling towers
- Incinerator

### 2.3.3 BUILDING THERMAL ENVELOPE

#### 2.3.3.1 Minimum Compliance

The building thermal envelope shall comply with ASHRAE Standard 90.1 – 2007 for all new construction.

#### 2.3.3.2 New Construction (Compliance in Excess of ASHRAE 90.1 – 2004)

To meet the mandated goal of energy conservation set in the federal mandates (see Chapter 1), the A/E shall perform a building thermal envelope study to evaluate the most cost-effective system to meet VA requirements.

Include thermal parameters of the building components (roof, wall, floor, and glass), associated costs, and recommendations. Design options may include elimination of perimeter heating system if a superior building thermal envelope results in related reduced first cost of HVAC systems. ***Based on the outcome of the study, VA Authorities may select an envelope more efficient than ASHRAE Standard 90.1 – 2007.***

#### 2.3.3.3 Existing Construction

Evaluate each component of the building thermal envelope to achieve an energy-efficient design. For the existing spaces to be equipped with winter humidification, special attention shall be paid to vapor proofing to prevent moisture migration. Ensure coordination with the architectural discipline. Leakage of outdoor air can be a significant issue in existing construction. Minimize infiltration of cold outdoor air.

### 2.3.4 HEAT RECOVERY DEVICES

The A/E shall conduct a study and perform a life-cycle cost analysis of applicable heat recovery systems for each qualified HVAC system in the project. The study shall include estimates of the initial cost, maintenance cost, net energy savings, and impact on the space and other disciplines. Even though ASHRAE Standard 90.1 – 2007 mandates the use of a heat recovery system, VA has opted to evaluate the applicability and suitability of heat recovery systems before such systems are included in the HVAC design.

#### 2.3.4.1 Sensible Heat Transfer

The analysis shall include each of the following systems where applicable to sensible transfer only:

**(a)** Runaround System

- Simplest system utilizing a piping loop and circulator pump.
- The loop connects a finned-tube coil in the exhaust plenum with a finned tube coil in the makeup air plenum or AHU. Typically operates to preheat outdoor makeup air but also to pre-cool the make-up air when the exhaust air stream is cooler than the outdoor make-up air. Evaluate the effects of glycol.

**(b)** Fixed-Plate System (Air-to-Air)

- Plates augmented with fins separate air streams.
- No transfer media other than the plate-forming wall is used.

**(c)** Heat Pipes

- Heat source boils a heat transfer fluid and a heat sink condenses the fluid back to its liquid state, liberating the energy transferred from the fluid's phase change.
- Transfer fluid is contained within a pipe.
- Supply and exhaust streams must be in close proximity. Use sealed-tube thermosyphon.
- Corrosion resistance of the pipe must be ensured.

**(d)** Heat Wheel

- Rotary air-to-air heat exchange.
- Low-pressure drop of 0.4 – 0.7 inch WG [100 – 175 Pascal] of water.
- Airstreams must be adjacent.
- Airstreams must be filtered if particulate is present.
- Fill medium requires periodic cleaning.
- Since cross-contamination of airflows can occur, use of the heat recovery wheels is not permitted for the air-handling units serving the surgical suite and the SPD department.
- Ensure outside air is pressurized greater than exhaust air.

### 2.3.4.2 Sensible and Latent Heat Transfer

The analysis shall include each of the following systems where applicable to both sensible and latent transfer:

- Desiccant (Enthalpy) Heat Wheels
    - Typical in laboratory facilities where more than half of the total HVAC load is latent.
    - The use of a three Angstrom molecular sieve provides sensible and latent energy recovery with a very low level of cross-contamination between the incoming outdoor air and exhaust system discharge.
    - Cross-contamination limit of less than 0.04% by particulate count.
    - Heat transfer efficiency of 75-90%.
    - No wet surfaces to support microbial growth or chemical byproducts associated with boiler steam humidification.
    - Since cross-contamination of airflows can occur, use of the heat recovery wheels is not permitted for the air-handling units serving the surgical suite or the SPD department.
    - Ensure outside air is pressurized greater than exhaust air.

### 2.3.4.3 Load Credit

**(a)** Savings in cooling and heating energies due to the heat recovery devices, shall ***not*** be taken when selecting air-handling units. Such savings can be projected into the energy analysis or life-cycle analysis, but actual equipment selection shall not “trim” the cooling and/or heating components.

**(b)** Include two sets of operating conditions in the equipment schedule, one with and one without heat recovery devices.

### 2.3.4.4 Exceptions

In addition to the exceptions identified in ASHRAE Standard 90.1 - 2007, listed below are situations in which heat recovery is not permitted:

- All fume hood exhaust
- Kitchen exhaust (range hood and wet exhaust)
- Autopsy exhaust
- Isolation room exhaust
- Wet exhaust from cage and cart washers
- ETO – Ethylene Oxide Sterilizers exhaust

## 2.3.5 COMPREHENSIVE CHILLED WATER STUDY

See Chapter 4.

## 2.4 BASIS OF DESIGN

### 2.4.1 OUTDOOR DESIGN CONDITIONS

Weather conditions for the VA facilities are given in Chapter 7. These conditions are based on the locations closest to the VA facilities and given in 2005 ASHRAE Handbook of Fundamentals. The A/E can recommend and use (subject to prior approval of the VA Authorities) more severe conditions than those listed in the Handbook, based on experience and knowledge of local weather conditions.

#### 2.4.1.1 Cooling and Heating Load Calculations

Use the following conditions for calculating the cooling and heating loads:

- Cooling – 0.4 Percent Dry-Bulb and Wet-Bulb Temperatures – Column 1a
- Heating – 99.6 Percent Dry-Bulb Temperatures – Column 1b

#### 2.4.1.2 Cooling Tower Selection

- 1 F [0.56 C] above 0.4 Percent Wet-Bulb Temperatures – Column 3

#### 2.4.1.3 Preheat Coil Selection

- Annual Extreme Daily Mean Dry-Bulb Temperatures – Minimum Column

#### 2.4.1.4 Electrical Heating Devices Using Emergency Power

- 99.6 Percent Dry-Bulb Temperatures – Column 1b

### 2.4.2 INSIDE DESIGN CONDITIONS

Inside design conditions for all typical spaces are given in Appendix 6-A and Appendix 6-B. Provide humidification to maintain minimum 40 F [4.4 C] dew-point temperature of the supply air.

#### 2.4.2.1 Commonly Used Inside Design Temperatures and Humidity Ranges

70 F to 75 F [21 C to 24 C] and 30% to 50% RH have different implications depending upon the application and system configuration, as shown below:

#### 2.4.2.2 Year Around Conditions

**70 F to 75 F [21 C to 24 C] and 30% to 50% RH**
As defined in 2007 ASHRAE Handbook of Applications, the system shall be capable of maintaining temperatures within the range during normal working conditions. The cooling load for these spaces shall be calculated to maintain 70 F [20 C] at 50% RH and the heating load shall be calculated to maintain 75 F [24 C] at 30% RH. See Appendix 6-A and Appendix 6-B for the specific applications. The year around conditions can be used for variable air volume (VAV) or constant volume (CV) systems. Year around design conditions shall be used for all patient areas.

#### 2.4.2.3 Variable Air Volume (VAV) with Dead-Band

**70 F to 75 F [21 C to 24 C] and 30% to 50% RH**
As defined in ASHRAE Standard 90.1 – 2007, the space thermostat shall be capable of providing the above range and a dead-band of 5 F [2.8 C] within which the supply of cooling and heating energy to the space is shut off or reduced to a minimum. The dead-band is mandated for the qualified spaces.

#### 2.4.2.4 Constant Volume (CV) System

**70 F to 75 F [21 C to 24 C] and 30% to 50% RH**
For constant volume systems serving non-patient applications, the space temperature is allowed to drop to 70 F [21 C] before heating is activated. The difference is adjustable.

### 2.4.3 ROOM AIR BALANCE

#### 2.4.3.1 Definition

**(a)** Maintain the specified volumetric air balance between the supply and exhaust or return air as stipulated in the Room Data Sheets. Locate the supply air outlets and return/exhaust air inlets to create a directional airflow required to maintain the intended air balance. Provide devices such as airflow control valve to measure and verify the design air balance.

**(b)** Positive or negative air balance is also required to create a difference in space pressure. Where pressure measurement and control are required, use a pressure differential sensor and matching control devices.

#### 2.4.3.2 Neutral (0) Air Balance

Supply Air = Exhaust Air or Return Air or [Exhaust Air + Return Air]

#### 2.4.3.3 Negative (-) Air Balance

Exhaust Air or Return Air = [Supply Air + 15%]

#### 2.4.3.4 Double Negative (- -) Air Balance

**Exhaust Air or Return Air = [Supply + 30%]**
Some applications may not require supply air to maintain double negative air balance. The intended air balance is maintained by 100% make-up air, transferred by the door undercuts and transfer grilles.

#### 2.4.3.5 Positive (+) Air Balance

Exhaust Air or Return Air = [Supply Air – 15%]

#### 2.4.3.6 Double Positive (+ +) Air Balance

Exhaust Air or Return Air = [Supply Air – 30%]

### 2.4.4 OCCUPANCY

Refer to the VA Design Guides and/or project program for design occupancy.

### 2.4.5 LIGHT AND POWER LOAD

The designer shall estimate the light and power load based on actual lighting layout and equipment manufacturers' data. See VA Design Guides where applicable for preliminary estimate.

### 2.4.6 OUTSIDE AIR VOLUME

Minimum outside air for ventilation shall be the highest of the following:

- Compliance – ASHRAE Standard 62.1 – 2007
- VA Requirement – 15% of Supply Air Volume
- Exhaust Air – As calculated below and shown in the Room Data Sheets (Appendix 6-A and Appendix 6-B)
- Specified Minimum Air Changes per Hour – Table 3 (Chapter 7), ASHRAE 2007 Applications Handbook

### 2.4.7 TOTAL EXHAUST AIR VOLUME

Calculation of the total and room-by-room exhaust air volume shall be as follows:

#### 2.4.7.1 Toilets and Housekeeping Aide's Closet

**(a) Public Toilets** – See Appendix 6-B
**(b) Patient Toilets** – See Appendix 6-B
**(c) Housekeeping Aide Closet (HAC)/Janitor's Closet** – See Appendix 6-B

#### 2.4.7.2 Public Patient Areas

Conditioned air supplied to all designated patient registration and waiting areas shall be exhausted outdoors and not returned back to the serving air-handling unit.

#### 2.4.7.3 Locker Rooms

- **Without Adjoining Toilets and/or Showers**

0.5 CFM/Square Foot [2.5 Liters/Second/Square Meter]

- **With Adjoining Toilets and/or Showers**

75 CFM [35.4 Liters/Second] per urinal and/or water closet

#### 2.4.7.4 Soiled Storage Rooms

6 air changes per hour

#### 2.4.7.5 Equipment Exhaust

Coordinate exhaust needs with the equipment manufacturers.

#### 2.4.7.6 Hoods (Fume, Kitchen, or Canopy)

Coordinate exhaust needs with the hood manufacturers based on the mandated face velocity over the sash open area and the published exhaust data.

#### 2.4.7.7 Space Pressurization Allowance

Minimum 5% of the calculated supply air volume shall be retained in the space for space pressurization and included as an allowance to curtail infiltration.

#### 2.4.7.8 Make-Up Air for Volumetric Air Balance

Include make-up air for the negative air balance in the exhaust air tabulations.

## 2.5 COOLING AND HEATING LOAD CALCULATIONS

Using an ASHRAE-based, public domain (DOE) or commercially available software program (Trane, Carrier, and/or any other approved), the A/E shall calculate the following design parameters:

### 2.5.1 ROOM-BY-ROOM COOLING AND HEATING LOADS

#### 2.5.1.1 Load Credit

While calculating the heating load, do not include occupancy, lighting load, or heat gain due to equipment.

#### 2.5.1.2 Room Data Output

The computer printout shall include a unique output sheet for each space. The output shall include peak room sensible and latent loads and peak room supply air volume. The air terminal unit schedule shall indicate the peak supply air volume. See Appendix 1-C for detailed room-by-room listing.

### 2.5.2 BLOCK COOLING LOADS

Cooling load calculations shall establish:

- Peak (Block) Zone Cooling Load
- Peak (Block) Zone Supply Air Volume
- Peak (Block) Building Cooling Load

#### 2.5.2.1 Peak (Block) Zone Cooling Load

- A zone is an air-handling unit, serving a group of rooms. Zone peak cooling load is the sum of the maximum cooling load due to the sensible and latent loads of the group of rooms treated as a single room, and the peak-cooling load due to ventilation air.
- Zone peak cooling load is not the sum of the peak cooling loads of the individual rooms, which may occur at different times, in different months, and due to differing orientations.
- If the chiller serves a single air-handling unit, use the zone peak cooling load for selecting the cooling coil, chilled water flow rate, and chiller capacity.

#### 2.5.2.2 Peak (Block) Zone Supply Air Volume

- Zone peak supply air volume is the peak supply air volume demand due to the space sensible cooling loads of the group of rooms when treated as one room, but without the cooling load due to ventilation air.
- Zone peak supply air volume is not the sum of the peak supply air volumes of the individual rooms that may occur at different times, in different months, and due to differing orientations. Note that the zone peak cooling load and zone peak supply air volume may occur at different times.
- Use zone peak supply air volume for selecting the air-handling unit size and air distribution system.

#### 2.5.2.3 Building Peak Cooling Load

- Building cooling load is the maximum cooling load due to the sensible and latent loads of the entire building, treated as a single room, and the peak cooling load due to the ventilation demand of the entire building.
- Building peak cooling load is not the sum of the peak cooling loads of the individual zones that may occur at different times, in different months, and due to differing orientations.
- Use building peak cooling load for selecting the refrigeration equipment and associated components.

### 2.5.3 SUPPLY AIR VOLUME (AHU CAPACITY)

Calculated supply air volume shall be rounded off to the next 100 CFM or Liters/Second and increased by 4% to account for the ductwork and the system component air leakage. Increase the supply air volume by an additional 5% safety factor. Thus, the calculated supply air volume shall be increased by calculated supply air x 1.04 x 1.05 = 1.092, that is, 9.2% more than the calculated air volume.

### 2.5.4 PSYCHROMETRIC ANALYSIS PROGRAM

The A/E shall perform software-based psychrometric analysis plotting for all air-handling unit systems, the parameters, processes, loads, and flow rates for each air-handling unit system. The analysis shall show system losses, including supply and return air fan motor heat gain. Psychrometric chart data shall be transferred to chilled cooling coil equipment schedule.

## 2.6 ECONOMIZER CYCLE

Evaluate and incorporate economizer cycle based on ASHRAE 90.1 – 2007.

### 2.6.1 AIRSIDE ECONOMIZER CYCLE

**(a)** Provide a dry-bulb temperature actuated or enthalpy-controlled, airside economizer where life-cycle cost-effective.

**(b)** When dry-bulb temperature actuated economizer cycle is used, the selection of the switchover temperature must not result in higher dehumidification or humidification loads.

### 2.6.2 WATERSIDE ECONOMIZER CYCLE

#### 2.6.2.1 General

Evaluate and provide a waterside economizer, if proven cost-effective by the life-cycle analysis.

#### 2.6.2.2 Description

The system shall consist of a hydronic circuit using cooling tower water in conjunction with a plate heat exchanger and a circulating pump. The system shall deliver cold water at +/- 45 F [7.2 C] into the distribution loop of the central chilled water plant to meet the winter cooling load and if possible postpone start-up of a central plant chiller at low-load conditions.

## 2.7 INDIVIDUAL ROOM TEMPERATURE CONTROL

### 2.7.1 GENERAL

A space is defined as individually controlled only when a dedicated air terminal unit and a room temperature sensor/controller serve it. Individual room temperature control is required for all patient bedrooms, patient treatment and examination rooms, and the healthcare functions and other spaces identified in Appendix 6-A and Appendix 6-B.

### 2.7.2 ROOM TEMPERATURE CONTROLS

Listed below are applications where group control can be provided in lieu of dedicated room temperature control:

#### 2.7.2.1 Office Perimeter Spaces (Group)

A single terminal unit can serve as many as three perimeter office rooms located on the same exposure and with identical functions and load characteristics.

**Exception:** A corner office room with multiple exposures shall have its individual room temperature control.

#### 2.7.2.2 Interior Spaces (Group)

A single terminal unit can serve as many as four interior office or patient examination rooms that have identical functions and load characteristics.

### 2.7.3 OPEN SPACES

Open spaces with exposed perimeter and interior areas shall be zoned such that one dedicated air terminal unit serves the perimeter and another serves interior zones. The perimeter zone is defined as an area enclosing exposed length and 12 to 15 Feet [3.7 to 4.6 Meters] width. An interior zone does not have exposed walls.

## 2.8 PERIMETER HEATING REQUIREMENTS

### 2.8.1 GENERAL

Provide supplementary perimeter-heating system for:

#### 2.8.1.1 Patient Bedrooms

where heat loss exceeds 180 BTUH/Linear Foot [173 Watts/Linear Meter] of the exposed wall.

#### 2.8.1.2 All Other Occupied Spaces

where heat loss exceeds 210 BTUH/Linear Foot [202 Watts/Linear Meter] of the exposed wall.

#### 2.8.1.3 Exception

See Building Thermal Envelope Study (this chapter) for the possibility of eliminating the perimeter-heating system.

### 2.8.2 PERIMETER HEATING SYSTEM DESCRIPTION

#### 2.8.2.1 System Configuration

**(a)** All patient bedrooms, associated toilets, and all occupied spaces that qualify for supplementary heating, shall use **only radiant ceiling panels**, unless approved by the VA Authorities. During design development, provide coordinated detail of perimeter reflected ceiling plan showing linear diffusers and radiant ceiling panels. Design shall optimize performance while maximizing aesthetics.

**(b)** For all other spaces such as non-patient toilets, exterior stairs, vestibules, and unoccupied spaces, thermostatically-controlled perimeter heat shall be delivered by unit heaters, cabinet heaters, convectors, or baseboard radiators.

#### 2.8.2.2 Heating Medium

Hot water available from the central heating plant shall be used as the heating medium. Use two-way modulating control valves to control the hot water flow. Minimum flow per each heating circuit shall not be less than 0.5 GPM [0.032 Liters/Second].

#### 2.8.2.3 System Sizing and Control Criteria

It is essential to ensure that the terminal unit heating coil and the perimeter heating system are correctly sized to share the total heating load and that they operate in sequence. For example, if the terminal reheat coil is oversized, or not controlled to limit its share of heating duty, the perimeter heating system may not come online. See VA Standard Detail for the schematic control diagram and suggested sequence of operation.

## 2.9 DESIGN CRITERIA – AIR DISTRIBUTION SYSTEMS

### 2.9.1 DUCT DESIGN – GENERAL

#### 2.9.1.1 Compliance

Air distribution system shall be designed in accordance with applicable ASHRAE and SMACNA Standards. Parameters listed below shall govern in the event of discrepancies from the ASHRAE or SMACNA Standards. Use applicable sections of the SMACNA Standard to select the air distribution ductwork pressure classification.

#### 2.9.1.2 Duct Materials

Ductwork shall be fabricated from galvanized steel, aluminum, or stainless steel depending upon applications.

#### 2.9.1.3 Duct Selection Criteria

**(a)** **Sizing Parameters:** Duct size selection must satisfy two limiting parameters: maximum air velocity and maximum static pressure drop. All supply air duct mains for all air-handling units shall be sized to carry 25% more air without exceeding the two limiting parameters. The fan static pressure shall be calculated based on actual airflow rate. The duct pressure classification shall be based on the increased (25%) flow rate.

**(b)** **Sizing Criteria:** Use equal friction method for sizing low-pressure ductwork. Use static-regain method for sizing medium pressure ductwork.

**(c)** **Exposed Ductwork:** All exposed (visible in space) ductwork in the occupied conditioned spaces shall be designed and fabricated from double-wall, flat, oval, or round ductwork with galvanized outer shell and non-perforated, galvanized, inner lining with 1 inch [25 mm] thick glass fiber insulation between the two walls. Duct painting and finish requirements shall be coordinated with the VA Authorities.

#### 2.9.1.4 Mandatory Requirement

***All ductwork, without exception, shall be shown in double lines on all floor plans and cross-sections. See Appendix 1-C.***

#### 2.9.1.5 Duct Pressure Classification

Show duct pressure requirements for all ductwork on the floor plans. Required duct classification shall be shown as ½ inch, 1 inch, 2 inch, 3 inch, and 4 inch [20 mm, 25 mm, 50 mm, 75 mm, and 100 mm].

#### 2.9.1.6 Flexible Ducts

**(a)** Use of flexible duct shall be restricted to connections between the VAV/CV air terminal units and the medium or high-pressure supply air duct and connections between the supply air diffusers and the low-pressure supply air ductwork.
**(b)** Do not use flexible duct on exposed ductwork in occupied areas.
**(c)** Maximum length of flexible ductwork shall not exceed 5 Feet [1.5 Meters].
**(d)** Do not penetrate firewalls and interstitial decks with flexible ducts.

#### 2.9.1.7 Underground Duct

Use of underground and concrete ducts is not permitted.

#### 2.9.1.8 Shielded Ducts

Coordinate locations of shielded rooms with the architectural drawings. Generally, lead lining in walls terminates at or below the ceiling level. However, in special instances where lead linings extend higher and ducts penetrate the lining, ducts shall be wrapped with lead sheet of the same thickness as the wall lining. Consult medical equipment vendor for specific recommendations.

**Exceptions:**

- In super voltage therapy rooms with thick concrete walls, lead shielding may not be required for ducts penetrating the room wall. A registered health physicist shall check adjacency uses and determine lead shielding requirements.
- Dark rooms require full height lead lining. For walls of dark rooms located adjacent to rooms with walls having 7 Feet [2.0 Meters] high lead lining, lead shielding of the ductwork penetrating above the suspended ceiling is not required.

#### 2.9.1.9 Minimum Duct Size

- Rectangular Ducts: 8 inches x 6 inches [200 mm x 150 mm]
- Round Ducts: 6 inches [150 mm]

### 2.9.2 LIMITING DUCT SIZING PARAMETERS

| Table 2-1: DUCT SIZING CRITERIA | | |
|---|---|---|
| **Duct Description** | **Maximum Air Velocity** | **Maximum Static Pressure Drop** |
| Low Pressure Duct<br>• Supply<br>• Return<br>• Relief<br>• Exhaust | 1,500 Feet/Minute<br>[7.6 Meters/Second] | 0.08 inch WG/100 Feet<br>[0.66 Pascal/Meter] |
| Medium/High Pressure Duct<br>• Supply | 2,500 Feet/Minute<br>[12.7 Meter/Second] | 0.2 inch WG/100 Feet<br>[1.64 Pascal/Meter] |
| Return Air Transfer Duct | 750 Feet/Minute<br>[3.8 Meter/Second] | 0.04 inch WG/100 Feet<br>[0.33 Pascal/Meter] |

## 2.10 DESIGN CRITERIA – PIPING SYSTEMS

### 2.10.1 PIPE DESIGN – GENERAL

#### 2.10.1.1 Pipe Selection Criteria

Pipe size selection must satisfy both limiting parameters, maximum water velocity and maximum fluid pressure drop.

#### 2.10.1.2 Minimum Pipe Size

For closed loop piping systems, the minimum size of the individual takeoff shall not be less than ¾ inch [20 mm].

#### 2.10.1.3 Mandatory Requirements

***All piping 6 inch [150 mm] and larger shall be shown in double lines on all floor plans in the final submission.***

#### 2.10.1.4 Miscellaneous Requirements

- Dielectric unions where connecting two dissimilar metals
- Drain connections at all low-points in piping
- Manual air vents at all high-points in piping

### 2.10.2 LIMITING PIPE SIZING PARAMETERS

**Table 2-2: Pipe Sizing Criteria**

| Pipe Type and Size | Maximum Fluid Velocity | Maximum Pressure Drop |
|---|---|---|
| Chilled Water<br>Hot Water<br>Hot Glycol Water<br>2 inch [50 mm] and below | 6.0 Feet/Second<br>[1.8 Meters/Second] | 2.0 Feet/100 Feet WG<br>[0.2 KPA/Meter] |
| Chilled Water<br>Hot Water<br>Hot Glycol Water<br>Above 2 inch [50 mm] | 10.0 Feet/Second<br>[3.0 Meters/Second] | 2.0 Feet/100 Feet WG<br>[0.2 KPA/Meter] |
| Condenser Water<br>Any Size | 10.0 Feet/Second<br>[3.0 Meters/Second] | 2.0 Feet/100 Feet WG<br>[0.2 KPA/Meter] |
| High Pressure Steam<br>Any Size | 10,000 Feet/Minute<br>[50.0 Meters/Second] | 2.0 PSIG<br>[13.8 KPA] |
| Low Pressure Steam<br>Any Size | 5,000 Feet/Minute<br>[25.0 Meters/Second] | 0.5 PSIG<br>[3.5 KPA] |
| Pumped Condensate<br>Any Size | 10.0 Feet/Second<br>[3.0 Meters/Second] | 4.0 Feet/100 Feet WG<br>[0.4 KPA/Meter] |

**Note:** For closed-loop hydronic chilled water, heating hot water, and glycol/hot water systems, pipe sizing is based on "Cameron Hydraulic Data."

- C = 100 for open cooling tower systems
- C = 150 for closed systems

## 2.11 VIBRATION CONTROL

Refer to Master Specification 23 05 41 (15200), Noise And Vibration Control For HVAC Piping And Equipment. Select vibration isolators in accordance with Appendix 2-A and with the equipment manufacturer's recommendations. Provide appropriate standard details. Indicate the type of isolation on the equipment schedule.

## 2.12 SEISMIC REQUIREMENTS (HVAC)

### 2.12.1 GENERAL

#### 2.12.1.1 Compliance

Earthquake-resistive design shall comply with the requirements of latest edition of VA Handbook H-18-8, Seismic Design Requirements, and the International Building Code (IBC 2006).

#### 2.12.1.2 Applications

Earthquake-resistive design for equipment, piping, and ductwork shall be as follows:

**(a)** **New Buildings:** For new buildings, apply seismic restraints for equipment as indicated in VA Handbook H-18-8.

**(b)** **Existing Buildings**: For existing buildings, apply seismic restraints for equipment in locations of Moderate High, High, and Very High Seismic activity, as indicated in VA Handbook H-18-8.

**(c)** **New and Existing Buildings – Piping:** For new and existing buildings, apply seismic restraints for piping and ductwork in locations of Moderate High, High, and Very High Seismic activity, as indicated in H-18-8.

**(d)** **Local Codes:** Where local Seismic Code is more stringent, comply with local code.

#### 2.12.1.3 Omissions

HVAC equipment, ductwork, and piping shall be braced in accordance with the most current edition of Seismic Restraint Manual Guidelines for Mechanical Systems (SMACNA). There are conditions listed in SMACNA under which seismic bracing may be omitted. However, a design professional shall review and may revoke such omissions for the specific project.

### 2.12.2 CONFORMANCE WITH SMACNA

SMACNA does not cover all conditions such as providing bracing details for seismic restraints of equipment, details of flexible joints when crossing seismic or expansion joints, or bracing of in-line equipment, etc. Also, in locations of Very High Seismicities, SMACNA details should be used with special care.

### 2.12.3 CALCULATIONS

Unless otherwise shown by SMACNA, provide detailed structural calculations for VA's review on the design of hangers, supports, anchor bolts, welds, and connections. Show sizes, spacing, and length for securing equipment, piping, and ductwork to structural members. The design calculations shall be prepared and certified by a registered structural engineer.

### 2.12.4 DRAWINGS

#### 2.12.4.1 General

Where SMACNA details are incomplete or not applicable, provide necessary seismic restraint details. Coordinate mechanical, architectural, and structural work.

#### 2.12.4.2 Ductwork and Piping Plans and Sections

Show locations of required restraints with reference to SMACNA or special restraint details, whichever is applicable.

#### 2.12.4.3 Equipment Restraints

Provide special details (not covered by SMACNA), where required. Provide special attention to the seismic provision for the suspended equipment.

## 2.13 FIRE AND SMOKE PROTECTION

### 2.13.1 COMPLIANCE

**(a)** HVAC design and equipment shall be in compliance with NFPA 90A and shall be equipped with the devices such as fire dampers, smoke dampers, and duct-mounted smoke detectors. Compliance with the following codes is also mandatory:

- NFPA 45: Standard on Fire Protection for Laboratories
- NFPA 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
- NFPA 99: Standard for Health Care Facilities
- NFPA 101: Life Safety Code

**(b)** While the local codes and ordinances are not binding to the VA, wherever possible, such provisions shall be reviewed with the VA and implemented upon approval.

**(c)** See Figure 2-1 for typical smoke control for air-handling units.

### 2.13.2 ADDITIONAL REQUIREMENTS

#### 2.13.2.1 Fire Dampers

Show all fire dampers on the floor plan.

#### 2.13.2.2 Smoke Dampers

**(a)** Show all smoke dampers and smoke detectors on the floor plan and in the control schematic diagrams.

**(b)** Smoke dampers are ***not*** required at the designated smoke barriers for a fully sprinklered building that is equipped with quick response heads.

**(c)** Smoke dampers are also not required where penetrating the interstitial deck.

**(d)** Installation of smoke dampers and detectors shall be done in compliance with the manufacturer's published recommendations for duct clearance distances and elbow locations.

#### 2.13.2.3 Wiring

Specify that the smoke detectors and dampers shall be hard-wired.

#### 2.13.2.4 Alarms

Design the control sequence to initiate an alarm at the ECC (Engineering Control Center).

#### 2.13.2.5 End-Switch

Provide an end-switch with the smoke dampers to ensure that the dampers are proven fully open before the fan starts.

### 2.13.3 STAIR PRESSURIZATION

For VA facilities, stair pressurization is not used.

### 2.13.4 ATRIUM SMOKE CONTROL

See Appendix 6-A for the smoke removal system design.

### 2.13.5 ELEVATOR SHAFT VENTING

#### 2.13.5.1 Compliance

Rule 100.4 of ANSI.1, Elevator Safety Code.

#### 2.13.5.2 Hardware

Provide a normally closed, two-position, motorized damper in the hoist way for venting smoke. See VA Standard Detail for additional information. The damper shall open when activated by the space detector located at the top of each elevator hoist way. Status of the hoist way shall be monitored by the DDC controls.

## 2.14 DESIGN CONSIDERATIONS FOR EXISTING BUILDINGS

While the scope of work and the conditions are project-specific, the following guidelines are derived based on past experience.

### 2.14.1 SITE SURVEY

#### 2.14.1.1 As-Built Drawings

Do ***not*** rely solely on the available as-built drawings. Take photographs and actual measurements where tight conditions prevail and provide cross-sections of such locations.

#### 2.14.1.2 Site Visits

Coordinate site visits in advance with the VA facility personnel and become familiar with entry, exit, parking, storage, and security requirements.

#### 2.14.1.3 Site Survey

Perform an extensive site survey, record crucial measurements, and interview the maintenance and operating personnel to visualize the actual field conditions, access requirements, and maintenance history of the existing equipment. Include the site interview report in the project submission and describe the chronic problems and shortcomings which may impact the project scope of work.

Should the site survey result in additional work affecting the scope of work, the Project Manager should be notified as soon as possible. Any additional work resulting from the site survey must be authorized in advance before it is included in the design.

### 2.14.2 PROJECT PLANNING

The HVAC system design and development shall be affected by the considerations listed below:

#### 2.14.2.1 Phasing

Coordinate the phasing requirements with the facility personnel. Phasing will have significant impact on the need for the swing space, schedule, and the system design itself. Testing, Adjusting, and Balancing (TAB) cost and the commissioning cost are also dependent upon phasing, as some TAB work may have to be repeated.

#### 2.14.2.2 Utility Connections and Outage

Coordinate outdoor utility routing, available capacity, and the intended outage with the facility personnel. Provide signs showing revised traffic patterns and revisions to parking.

### 2.14.3 TECHNICAL CONSIDERATIONS

#### 2.14.3.1 Demolition Work

Extent of demolition work shall be clearly documented with points of disconnections and connections clearly shown. The demolition drawings shall also show the locations where new shutoff valves, blank-offs, and dead-end flanges may be required.

#### 2.14.3.2 Modifying Existing Systems

Work on the existing systems shall include the following measures:

**(a) Steam Radiators:** Existing steam radiators shall be dismantled and replaced by hydronic hot water heat. If this measure is not feasible, the existing radiators shall be equipped with modulating control valves, controlled by the room thermostat responsible for cooling the space. A single thermostat shall prevent cooling and heating in operation at the same time.

**(b) DDC Controls:** All new control devices shall be equipped with electric actuators. For a major renovation of the existing facilities, where an updated control system is being installed, replace pneumatic with electric actuators.

**(c) Existing Ductwork:** Where connections are made between the new and existing ductwork, the existing ductwork shall be pressure tested, thoroughly cleaned, and sanitized to avoid any possibility of contamination.

**(d) Refrigerant Removal:** Refrigerant from the existing equipment to be dismantled and removed shall be handled, stored in containers per EPA guidelines, and disposed of in accordance with the EPA guidelines. Consult local VA Authorities for logistic details and support.

**(e) System Selection:** Provide an all-air system unless space constraints dictate otherwise. The A/E shall fully document and demonstrate that the installation of an all-air system is not feasible. See Chapter 3 for the use of the fan coil units with central ventilation system for minimum air.

**(f) Attic/Crawl Spaces:** Affected attic and crawl spaces shall be ventilated, insulated (as required and feasible), and heated. See the Room Data Sheets (Chapter 6) for additional information.

**(g) Roof-Mounted Air-Handling Equipment:** See this chapter for the general policy statement.

## 2.15 LOCATIONS OF OUTSIDE AIR INTAKES AND EXHAUST AIR OUTLETS

### 2.15.1 GENERAL

Coordinate the requirements given below with the Physical Security Manual.

Outside air intake and exhaust air outlets shall be located to avoid health hazards, nuisance odors, reduction in capacity of air-conditioning equipment, and corrosion of equipment caused by re-entry of exhaust air from laboratories, transportation systems, cooling towers, and air-cooled condensers. See specifications for the types of louvers and limiting velocities and pressure drops.

### 2.15.2 MINIMUM REQUIREMENTS

#### 2.15.2.1 Louver Location

Coordinate the louver location with Physical Security Manual.

#### 2.15.2.2 Operating Room Air Intake

Air intake for the AHU serving surgical suites shall be at least 30 Feet [9.1 Meters] above the ground. Provide more distance if required by the dispersion analysis.

#### 2.15.2.3 Laboratory and Research Exhaust

Terminate exhaust from the fume hood and the laboratory general exhaust at the highest point of the building and in accordance with NFPA 99, Standard for Health Care Facilities.

#### 2.15.2.4 Physical Security Compliance

Air intakes and exhausts shall be designed in accordance with the Physical Security Design Manual for VA Facilities – Mission Critical Facilities and Life Safety Protected Facilities.

#### 2.15.2.5 Common Outside Air Intake

Common outside air intake can be used in conjunction with multiple air-handling units, provided the outside air intake plenum is partitioned with a dedicated intake for each air-handling unit.

#### 2.15.2.6 Hurricane and Natural Disaster Locations

For hurricane areas, HVAC systems for the mission-critical facilities shall be designed in accordance with the Physical Security Manual.

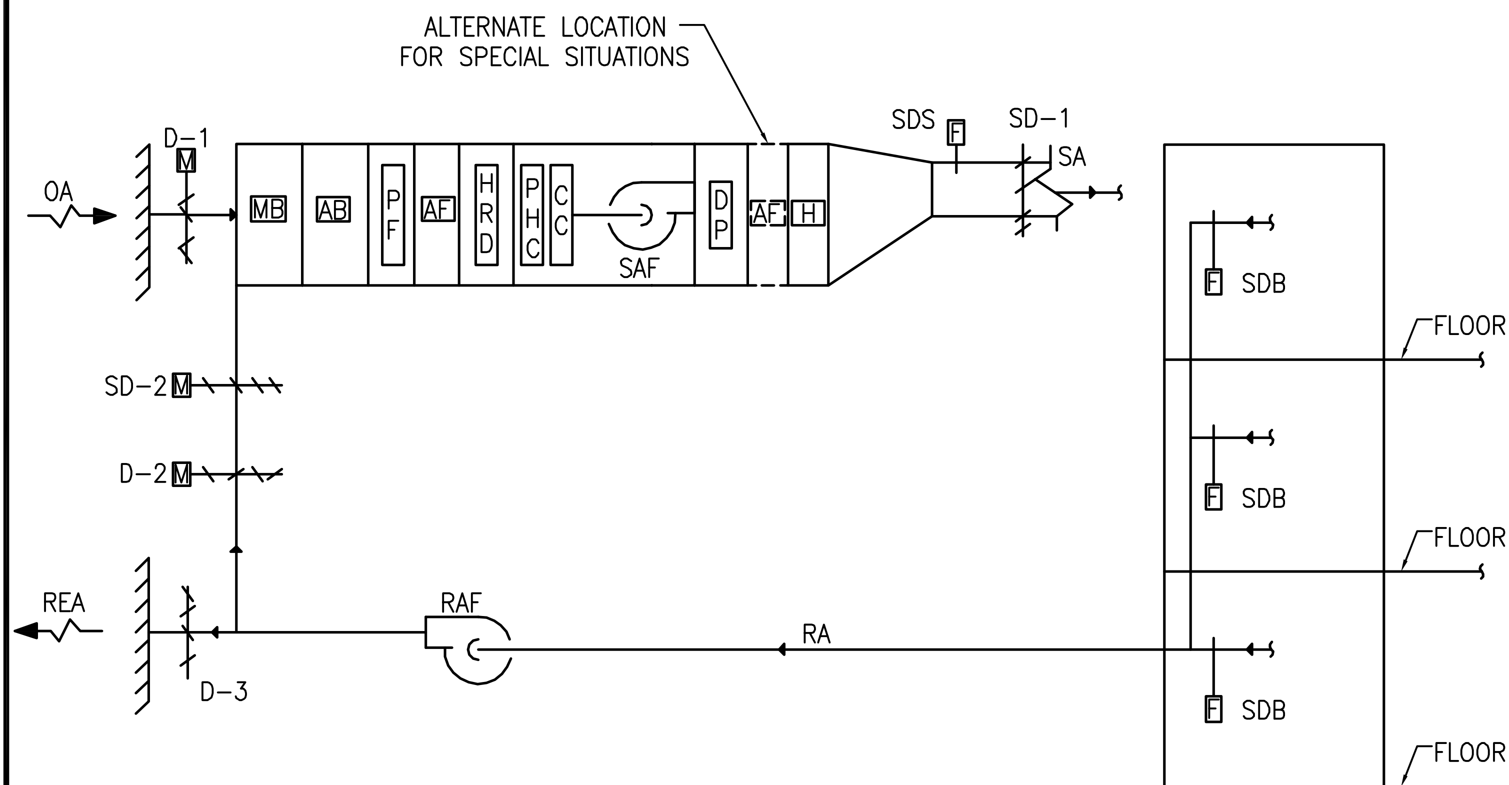
## 2.16 COORDINATION

### 2.16.1 GENERAL

It is vital to ensure that bid documents are coordinated within the discipline and across disciplines to avoid delays and costly change orders/claims.

### 2.16.2 CERTIFICATION

Before the construction documents are released for bid, the A/E shall issue a letter to the VA Authorities certifying that the design of the HVAC systems is fully coordinated within the HVAC discipline and among the disciplines. The letter shall be signed by the design firm’s principal.




NOTES:

1. THIS DIAGRAM IS APPLICABLE TO SYSTEMS WITH CAPACITY OF 15,000 CFM [7,075 LITER/SECOND] OR GREATER. SMOKE DAMPERS ARE NOT REQUIRED IF AHU IS LOCATED ON FLOOR SERVED AND SERVICES ONLY THAT FLOOR OR LOCATED ON ROOF DIRECTLY ABOVE FLOOR SERVED. SEE NFPA 90A.

## SMOKE CONTROL FOR AIR HANDLING UNIT SYSTEMS

Not to Scale

## APPENDIX 2-A: SELECTION GUIDE FOR VIBRATION ISOLATORS

| EQUIPMENT | | ON GRADE | | | 20 FT FLOOR SPAN | | | 30 FT FLOOR SPAN | | | 40 FT FLOOR SPAN | | | 50 FT FLOOR SPAN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| **REFRIGERATION MACHINES** | | | | | | | | | | | | | | | | |
| ABSORPTION | | --- | D | --- | --- | SP | 1.0 | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 1.7 |
| PACKAGED HERMETIC | | --- | D | --- | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 1.7 | R | SP | 2.5 |
| OPEN CENTRIFUGAL | | B | D | --- | B | SP | 1.0 | --- | SP | 1.7 | B | SP | 1.7 | B | SP | 3.5 |
| RECIPROCATING: | | | | | | | | | | | | | | | | |
| 500 - 750 RPM | | --- | D | --- | --- | SP | 1.7 | R | SP | 1.7 | R | SP | 2.5 | R | SP | 3.5 |
| 751 RPM & OVER | | --- | D | --- | --- | SP | 1.0 | --- | --- | 1.7 | R | SP | 2.5 | R | SP | 2.5 |
| **COMPRESSORS AND VACUUM PUMPS** | | | | | | | | | | | | | | | | |
| UP THROUGH 1-1/2 HP | | --- | D,L, W | --- | ---- | D,L, W | --- | --- | D,L, W | --- | --- | D,L, W | --- | --- | D,L, W | --- |
| 2 HP AND OVER: | | | | | | | | | | | | | | | | |
| 500 - 750 RPM | | --- | D | --- | --- | S | 1.7 | --- | S | 2.5 | --- | S | 2.5 | --- | S | 2.5 |
| 750 RPM & OVER | | --- | D | --- | --- | S | 1.0 | --- | S | 1.7 | --- | S | 2.5 | --- | S | 2.5 |
| **PUMPS** | | | | | | | | | | | | | | | | |
| CLOSE COUPLED | UP TO 1-1/2 HP | --- | --- | --- | --- | D,L, W | --- | --- | D,L, W | --- | --- | D,L, W | --- | --- | D,L, W | --- |
| | 2 HP & OVER | --- | --- | --- | I | S | 1.0 | I | S | 1.0 | I | S | 1.7 | I | S | 1.7 |
| BASE MOUNTED | UP TO 10 HP | --- | --- | --- | --- | D,L, W | --- | --- | D,L, W | --- | --- | D,L, W | --- | --- | D,L, W | --- |
| | 15 HP THRU 40 HP | I | S | 1.0 | I | S | 1.0 | I | S | 1.7 | I | S | 1.7 | I | S | 1.7 |
| | 50 HP & OVER | I | S | 1.0 | I | S | 1.0 | I | S | 1.7 | I | S | 2.5 | I | S | 2.5 |

| EQUIPMENT | ON GRADE | | | 20 FT FLOOR SPAN | | | 30 FT FLOOR SPAN | | | 40 FT FLOOR SPAN | | | 50 FT FLOOR SPAN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| **ROOF VENTILATORS** | | | | | | | | | | | | | | | |
| ABOVE OCCUPIED AREAS: | | | | | | | | | | | | | | | |
| 5 HP & OVER | --- | --- | --- | CB | S | 1.0 | CB | S | 1.0 | CB | S | 1.0 | CB | S | 1.0 |
| **CENTRIFUGAL BLOWERS** | | | | | | | | | | | | | | | |
| UP TO 50 HP: | | | | | | | | | | | | | | | |
| UP TO 200 RPM | B | N | 0.3 | B | S | 2.5 | B | S | 2.5 | B | S | 3.5 | B | S | 3.5 |
| 201 - 300 RPM | B | N | 0.3 | B | S | 1.7 | B | S | 2.5 | B | S | 2.5 | B | S | 3.5 |
| 301 - 500 RPM | B | N | 0.3 | B | S | 1.7 | B | S | 1.7 | B | S | 2.5 | B | S | 3.5 |
| 501 RPM & OVER | B | N | 0.3 | B | S | 1.0 | B | S | 1.0 | B | S | 1.7 | B | S | 2.5 |
| 60 HP & OVER: | | | | | | | | | | | | | | | |
| UP TO 300 RPM | B | S | 1.7 | I | S | 2.5 | I | S | 3.5 | I | S | 3.5 | I | S | 3.5 |
| 301 - 500 RPM | B | S | 1.7 | I | S | 1.7 | I | S | 2.5 | I | S | 3.5 | I | S | 3.5 |
| 501 RPM & OVER | B | S | 1.0 | I | S | 1.7 | I | S | 1.7 | I | S | 2.5 | I | S | 2.5 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **COOLING TOWERS** | | | | | | | | | | | | | | | |
| UP TO 500 RPM | --- | --- | --- | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 2.5 | --- | SP | 3.5 |
| 501 RPM & OVER | --- | --- | --- | --- | SP | 1.0 | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 2.5 |
| **INTERNAL COMBUSTION ENGINES** | | | | | | | | | | | | | | | |
| UP TO 25 HP | I | N | 0.3 | I | N | 0.3 | I | S | 1.7 | I | S | 2.5 | I | S | 2.5 |
| 30 THRU 100 HP | I | N | 0.3 | I | N | 1.7 | I | S | 2.5 | I | S | 3.5 | I | S | 3.5 |
| 125 HP & OVER | I | N | 0.3 | I | N | 2.5 | I | S | 3.5 | I | S | 4.5 | I | S | 4.5 |

| EQUIPMENT | ON GRADE | | | 20 FT FLOOR SPAN | | | 30 FT FLOOR SPAN | | | 40 FT FLOOR SPAN | | | 50 FT FLOOR SPAN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| **AIR HANDLING UNIT PACKAGES** | | | | | | | | | | | | | | | |
| SUSPENDED: | | | | | | | | | | | | | | | |
| UP THRU 5 HP | --- | --- | --- | --- | H | 1.0 | --- | H | 1.0 | --- | H | 1.0 | --- | H | 1.0 |
| 7-1/2 HP & OVER: | | | | | | | | | | | | | | | |
| UP TO 500 RPM | --- | --- | --- | --- | H, THR | 1.7 | --- | H, THR | 1.7 | --- | H, THR | 1.7 | --- | H, THR | 1.7 |
| 501 RPM & OVER | --- | --- | --- | --- | H, THR | 1.0 | --- | H, THR | 1.0 | --- | H,TH R | 1.7 | --- | H,TH R | 1.7 |
| FLOOR MOUNTED: | | | | | | | | | | | | | | | |
| UP THRU 5 HP | --- | D | --- | --- | S | 1.0 | --- | S | 1.0 | --- | S | 1.0 | --- | S | 1.0 |
| 7-1/2 HP & OVER: | | | | | | | | | | | | | | | |
| UP TO 500 RPM | --- | D | --- | R | S, THR | 1.7 | R | S, THR | 1.7 | R | S, THR | 1.7 | R | S, THR | 1.7 |
| 501 RPM & OVER | --- | D | --- | --- | S, THR | 1.0 | --- | S, THR | 1.0 | R | S, THR | 1.7 | R | S, THR | 1.7 |
| **IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED: (APR 9)** | | | | | | | | | | | | | | | |
| UP THRU 50 HP: | | | | | | | | | | | | | | | |
| UP TO 300 RPM | --- | D | --- | R | S | 2.5 | R | S | 2.5 | R | S | 2.5 | R | S | 3.5 |
| 301 - 500 RPM | --- | D | --- | R | S | 1.7 | R | S | 1.7 | R | S | 2.5 | R | S | 2.5 |
| 501 - & OVER | --- | D | --- | --- | S | 1.0 | --- | S | 1.0 | R | S | 1.7 | R | S | 2.5 |
| 60 HP AND OVER: | | | | | | | | | | | | | | | |
| 301 - 500 RPM | R | S | 1.0 | R | S | 1.7 | R | S | 1.7 | R | S | 2.5 | R | S | 3.5 |
| 501 RPM & OVER | R | S | 1.0 | R | S | 1.7 | R | S | 1.7 | R | S | 1.7 | R | S | 2.5 |

**NOTES:**

**(1)** Refer to MASTER SPECIFICATION 23 05 41 (15200), NOISE AND VIBRATION CONTROL for isolators and symbols. Edit to show where isolators other than the ones shown are used, such as for seismic restraints and position limit stops.

**(2)** For suspended floors lighter than 4 inch [100 mm] thick concrete, select deflection requirements from next higher span.

**(3)** For separate chiller building on grade, pump isolators may be omitted.

**(4)** Direct bolt fire pumps to concrete base. Provide pads (D) for domestic water booster pump package.

**(5)** For projects in seismic areas, use only SS and DS type isolators and snubbers.

**(6)** Isolators are not required when cooling tower is located on grade or on the roof over the mechanical room.

**(7) Floor mounted (APR 1):** Use "B" type in lieu of "R" type base.

**(8) Suspended:** Use "H" isolators of same deflection as floor mounted.

# CHAPTER 3: AIRSIDE HVAC SYSTEMS AND EQUIPMENT

## Table of Contents

## 3.1 INTRODUCTION

This chapter deals with the airside of the HVAC systems and associated equipment. Information given below shall be used in conjunction with the VA Standard Details, Master Specifications, and applicable documents, described in the TIL (Chapter 1).

Evaluated systems are:

- All-Air Systems
- Fan Coil Unit Systems
- Heating and Ventilation Systems
- Exhaust Systems
- Miscellaneous Systems/Components

## 3.2 ALL-AIR SYSTEMS

### 3.2.1 SPECIAL REQUIREMENTS

#### 3.2.1.1 Mandatory Use

All-air systems shall be used for all new facilities and major renovations of existing facilities, where ceiling clearance is available to accommodate HVAC ducts. Design of all-air systems shall be based on admitting minimum outside air, or 100% outside air, with variable air volume (VAV) or constant volume (CV) configuration.

#### 3.2.1.2 AHU Configuration

**(a)** Air-handling units shall be ARI-certified, factory-fabricated, and standard products of one manufacturer. All air-handling units shall be constructed in modular, vertical or horizontal, and draw-through configuration. ***Use of the blow-through air-handling units is not permitted, as fully saturated air leaving the cooling coil causes damage to the filters and sound attenuators on the downstream side*.** See Figure 3-1 for the typical air-handling unit configuration.

**(b)** Each air-handling unit shall be installed as a standalone entity without any physical interface with another air-handling unit. Selection of stacked (one on the top of another) air-handling units is not permitted. Use of a common return air fan for two or more air-handling units is also not permitted.

#### 3.2.1.3 AHU Capacity

The capacity of a single air-handling unit shall not exceed **40,000 CFM [18,688 Liters/Second].**

#### 3.2.1.4 Air Distribution

**(a)** All supply, return, exhaust, relief, and outside air systems shall be fully ducted between the fans and air inlets/outlets. ***Use of the space between the structural ceiling and the suspended ceiling is not permitted as an air plenum.***

**(b)** Generally a single supply air duct shall run from the supply air fan discharge to the air outlets. ***Use of a dual-duct air distribution system is not permitted.***

#### 3.2.1.5 Air Terminal Units

All air terminal units (constant volume or variable air volume) serving perimeter or interior spaces shall be equipped with integral reheat coils. When terminal units serving interior spaces are not equipped with reheat coils, and set at 0 CFM [0 Liters/Second], small but sustained leakage of supply air tends to overcool the space during prolonged no-load conditions. Use heating hot water where available, with modulating control. See further details in this chapter.

#### 3.2.1.6 Fan Coil Units

Fan coil units are not permitted in new construction. Fan coil units are also not permitted in major renovation projects, where space is available to accommodate air distribution ductwork between the structural ceiling and the suspended ceiling. See further details in this chapter.

**Exception:**
Fan coil units (two-pipe, cooling-only) can be used to serve miscellaneous spaces requiring year around cooling. See Appendix 6-B for specific applications.

### 3.2.2 VAV SYSTEMS

#### 3.2.2.1 General

VAV systems shall be designed to vary the supply air volume in response to the prevailing cooling load while still maintaining minimum outside air for ventilation under all operating conditions, from full-load to part-load conditions at the air-handling unit level.

#### 3.2.2.2 System Controls and Components

The system design shall include:

- Variable speed drives for supply and return/relief air fans
- Airflow measuring devices in supply, return, and minimum outside air ducts
- Supply air fan speed shall be controlled by polling all air terminal units

Airflow measuring devices shall facilitate a tracking sequence in which a constant difference between the supply and return/relief air fans shall be maintained. Limit the tracking and speed reduction sequences to avoid return/relief air fan stalling while still maintaining minimum outside air.

### 3.2.3 CONSTANT VOLUME ALL-AIR SYSTEMS

Constant volume AHUs shall be similar to the VAV all-air units with the exception that the supply and return air fans do not require variable speed drives unless the application calls for constant air volume delivery under varying filter static pressure drops.

### 3.2.4 SYSTEM COMPONENTS

#### 3.2.4.1 Supply Air Fan

**(a) General:** Select statically and dynamically-balanced centrifugal fans in the configuration and design suited for the specific applications. Select the fan type and construction to deliver design air volume at the estimated static pressure without exceeding the required noise and vibration criteria. Limit fan speed to 1,600 RPM. ***Use of plug/plenum centrifugal fans is not permitted.***

**(b) Selection Criteria:** Select the supply air fan and motor for the calculated air volume and static pressure, adjusted for altitude, temperature, fan inlet/discharge conditions (system effect) as specified in AMCA 201-02. Fan selection shall be made within the stable range of operation at an optimum static efficiency.

The fan motor BHP [KW] at the operating point on the fan curves shall be increased by 10% to cover the drive losses and field conditions. The fan motor shall be selected within the rated nameplate capacity and without relying upon NEMA Standard Service Factor. Wherever the variable frequency drive is specified, the fan motor selection shall be compatible with variable frequency drive motor controller duty.

Additional information for energy efficient motors is given in the TIL

#### 3.2.4.2 Return Air Fan

When room air is returned to the air-handling unit, provide a dedicated return or relief air fan for each air-handling unit to facilitate the room-by-room air balance. The fan system shall incorporate the use of an airside economizer cycle, as specified in Chapter 2. Provide an electronic interlock between the:

- Supply and return/relief air fans
- Supply and exhaust air fans associated with the air-handling unit

#### 3.2.4.3 Exhaust Fan(s)

Provide general and special exhaust fans as required, electronically interlocked with the AHU supply air fan. A single AHU may be interlocked with multiple exhaust fans serving multiple applications such as fume hood exhaust, “wet exhaust,” and general exhaust systems.

#### 3.2.4.4 Motor Voltages

Motor voltages shall conform to NEMA/ANSI standard as follows:

| **Table 3-1: Motor Voltage Sizing Criteria** | | |
|---|---|---|
| **System Voltage (Transformers)** | | **Utilization Voltage (Motors)** |
| Nominal | With 4% Drop | Standard (For Schedule) |
| 120 | 115.2 | 115 |
| 208 | 199.7 | 200 |
| 240 | 230.4 | 230 |
| 480 | 460.8 | 460 |
| 600 | 576.0 | 575 |
| 2400 | -- | 2300 |
| 4160 | -- | 4000 |

#### 3.2.4.5 AHU Casing

The AHU casings shall be solid (without perforations) double-wall type, with thermal insulation between the inner and outer casings. Use of exposed interior insulation is not permitted. Combination of the casing gages and thermal insulation shall ensure the following:

**(a)** There is no condensation on the exterior surface of the AHU or viewing windows when located in the non-conditioned spaces such as mechanical rooms, basements, and attic spaces.

**(b)** Composite assembly comprising of casings and insulation shall provide adequate stiffness to limit vibrations and radiated noise.

**(c)** See AHU specifications for the construction details.

#### 3.2.4.6 Access and Mixing Sections

The design shall include access sections, as shown in the Figure 3-1. The designer shall show access sections and door swings on the floor plans. Include factory-fabricated mixing boxes to mix the return and outside airstreams. Provide a bender section, where warranted, to mix return and supply air and prevent stratification.

#### 3.2.4.7 Drain Pans

**(a)** Provide insulated, stainless steel, double-wall, and double sloping drain pans for removing cooling coil condensate from the pan as soon as it is formed. The drain pans shall be coated with factory-applied, anti-bacterial finish.

**(b)** Where two coils are stacked on top of each other, include an intermediate drain pan for draining condensate from the top coil into the main drain pan.

**(c)** Raise all floor-mounted air-handling units from the finished floor levels to gain adequate static head for the installation of the cooling coil condensate traps and steam traps, where steam pre-heat coils are used.

#### 3.2.4.8 Cooling Coils

**(a)** Chilled water and DX cooling coils shall be copper tube and aluminum fin construction. Select cooling coils at face velocity of 500 Feet/Minute [2.5 Meters/Second], with the fin spacing not to exceed 132 Fins/Foot [433 Fins/Meter].

**(b)** Evaluate the option of lowering the cooling coil face velocity if life-cycle cost-effective.

**(c)** Equip cooling coils with copper fins in high humidity areas. See Chapter 7.

#### 3.2.4.9 Preheat Coils

Provide preheat coils for ***all*** AHUs where winter design temperature is 30 F [-1.1 C] or less. Provide steam, hot water/glycol, hot water, or electric pre-heat coils. Provide face velocity identical to the cooling coils. Ensure freeze protection by evaluating and including one or more of the options below:

**(a) Steam Heating Coils:** Steam coils with integral face and bypass dampers and two-position on/off control valves. As an option, for non-100% outside air units, consider the use of distributing type of steam coil with a modulating control valve to ensure uniform heat distribution and to minimize air stratification. Ensure that the steam condensate is removed from the coil as soon as it is formed. Ensure correct sizing of steam trap, availability of the gravity drain leg (static height), and recommended slope for the gravity return. See VA Standard Detail.

**(b) Hot Water/Glycol Coils:** Evaluate the use of hot water/glycol preheat coils where the preheat coil surface comes in contact with ambient air below freezing temperatures. Use propylene glycol solution specifically manufactured for HVAC applications with inhibitors for corrosion resistance. See Appendix 4-A for the glycol properties and Chapter 4 for system description. Include additional freeze protection measures in the system design, as indicated by ASHRAE.

- Provide a dedicated circulating pump in the coil circuit with hydronic separation between the coil circuit and the incoming hot water piping. See VA Standard Detail, Hot Water Preheat heating Coil and Inline Pump.
- Maintain constant water velocity through the preheat coil tubes at 3.0 Feet/Second [0.9 Meters/Second].
- Select coils with wider fin spacing at the rate of 6 or 8 Fins/Inch.
- Provide coil connections to ensure that the coldest air faces the hottest fluid.

**(c) Hot Water Coils:** Glycol can be omitted for the locations where the outdoor design temperature is above 32 F [0 C].

**(d) Electric Coils:** Use of electric preheat is permitted only where steam and hot water are not available. Select low-watt density electric coils complete with safety and SCR (Silicon-Controlled-Rectifier) controls to ensure modulating operation.

#### 3.2.4.10 Unit-Mounted Reheat Coils

Where application permits the use of an AHU-mounted reheat coil (example: for a single zone), use hot water reheat coils, with modulating temperature control. Freeze protection measures are not required. Use of electric reheat is permitted only where hot water is not available.

#### 3.2.4.11 Heat Recovery Systems

See Chapter 2.

#### 3.2.4.12 Economizer Cycle

See Chapter 2.

### 3.2.4.13 Filters

**(a) General:** For each air-handling unit, provide two filter sections: pre-filters and after-filters. Locate pre-filters and after-filters back-to-back, on the suction side of the fan. Provide adequate space between the two filter sections to locate sensors and tubing for measuring the pressure drops through both pre-filters and after-filters.

**(b) Special Applications:** For specialized applications in Appendix 6-A, three sets of filters shall be provided. Provide pre-filters and after-filters, as described above, on the upstream side of the supply air fans. Provide final-filters on the downstream side of the supply air fan, or multiple terminal filters on the downstream side of the individual air terminal units. Provide a diffuser section between the supply air fan and final-filters when the final-filters are located immediately the supply air fan. The diffuser section shall ensure uniform distribution air across the filter face area.

**(c) Filter Efficiency:** Filter efficiencies shall comply with ASHRAE Standard 52.2 – 1999 (Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size). All filter efficiencies shall be expressed as MERV (Minimum Efficiency Reporting Value).

**Pre-Filters (VA Grade A)**

MERV Rating = 8

Particle Sizes = 3 to 10 Microns

Average Dust-Spot Efficiency = 30 to 35%

Filter Size = 2 inch Thick Throwaway

**After-Filters (VA Grade B)**

MERV Rating = 11

Particle Sizes = 1 to 3 Microns

Average Dust-Spot Efficiency = 60 to 65%

Filter Size = 6 inch Thick Cartridge Throwaway

**After-Filters (VA Grade C)**

MERV Rating = 14

Particle Size = 0.3 to 1.0 Micron

Average Dust-Spot Efficiency = 90 to 95%

Filter Size = 12 inch Thick Cartridge Throwaway

**After-Filters (VA Grade D)**

MERV Rating = 15

Particle Size = 0.3 to 1.0 Micron

Average Dust-Spot Efficiency = Greater Than 95%

Filter Size = 12 inch Thick Cartridge Throwaway

**After-Filters (VA Grade E, HEPA Filters)**

MERV Rating = 17

Particle Size = 0.3 Micron or Smaller

Efficiency = 99.97% on 0.3 Micron-Sized Particles

IEST (Institute of Environmental Sciences and Technology) Type A

**(d) Applications:** See Appendix 6-A for specific applications.

**(e) Manual Pressure Gages:** Provide a single dial-type differential pressure gage with air sampling tubing and three isolation valves (ball valves) to measure static pressure drop through each filter section and/or the total static pressure drop through pre-filters and after-filters.

Provide a dedicated pressure gage for the final-filters.

**(f) Automatic DDC Sensors:** Provide a dedicated DDC pressure differential sensor for each filter section to register the actual pressure drop. The DDC sensors shall interface with the building ECC system to remotely provide a maintenance alarm capability.

**(g) Filter Pressure Drops:** Estimate the fan static pressure with filters in dirty condition at the manufacturer's published data for the recommended changeover conditions. Do not use filter static pressure drop at clean condition. In the equipment schedule show both static pressure drops for each filter section, that is, at the clean and replacement conditions.

**3.2.4.14 Humidifiers**

**(a) General:** Central or primary humidifiers shall be sized to maintain zone humidity as specified. Terminal humidifiers, when used, shall be used for additional humidification and room level control. See Appendix 6-A and Appendix 6-B for terminal humidification applications.

**(b) Type:** Humidifiers shall be steam manifold jacketed type, designed to attain full dispersion of steam into the airstream. Humidifiers shall be located in the air-handling unit or in the main supply air duct. When located in the supply air duct, design shall include pitched, welded duct section of stainless steel construction. Provide a drain connection at the bottom face of the duct at the lowest point. See VA Standard Details.

**(c) Steam-to-Steam Generator:** Provide a steam-to-steam, unfired steam generator to produce low-pressure "clean steam" at 15 PSIG [103.4 Kilo-Pascal]. Verify the actual pressure at which high-pressure steam is generated at the central boiler plant in the winter season. See VA Standard Detail, Steam-To-Steam Unfired Generator.

**(d) Humidifier Controls:** Provide a modulating steam control valve to control and maintain the space humidity. Provide a return air duct-mounted sensor to control the humidity set-point. Provide a high-limit humidity sensor in the supply air duct to stop humidification if the measured humidity exceeds 85% (adjustable). Ensure full integration of the humidifier controls with the ECC, including remote alarm capability.

**(e) Water Quality:** Provide incoming water on the low-pressure side steam generator in accordance with the manufacturer's recommendations. Use an actual sample of the available make-up water. Provide recommended water treatment and lower the incoming dissolved solids to 80 PPM (Parts Per Million).

### 3.2.4.15 Supply Air Terminals

**(a) General:** Provide pressure-independent, DDC-controlled air terminal units (also referred to as boxes), for the constant and/or variable air volume applications. Each box shall be equipped with integral, hot water reheat coil. Provide two-way, modulating control valves.

**(b) Limiting Capacities:**

- Maximum capacity of a single box shall not exceed 3,000 CFM [1,416 Liters/Second]
- Minimum hot water flow shall not be lower than 0.5 GPM [0.03 Liters/Second]

**(c) Terminal Settings:** Design maximum and minimum air volumes shall be factory-set, but field-adjustable. The minimum setting shall satisfy the following:

- Provide make-up air for exhaust
- Meet the minimum ventilation needs
- Limit the supply air temperature to 95 F [35 C] in heating mode. Increase the supply air airflow as required to provide more heat.

**(d) Series Fan-Powered Air Terminal Units:** For non-patient areas, evaluate and include series fan-powered boxes in the HVAC system design. Provide a solid-state speed controller to adjust the fan speed. Provide a 1 inch [25 mm] thick throwaway filter in the return air intake opening. Use of the series fan-powered boxes offer following advantages:

- Constant air circulation even at part-load conditions, avoiding the sense of stagnation
- Simplified control sequences for the night setback and morning warm-up cycles, avoiding the use of the primary air-handling units

**(e) Acoustic Treatment:** Provide terminal sound attenuators, as recommended by the acoustic analysis.

### 3.2.4.16 Supply Air Outlets

**(a) Linear Diffusers:**

- For all occupied spaces with exposed perimeter windows, the design shall be based on linear supply air diffusers. The minimum length of the supply air diffusers shall match the window width. The design shall include a factory-furnished, internally-insulated supply-air plenum over the diffuser. Provide a single feed or multiple feeds to the plenum, as recommended by the manufacturer, to ensure uniform velocity distribution.

- For spaces such as lobby and reception areas with high glass, include wall-to-wall linear diffusers in the design. Provide supply air plenum continuously or intermittently as required to ensure required throw and air diffusion. Include blank-offs for the diffuser segments, where plenums are not required.

- Provide a manual volume control damper for each takeoff feeding the linear diffuser.

**(b) Square/Rectangular Diffusers:**

- For interior spaces and elsewhere (where required), include square 24 inch [600 mm] x 24 inch [600 mm] or 12 inch [300 mm] x 12 inch [300 mm] supply air diffusers with neck sizes as required to meet the duty conditions. Provide multiple supply air diffusers to achieve uniform air distribution without dead spots.

- Use rectangular supply air diffusers for uneven air distribution.

- For corridors, provide two-way blow diffusers to suit the space geometry.

- Limit the capacity of a single diffuser to 400 CFM [187 Liters/Second].

**(c) Round Diffusers:** Use round diffusers for the exposed occupied spaces.

## 3.3 FAN COIL UNITS SYSTEMS

### 3.3.1 SYSTEM DESCRIPTION

Where the use of fan coil units is permitted, design 4-pipe fan coil units systems to heat and cool the occupied spaces. For minimum ventilation, provide a dedicated, 100% outside air unit to cool and dehumidify or heat and humidify the ambient air. Provide a fully-ducted, distribution system to supply conditioned, minimum ventilation air directly into the space. Admission and distribution of minimum ventilation air (conditioned or raw) is ***not*** permitted through the fan coil units.

See Chapter 2 for the estimation of the minimum outside air requirements.

### 3.3.2 SYSTEM APPLICATIONS

#### 3.3.2.1 Interior Spaces

**(a)** Generally the use of 4-pipe fan coil systems shall be limited to serve the perimeter spaces only.

**(b)** Fan coil units shall not be used to serve isolated interior spaces. Use minimum ventilation air to condition and ventilate such occupied spaces. Provide room temperature control.

#### 3.3.2.2 Ventilation Air Control

Do not deliver minimum ventilation air at “neutral” condition, where air is reheated almost up to the room air temperature after dehumidification. Provide dynamic control of the ventilation air temperature to take full advantage of its available cooling capacity in cooling mode and heating capacity in heating mode. Ensure that the variations in the ventilation air temperature do not compromise dehumidification.

#### 3.3.2.3 Ventilation Air Outlets

Minimum ventilation air outlets shall be designed to provide the required air throw to the occupied areas. With smaller ventilation air volumes, 20 CFM [9.5 Liters/Second], selection of suitable outlets is necessary. Use of the jet type of side outlets, generally used in aircrafts, shall be evaluated to meet the design intent.

### 3.3.3 SYSTEM COMPONENTS

#### 3.3.3.1 Central Ventilation Unit (100% Outside Air)

**(a) General:** The system components shall be similar to the air-handling unit described under all-air systems in this chapter. Mixing boxes and blenders is not required with 100% outside air units. Use a low-velocity supply air system.

**(b) Filtration:**

Pre-Filters – Grade A

After-Filters – Grade B

Instrumentation and static pressure selection criteria shall be similar to the all-air systems.

**(c) Humidification:** Provide zone-controlled humidification where required to maintain +/- 30% space humidity with equipment similar to those described for the all-air systems.

**Heat Recovery Systems:** See Chapter 2.

#### 3.3.3.2 Fan Coil Units

**(a) General:** Fan coil units can be used in vertical, floor-mounted or in horizontal, ceiling-suspended configurations. Vertical units are generally located under the windows to control cold drafts and solar radiation. Ceiling suspended units can be recessed or concealed with air distribution ductwork as needed.

**(b) Cooling Coil Condensate Piping:** Design shall ensure that the cooling coil condensate is removed without clogging the drain pan and drainlines. Minimize the extent of horizontal runs and provide cleanouts at each turn in the direction of flow. Pitch the drainline in the direction of flow to facilitate flow by gravity.

**(c) Filtration:** Provide manufacturer's standard filters.

**(d) Acoustic Measures:** See Chapter 2.

**(e) Controls:** 4-pipe fan coil units shall be equipped with separate cooling and heating coils. Provide a two-way, modulating control valve for each coil to operate the cooling and heating modes in sequence.

## 3.4 HEATING AND VENTILATION SYSTEMS (HVU)

### 3.4.1 GENERAL

Heating and/or ventilation systems shall be provided where mechanical cooling is not required. See Appendix 6-B for applications.

### 3.4.2 SYSTEM CONFIGURATION

HVU systems can be designed in any viable configuration to suit the applications. HVU can be composite units, similar to the conventional air-handling units, capable of providing ventilation and heating. Alternately, providing the dedicated heating and ventilation sub-systems can separate heating and ventilation functions.

#### 3.4.2.1 Composite System

**(a) System Description:** The system shall comprise of a fan, filters, and coil sections to deliver a minimum of six or more air changes per hour, as required. The system shall be complete with supply air distribution ductwork and outlets to ensure uniform air distribution. The system shall operate continuously during occupied hours.

**(b) System Operation:**

- The system shall be capable of admitting minimum outside air (ASHRAE 62.1 – 2007) during heating mode up to 100% outside air when outside air temperature is greater than 68 F [20 C], adjustable.
- The ventilation and heating shall be thermostatically-controlled. During night setback and unoccupied mode, the temperature shall be set at 50 F [10 C] and maintained by cycling the unit in 100% re-circulatory mode without admitting any outside air.

#### 3.4.2.2 Separate Heating and Ventilation Systems

**(a) System Description (Ventilation):** The ventilation system shall comprise a single exhaust fan or multiple exhaust fans, as required to ensure uniform coverage of the space. The exhaust fans shall be controlled manually or thermostatically. Provide matching intake and exhaust louvers, equipped with motorized dampers.

- When ambient temperature is 68 F [20 C] and above, the system shall admit unfiltered, 100% outside air, to be discharged outdoors by the exhaust fans. During unoccupied hours, the system shall be inoperative.
- During heating mode, the system shall admit only minimum outside air to comply with ASHRAE 62.1 – 2007 by operating one fan out of the battery of multiple exhaust fans or using another means, such as two-speed fans.

**(b) System Description (Heating):** The heating system shall comprise multiple terminal heaters such as unit heaters or forced-flow heaters to distribute heat uniformly and re-circulate air in the space. Heaters shall be thermostatically-controlled.

- During occupied mode, the heaters shall maintain 68 F [20 C] with minimum ventilation supplied by the remote ventilation system.
- During unoccupied mode, the heaters shall maintain 50 F [10 C] with the remote ventilation system in inoperative mode.

## 3.5 GENERAL AND SPECIAL EXHAUST SYSTEMS

### 3.5.1 INTRODUCTION – GENERAL EXHAUST SYSTEM

Typically general exhaust systems are centralized with the following system components:

- Exhaust Fan
- Exhaust Air Ductwork
- Exhaust Air Inlets
- Exhaust Air Discharge Arrangement (example: louvers)
- Motorized Damper(s)

- Controls (Interlocks)

### 3.5.2 APPLICATIONS – GENERAL EXHAUST SYSTEM

**(a)** The general exhaust systems serve the following spaces:

- Toilets
- Showers
- Locker Rooms
- Janitor's Closets
- Canopy Hoods
- Dark Rooms
- General Storage Spaces
- Soiled Utility Rooms

**(b)** General exhaust systems shall be provided for the spaces requiring 100% exhaust of supply air. Such exhaust systems are interlocked with the respective supply air system to ensure required air balance. See Appendix 6-A for examples:

- Supply Processing and Distribution (SPD) exhaust, less ETO exhaust and "wet exhaust"
- Kitchen and dining exhaust, less range hood exhaust and "wet exhaust"
- Laboratories, less fume hoods exhaust and biological safety cabinets exhaust
- Animal research facilities, less fume hoods exhaust and biological safety cabinets exhaust
- Surgical suite, less cylinder storage exhaust
- Bone Marrow Transplant (BMT)
- Autopsy suite

**(c)** General exhaust system can serve multiple air-handling units with identical hours of operation. Duct lengths shall not be excessive.

### 3.5.3 SPECIAL EXHAUST SYSTEMS

Described below are the special exhaust systems for fume hoods and Biological Safety Cabinets (BSC). Additional special exhaust systems such as ETO exhaust, isolation room exhaust, and kitchen grease hood exhaust are described in Appendix 6-A and Appendix 6-B.

### 3.5.4 ADDITIONAL CONSIDERATIONS

#### 3.5.4.1 Fan Location

Location and type of exhaust fans shall be project-specific. Install fans at the end of the exhaust ductwork and nearer to the discharge outdoors to keep the exhaust ductwork under negative air pressure. With the exception of roof ventilators, exhaust fans shall be housed in adequately-sized enclosed spaces.

#### 3.5.4.2 Heat Recovery System

See Chapter 2.

## 3.6 FUME HOOD EXHAUST SYSTEMS

### 3.6.1 GENERAL

Provide exhaust systems for the hoods mentioned below. Coordinate quantities, sizes, and types of fume hoods with the architectural drawings and project-specific program needs. In this section, the following three different types of hoods are covered:

- Radioisotope Hoods (VA Type H3)
- General Purpose and Chemical Hoods (VA Type H7)
- Perchloric Acid Hoods (VA Type H14)

### 3.6.2 SPECIAL REQUIREMENT

Use of auxiliary make-up air hoods is not permitted.

### 3.6.3 COMPLIANCE

- NFPA 45
- ANSI/ASHRAE Standard 110-1999 (Hood Testing)
- OSHA 29 CFR (Part 1910)

### 3.6.4 BASIS OF DESIGN (H3 AND H7 HOODS)

#### 3.6.4.1 General

The basic premise of the fume hood exhaust systems is to maintain constant, face velocity at 100 Feet/Minute [0.5 Meter/Second] over the hood sash area, under varying sash positions. The sash is defined as the movable glass panel, which covers the face area of the hood. The sash position can vary from almost fully closed to fully open to a pre-determined intermediate stop with a fixed sash stop.

#### 3.6.4.2 Specific Requirements

**(a)** Provide emergency power for the exhaust system and associated controls for all hood exhaust systems.

**(b)** Do not connect any exhaust from sources other than identical hoods to the fume hood exhaust system.

**(c)** H3 hoods can be grouped together to form a combined exhaust system. H7 hoods can be grouped together to form a combined exhaust system. H14 hoods cannot be grouped together. Each H14 hood must have its own dedicated exhaust system.

**(d)** Provide spark-proof construction fans and explosion-proof motors.

**(e)** Provide an airflow control valve with readout capability or a DDC CV/VAV terminal unit in each branch exhaust duct.

**(f)** Provide local and remote alarm capability at the ECC for each fume hood in the event of a system failure or the face velocity readout outside the high or low set-points.

**(g)** Provide round, stainless-steel welded ductwork for hood exhaust. Provide a stainless steel transition piece between the hood discharge connection and the exhaust duct.

**(h)** Keep entire exhaust ductwork under negative air balance.

**(i)** Discharge exhaust air from the highest level of the building. Provide a discharge stack at least 10 Feet [3.0 Meters] tall. Increase the stack height, as required to meet the dispersion analysis recommendations. The discharge velocity at the nozzle shall be 3,500 Feet/Minute [17.8 Meters/Second].

**(j)** Include the discharge air velocity pressure and the static pressure drop through hood in the fan static pressure calculations.

**(k)** Include recommended acoustic analysis measures to contain the fan noise traveling back to the exhaust fan in the system design. Measures shall also examine such items as:

- Fan Selection
- Duct Velocity
- Sound Attenuators

**(l)** Do not attempt any heat recovery from the exhaust ducts of fume hoods.

**(m)** Do not install fume hood exhaust ducts in the same shafts in which environmental ducts are housed. See NFPA 90A for additional information.

**(n)** Do not install fire dampers in fume hood exhaust ducts.

**(o)** For H3 hoods, include VA Grade E (HEPA Filter – MERV 17) and VA Grade A (pre-filters) in the exhaust air duct, on the suction side of the exhaust fan.

### 3.6.5 H14 HOODS

In addition to the specific requirements listed for H3 and H7 hoods, the following additional requirements apply:

**(a)** Provide exhaust fan with polyurethane or similar inorganic coating or acid-resistant metallic material.

**(b)** **Water Spray System:** Design a water spray system to wash down the entire exhaust system at the end of each use, including the exhaust fan, ductwork, hood, and the baffles. Ensure coordination with the plumbing and electrical disciplines for make-up water connections and heat tracing (with emergency power) of the cold water line, where required. The washdown cycle shall be either automatic or manual. Provide a hose bibb within 30 Feet [9.1 Meters] of the discharge stack to facilitate manual wash.

### 3.6.6 EXHAUST AIR VOLUME

**(a)** Hood exhaust air volume is the product of the nominal sash area multiplied by the design face velocity over the sash area. Nominal sash area is the product of the actual sash width multiplied by the operating sash height. Operating sash height is defined as the height at the working level, where all laboratory work is done. For the hoods equipped with fixed sash stops, operating height is the sash height at the fixed sash stop.

**(b)** Exact exhaust air volume data shall be obtained from the hood manufacturers. In the absence of data, for the purpose of preliminary planning, use the average exhaust air volumes given below for each size and type of the fume hoods.

| **Table 3-2: Radioisotope Hoods (H3) Preliminary Exhaust Air Volumes** | | |
|---|---|---|
| Hood Size Inches [mm] | CFM [Liters/Second] | Pressure Drop Inch WG [Pascal] |
| 48 [1200] | 875 [413] | 0.375 [93] |
| 60 [1500] | 1125 [531] | 0.375 [93] |
| 72 [1800] | 1375 [649] | 0.375 [93] |

| **Table 3-3: General Purpose or Chemical Hoods (H7) Preliminary Exhaust Air Volumes** | | |
|---|---|---|
| Hood Size Inches [mm] | CFM [Liters/Second] | Pressure Drop Inch WG [Pascal] |
| 36 [900] | 625 [295] | 0.36 [89] |
| 48 [1200] | 875 [413] | 0.30 [75] |
| 60 [1500] | 1125 [531] | 0.32 [89] |
| 72 [1800] | 1375 [649] | 0.24 [60] |
| 96 [2400] | 1875 [884] | 0.40 [100] |

| **Table 3-4: Perchloric Acid Hood (H14) Preliminary Exhaust Air Volumes** | | |
|---|---|---|
| Hood Size Inches [mm] | CFM [Liters/Second] | Pressure Drop Inch WG [Pascal] |
| 48 [1200] | 1030 [486] | 0.625 [156] |
| 60 [1500] | 1355 [639] | 0.50 [125] |
| 72 [1800] | 1680 [792] | 0.75 [187] |
| 96 [2400] | 2355 [1111] | 0.75 [187] |

### 3.6.7 EXHAUST SYSTEM DESIGN

#### 3.6.7.1 Constant Volume (CV) Design

For a small project involving fewer than four hoods, the fume hood exhaust system design may be a constant volume type. Two different configurations are described:

**(a) Integral Bypass Hoods:** Bypass hoods maintain constant exhaust air volume. Lowering of the hood sash exposes a bypass inlet located above the sash. The bypass inlet reduces the increase in the sash face velocity, which in turn reduces turbulence and loss of containment. Provide a dedicated exhaust fan with this arrangement.

**(b) External Bypass Hoods:** With the external bypass hood (see VA Standard Detail, External Bypass Hoods), exhaust air volume is either directed through the room connection or through the hood by on/off motorized dampers connected in parallel. With the use of modulating dampers, response to keeping the constant face velocity is enhanced.

### 3.6.7.2 Variable Air Volume (VAV) Hoods (H7 and H3 Hoods Only)

For new construction and major renovations to be in compliance with the mandated energy conservation directives, provide a variable air volume design for H3 and H7 fume hoods. This system is accurate and sophisticated in maintaining constant face velocity with varying sash positions by varying the exhaust air volume. The system has substantial potential to reduce energy consumption since it mostly operates at part-load conditions.

**(a) System Configuration and Controls:** The design shall comprise three separate systems:

- **Supply Air System:** The capacity of the variable air volume supply air system shall be selected to maintain inside design conditions and/or to meet the exhaust needs of the hoods. The complete system design shall include a variable speed drive for the supply air fan, an airflow measuring device, DDC-controlled VAV air terminal units, and a static pressure sensor.

- **Hood Exhaust Air System:** Design a dedicated, variable air volume system to serve all identical hoods (either H7 or H3). The capacity of the exhaust system shall be selected to satisfy all hoods operating at their nominal capacities. Each duct connection from the hood shall be equipped with an airflow control valve that modulates to vary the exhaust air volume to maintain the constant face velocity. Each hood shall be equipped with controls which continually measure and monitor sash position, velocity, and the required exhaust air volume. The complete system design shall include a variable speed drive for the exhaust air fan, an airflow measuring device, a HEPA filter (H3 hood only), and a static pressure sensor.

- **General Exhaust System:** Design a dedicated, variable air volume system which operates in parallel with the hood exhaust system. The capacity of the general exhaust system shall be sized to remove the room supply air when all hoods have assumed fully closed position. Note that even with the sash assuming a “fully-closed” position; the hood admits enough make-up air from the room to maintain negative air balance in the hood. The complete system design shall include a variable speed drive for the exhaust fan, an airflow measuring device, DDC-controlled airflow control valves (generally one per laboratory), and a static pressure sensor.

- **Controls:** For each laboratory, in response to the room temperature sensor and/or the sash positions of the fume hoods, the DDC controls shall orchestrate a synchronized operation of the VAV supply air terminal, VAV fume hood exhaust, and VAV general exhaust system to maintain a constant offset per each door, that is, the make-up air from the corridors shall be used to maintain negative air balance. Assume an offset of 100 CFM [47.2 Liters/Second] per each door. Each fan shall adjust its speed in response to a signal from its static pressure sensor to conform to the prevailing volumetric situation.

## 3.7 BIOLOGICAL SAFETY CABINETS (BSC) – VA TYPE H12

### 3.7.1 BIOLOGICAL SAFETY LEVEL 3 (BSL3)

See Appendix 3-A.

### 3.7.2 COMPLIANCE

- National Sanitation Foundation (NSF), Standard 49-2002 or the latest edition
- ASHRAE – Handbook of Applications (2007 or the latest edition)

### 3.7.3 CABINET CLASSIFICATION

**(a)** BSC protects research personnel, products, and environment from exposure to the biohazards and cross-contamination. Common sizes of the cabinet are: 4 Feet [12 Meters] and 6 Feet [18 Meters].

**(b) Cabinet and Safety Classification:** BSC are classified into three classes, as shown below:

**Table 3-5: Biological Safety Cabinet Classification**

| Classification | Bio-Safety Level | Application |
|---|---|---|
| Class I | 1, 2, 3 | Low to moderate risk biological agents |
| Class II | 1, 2, 3 | Low to moderate risk biological agents |
| Class III | 4 | High risk biological agents |

**(c)** Class I and Class III cabinets are rarely used. All Class II Cabinets require HEPA filters in the exhaust air system.

**(d)** VA does not have BSL 4 facilities.

#### 3.7.3.1 Class I Cabinets

**(a) General:** These cabinets do not protect the product because the “dirty” room air passes over the work surface and are identical to the chemical laboratory hoods.

**(b) Design Criteria:**

- Design face velocity is 75 Feet/Minute [0.4 Meters/Second].
- Filtration – Cabinet air must be filtered (VA Grades A and E) before it is exhausted outdoors or re-circulated in the laboratory. Use system configuration to suit the design intent. The available configurations are an integral exhaust fan or the building exhaust fan and hard duct connections or a thimble.
- Airflow Control Valve – Provide a pressure-independent airflow control valve to ensure constant exhaust air volume.
- Exhaust Ductwork – Provide welded stainless steel ductwork.
- Emergency Power – Provide emergency power for the exhaust fan.

### 3.7.3.2 Class II Cabinets

**(a) Classification:** Classification of BSC, Class II cabinet is based on NSF 2002.

| Table 3-6: Classification of Class II Biological Safety Closets | |
|---|---|
| **Classification** | **General Description** |
| A1 | ● 70% intake air re-circulated back to cabinet and 30% air exhausted outdoors<br>● Provide a duct “thimble connection” for exhaust to outdoors<br>● Provide cabinet air intake at 75 CFM [34.4 Liters/Second] capacity |
| A2 | ● 70% intake air re-circulated back to cabinet and 30% air exhausted outdoors<br>● Provide a duct “thimble connection” for exhaust to outdoors<br>● Provide cabinet air intake at 100 CFM [45.9 Liters/Second] capacity |
| B1 | ● 40% intake air re-circulated back to cabinet and 60% air exhausted outdoors<br>● Provide a dedicated exhaust air duct (hard connection) to outdoors<br>● Provide cabinet air intake at 100 CFM [45.9 Liters/Second] capacity |
| B2 | ● Provide a dedicated exhaust air duct (hard connection) to outdoors after passing over the unit-mounted HEPA filter<br>● Provide air intake at 100 FPM [45.9 Liters/Second] |

**(b) Exhaust Air Volumes:** The average exhaust air-quantities and pressure drops for type B1 and B2 and Class II cabinets are listed below:

| Table 3-7: H12 Cabinet Type B1 Exhaust Air Requirements | | |
|---|---|---|
| **Size<br>Inches [mm]** | **Exhaust Air<br>CFM [Liters/Second]** | **Pressure Drop<br>Inch WG [Pascal]** |
| 48 [1200] | 270 [124] | 1 [249] |
| 72 [1800] | 410 [188] | 1 [249] |

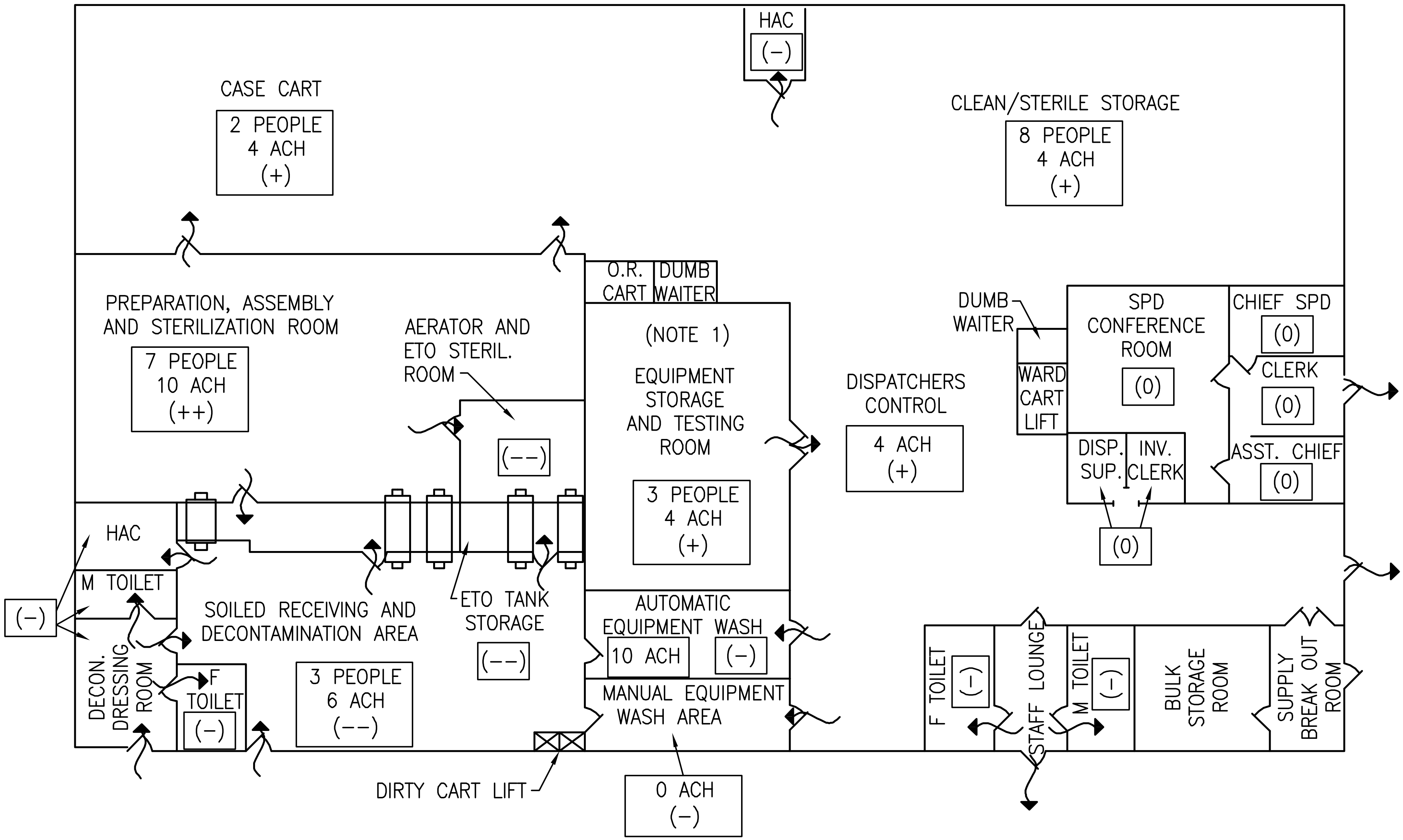
| Table 3-8: H12 Cabinet Type B2 Exhaust Air Requirements | | |
|---|---|---|
| **Size<br>Inches [mm]** | **Exhaust Air<br>CFM [Liters/Second]** | **Pressure Drop<br>Inch WG [Pascal]** |
| 48 [1200] | 730 [325] | 1 [249] |
| 72 [1800] | 1150 [527] | 1 [249] |

**(c) Filtration:** Class II, Type B1 and Type B2 safety cabinets come with two sets of HEPA filters, one for supply within the cabinet, and one for exhaust from the cabinet.

The pressure drops include friction loss through clean exhaust VA Grade E HEPA filters (the fact that the supply HEPA filter within the cabinet is not included as the internal blower maintains this filter) and transition fitting on the exhaust side. With a Type B1 hood, the exhaust filter is within the hood casing; the mounting is external with Type B2 hood.

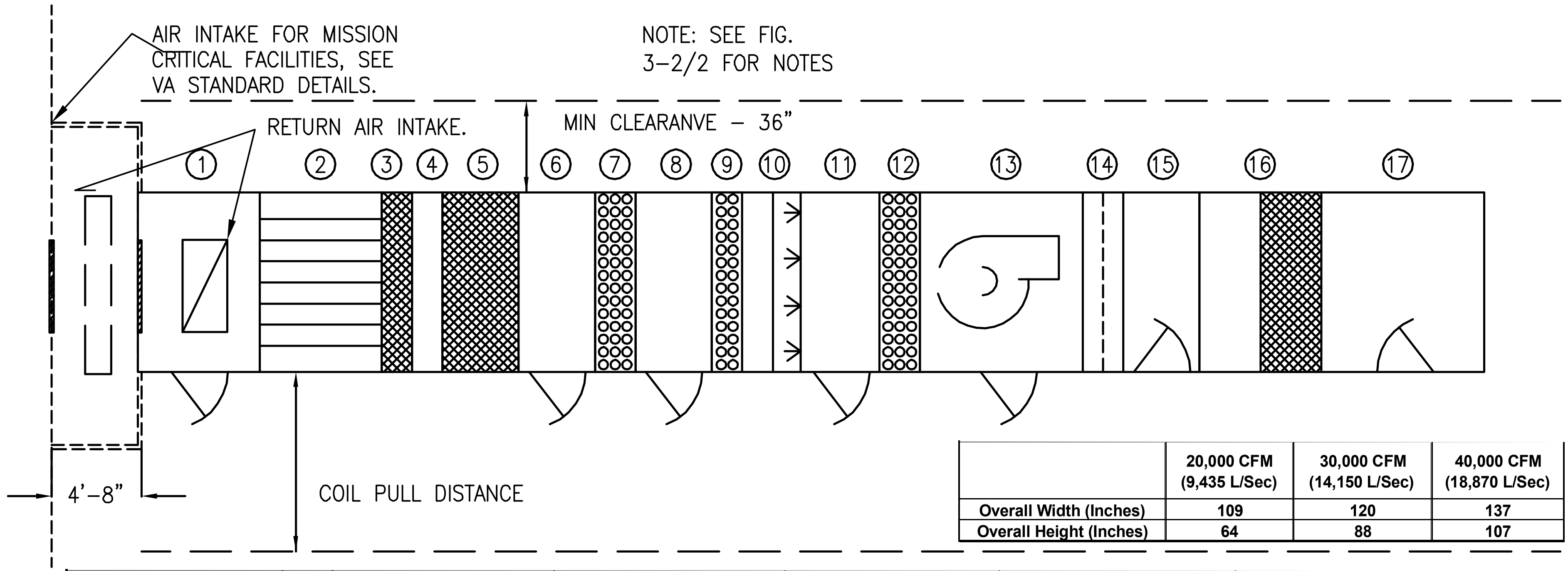
NOTE 1 : PARTITION WALLS ARE OPTIONAL
ACH : AIR CHANGES PER HOUR
(arrow symbol) : DIRECTION OF AIRFLOW

+ : POSITIVE AIR BALANCE
- : NEGATIVE AIR BALANCE
0 : NEUTRAL AIR BALANCE




## SUPPLY PROCESSING AIR FLOW DIAGRAM

Not to Scale




| | 20,000 CFM (9,435 L/Sec) | 30,000 CFM (14,150 L/Sec) | 40,000 CFM (18,870 L/Sec) |
|---|---|---|---|
| Overall Width (Inches) | 109 | 120 | 137 |
| Overall Height (Inches) | 64 | 88 | 107 |

| | AIR HANDLING UNIT | Item # | MINIMUM OUTSIDE AIR TWO BEDS OF FILTERS VAV | MINIMUM OUTSIDE AIR THREE BEDS OF FILTERS CV | 100% OUTSIDE AIR TWO BEDS OF FILTERS CV | 100% OUTSIDE AIR THREE BEDS OF FILTERS CV | LENGTH INCHES | | |
|---|---|---|---|---|---|---|---|---|---|
| | * AS REQUIRED | | | | | | 20,000 CFM (9,435 L/SEC) | 30,000 CFM (14,150 L/SEC) | 40,000 CFM (18,870 L/SEC) |
| * | Mixing Box | 1 | Yes | Yes | No | No | 48 | 48 | 54 |
| * | Blender Section | 2 | Yes | Yes | No | No | 48 | 48 | 54 |
| | Pre-Filters (Side Access) | 3 | Yes | Yes | Yes | Yes | 12 | 15 | 15 |
| | Inspection Section, small | 4 | Yes | Yes | Yes | Yes | 12 | 15 | 15 |
| | After-Filters (Side Access) | 5 | Yes | Yes | Yes | Yes | 30 | 30 | 30 |
| | Access Section, med-large | 6 | Yes | Yes | Yes | Yes | 30 | 30 | 30 |
| * | Heat Recovery Coil | 7 | No | No | Yes | Yes | 16 | 20 | 20 |
| * | Access Section, med-large | 8 | No | No | Yes | Yes | 30 | 30 | 30 |
| * | Pre-Heat Coil | 9 | Yes | Yes | Yes | Yes | 12 | 15 | 15 |
| * | Inspection Section, small | 10 | Yes | Yes | Yes | Yes | 12 | 15 | 15 |
| * | Humidifier | 11 | Yes | Yes | Yes | Yes | 32 | 40 | 40 |
| | Cooling Coil | 12 | Yes | Yes | Yes | Yes | 16 | 20 | 20 |
| | Fan | 13 | Yes | Yes | Yes | Yes | 64 | 69 | 92 |
| * | Diffuser | 14 | No | No | No | Yes | 16 | 20 | 54 |
| * | Access Section, med-large | 15 | No | No | Yes | Yes | 30 | 30 | 30 |
| * | HEPA Filter | 16 | No | No | No | Yes | 42 | 42 | 54 |
| * | Discharge Plenum (Vertical) | 17 | Yes | Yes | Yes | Yes | 64 | 64 | 64 |

## TYPICAL AIR HANDLING UNIT

Not to Scale

NOTES:

1. IF ITEMS 1 AND 2 ARE NOT INCLUDED, PROVIDE MED–LARGE ACCESS SECTION.
2. IF SPACE IS AVAILABLE, PROVIDE ACCESS DOORS ON BOTH SIDES OF AHU. IF SPACE IS NOT AVAILABLE, ENSURE EQUIPMENT IS SERVICEABLE FROM ONE SIDE OF THE AHU.
3. PROVIDE VAPOR TIGHT MARINE LIGHT IN EACH ACCESS SECTION, FACTORY WIRED TO A SINGLE WEATHERPROOF SWITCH LOCATED ON EXTERIOR OF CABINET.
4. INCLUDE A WIRE REINFORCED GLASS VIEW WINDOW IN EACH ACCESS AND FAN SECTION.
5. HUMIDIFIER LOCATION IS OPTIONAL AND MAY BE LOCATED IN THE AHU OR IN THE MAIN SUPPLY AIR DUCT.
6. SEE VA STANDARD DETAILS FOR OUTSIDE AIR PLENUM DETAIL. THE PLENUM LENGTH IS APPROXIMATELY 4 FEET – 8 INCHES.
7. THE INFORMATION GIVEN IN THE DETAIL IS MEANT FOR CONCEPTUAL DESIGN AND PLANNING. THE DESIGNER SHALL MAKE HIS OWN SELECTION BASED ON ENGINEERING CALCULATIONS AND UNIT BASIS OF DESIGN.

## AIR HANDLING UNIT NOTES

Not to Scale

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# APPENDIX 3-A: BIO-SAFETY LEVEL 3 (BSL3) FACILITIES

## 3-A.1 GENERAL

### 3-A.1.1 INTRODUCTION

VA Medical Centers use Bio-Safety Level 3 (BSL3) containment laboratories for the animal research and general research applications. ***Containment control is an essential goal of the facility design, operation, and maintenance. Primary and secondary barriers defined below are the mandatory provisions necessary to achieve the stated goal of containment.*** For new construction and existing construction with major renovation, the following design criteria shall be used.

### 3-A.1.2 CODE AND COMPLIANCE

The facility design shall comply with NFPA 45 and the Center for Disease Control (CDC) and the guidelines given in the National Institute of Health (NIH), Bio-Safety in Microbiological and Biomedical Laboratories (BMBL), 5th edition.

### 3-A.1.3 CERTIFICATION

Each facility shall be inspected and certified annually by the local safety officer and/or industrial safety hygienist in accordance with the procedure outlined by the National Institute of Health (NIH).

## 3-A.2 PRIMARY BARRIERS

### 3-A.2.1 BIOLOGICAL SAFETY CABINETS

**(a)** Perform all manipulations that may create aerosol or splatter inside a BSC (Biological Safety Cabinet) of appropriate size and classification (Class II or Class III). BSCs constitute ***primary barriers*** to protect the community, environment, and laboratory personnel. Access, ventilation, and other features described in the respective trades below are the ***secondary barriers*** to enhance the containment.

**(b)** See the VA Design Manual for the details on the biological safety cabinets. Coordinate quantity and type of cabinets with the end users. Open vessels and open batches shall not be used to perform such activities.

## 3-A.3 SECONDARY BARRIERS

### 3-A.3.1 LABORATORY – LOCATIONS

Locate BSL3 laboratories away from high-traffic areas to minimize exposure to the general public.

### 3-A.3.2 LABORATORY – ACCESS

Entry in the laboratory shall be through a dedicated and enclosed passageway or an anteroom, that is, through two sets of self-closing and self-locking doors. Provide interlocking mechanism to prevent the both sets of doors being open at the same time. The passageway or the anteroom can be used for changing clothes. Movement of supply and waste can be through a separate double-door access or autoclave.

### 3-A.3.3 ARCHITECTURAL CONSIDERATIONS

#### 3-A.3.3.1 Windows

All windows in the laboratory shall be closed and sealed. Provide high impact glass for the windows and doors with wire mesh inside for security concerns. Coordinate the glass characteristics with the VA Master Specifications.

### 3-A.3.3.2 Penetrations

All floor, wall, and ceiling penetrations shall be sealed to prevent any aerosol movement. All duct and piping openings shall also be sealed.

### 3-A.3.3.3 Walls, Ceilings, and Floors

**(a)** Provide smooth surfaces for the walls, ceilings, and floors. The surfaces shall be impermeable to liquids and resistant to the chemicals and disinfectants used in the laboratories.

**(b)** Floors shall be monolithic with continuous cove moldings that extend at least 4 inches [100 mm] up the wall.

**(c)** Use of the acoustic tile suspended ceiling is not permitted. Ceiling shall have a water-proof, hard surface for the ease of cleaning.

### 3-A.3.3.4 Doors

**(a)** Provide galvanized, epoxy-painted hollow metal doors with smooth impervious surfaces.

**(b)** Use of the wooden doors is ***not*** permitted.

## 3-A.4 PLUMBING AND FIRE PROTECTION CONSIDERATIONS

**(a)** All laboratory valves, gas cylinder manifold stations, vacuum system filters, and other plumbing and fire protection equipment that requires service and maintenance shall be located in a secured location outside of the BSL-3 laboratory suite.

**(b)** Provide a dedicated hands-free (sensor) hand washing sink located near the exit of the laboratory and not in the vestibule.

**(c)** The BSL-3 laboratory suite shall be on a separate sprinkler zonewith a dedicated supervised control valve.

**(d)** The sprinkler heads shall be concealed-type or a sprinkler design capable of being decontaminated on a regular basis.

**(e)** The suction side of the vacuum pump shall be piped to a 0.2 micron hydrophobic inline filter with valve bypass prior as close as possible to the laboratory. A mechanism for the decontamination of filters shall be incorporated into the design of the vacuum system.

**(f)** The vacuum pump discharge shall have a sampling port and shall be vented to atmosphere in a secured location at least 10 Feet [3 Meters] above any accessible location.

**(g)** An emergency shower/eyewash station shall be within the same room as a chemical fume hood. The emergency shower/eyewash station shall not have a floor drain.

**(h)** An autoclave shall be made available inside the laboratory for decontamination purposes.