DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
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01 March 2005

From: Commander, Naval Facilities Engineering Command, Capitol Improvements
To: Distribution

Subj: INTERIM TECHNICAL GUIDANCE (ITG) FY05-2, NAVFAC HUMID AREA HVAC DESIGN CRITERIA

Ref: (a) ITG FY03-4, "NAVFAC Mold Response Manual"
(b) Engineering Technical Letter (ETL) 04-3: Design Criteria for Prevention of Mold in Air Force Facilities, dtd 6 April 6 2004
(c) Engineering Technical Letter (ETL) 03-2: Design Criteria for Prevention of Mold in Air Force Facilities, dtd 12 August 2003

Encl: (1) "NAVFAC Humid Area HVAC Design Criteria," dtd 31 January 2005
(2) "Bachelor Housing 1 + 1E Apt Example"

1. Purpose. The purpose of this guide is to provide revised basic criteria and information concerning the design of facilities located in Humid Areas, with the intent to prevent the occurrence of mold and mildew growth.

2. Discussion. Reference (a) provides guidance on mold remediation and abatement, based upon increasing incidence of mold and mildew occurrence within Navy facilities. References (b) and (c) address prevention of similar problems within Air Force facilities. Enclosure (1) of this ITG incorporates substantial portions of the Air Force ETL, and supplements it with some additional information.

3. Action.

a. Design. All projects, located in Humid Areas, starting design 90 days after the effective date of this ITG will comply with enclosure (1). Projects currently under design shall be revised to comply, where schedule and funds permit.

b. Criteria. NAVFAC CI will coordinate the revision of existing and the drafting of new Unified Facilities Criteria (UFC) documents to incorporate the provisions of enclosure (1).

c. References to ITG FY05-02 have been added by changes to the following documents:

- UFC 1-200-01, *Design: General Building Requirements*
- UFC 3-410-0-02N, *Design: HVAC Systems*
- UFC 3-100-10N, *Architectural*
- UFC 3-400-10N, *Mechanical*

Subj: INTERIM TECHNICAL GUIDANCE (ITG) FY05-1, NAVFAC HUMID AREA HVAC DESIGN CRITERIA

Upon incorporation of Humid Area Design Criteria into existing and new documents, the above ITG FY05-02 and references to it will be cancelled.

4. Point of Contact. For clarification or additional information related to this subject, please contact Mr. Thomas J. Harris, PE, DSN 262-4206, Comm (757) 322-4206, email thomas.j.harris@navy.mil

S. P. GEUSIC
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01 March 2005

NAVFAC HUMID AREA HVAC DESIGN CRITERIA

1-1 Purpose. This guide provides design criteria for preventing mold inside Navy facilities.

1-2 "Humidity Control Basics." Successful control of humidity within Naval facilities, in order to prevent mold, requires the efforts of the several entities involved in the life cycle of the facility. The User must "Define the purpose of the project." The Architect must "Design a tight building." The HVAC designer must "Control the outdoor air." The Contractor must "Build low-leakage building and tight duct work." And the Building Operations Staff must "Maintain correct internal air pressure." Only then may the building meet the needs throughout the life cycle at minimum life cycle costs. The quotes courtesy of ASHRAE *Humidity Control Design Guide for Commercial and Institutional Buildings, Chapter 2,* see paragraph 3-1.4, below.

2-1 Application. This guide applies to new or renovated Navy facility projects that start design 90 days after the effective date of the ITG. Projects currently under design shall be revised to comply, where schedule and funds permit.

3-1 Referenced Publications:

3-1.2 Unified Facilities Criteria (UFC):
• UFC 3-400-02, *Design: Engineering Weather Data*
• UFC 3-400-10N, *Design: General Mechanical Requirements*
• UFC 4-721-10, *Design: Navy and Marine Corps Bachelor Housing,*

3-1.3 Unified Facilities Guide Specifications (UFGS):
• UFGS 15080, *Thermal Insulation for Mechanical Systems*
• UFGS 15950N, *Testing, Adjusting, and Balancing of HVAC Systems,*

3-1.4 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
• ASHRAE 52.2-1999, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*
• ANSI/ASHRAE 55-2004, *Thermal Environmental Conditions for Human Occupancy*
• ASHRAE 62.1-2004, *Ventilation for Acceptable Indoor Air Quality*
• ASHRAE 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings*
• Standard 90.1-2004 *User's Manual*
• *ASHRAE Fundamentals Handbook*
• ASHRAE *Humidity Control Design Guide for Commercial and Institutional Buildings*

3-1.5 Other Industry:
• National Roofing Contractors Association (NRCA) *Roofing and Waterproofing Manual* (fifth edition)
• International Code Council (ICC) *International Building Code 2003* (IBC)

4-1 Acronyms:

ANSI - American National Standards Institute
CFM - cubic feet per minute
CMS - cubic meter per second
F - Fahrenheit
HVAC - heating, ventilating, and air conditioning
ICC - International Code Council
MERV - Minimum Efficiency Reporting Value

5-1 Definitions:

5-1.1 Sensible Cooling Load: Heat gain that causes a change in dry bulb temperature at a constant humidity ratio.

5-1.2 Latent Cooling Load: The portion of the cooling load attributed to a change in the humidity ratio at a constant dry bulb temperature.

5-1.3 Humidity Ratio: The ratio of the mass of water vapor to the mass of dry air contained in a given moist air sample.

5-1.4 Humid Area (HA): Geographic location where UFC 3-400-02, Data Table (Page 1 of 18), Other Site Data, entry titled "Ventilation Cooling Load Index" indicates the annual latent cooling load (Ton-hr/cfm/yr) of outside (ventilation) air equals or exceeds three times the outside (ventilation) sensible cooling load, AND the monthly latent load exceeds the monthly sensible load, as evaluated by inspection of the graph (Page 14 of 18), titled "Average Ventilation and Infiltration Loads", for two or more consecutive months of the year.

6-1 Requirements.

6-1.1 Introduction. Navy facilities have experienced damage from moisture and/or mold, especially in locations within humid areas. The high ambient moisture and temperature common in high-humidity areas reverses vapor flow through building components and increases the latent cooling load on HVAC equipment, when compared to the design conditions for most other continental United States locations. These unique conditions require design criteria differing from the conventional wisdom used in other areas.

6-1.2 Site Drainage. Grade/slope building sites to drain away from buildings.

6-1.3 Building Envelopes. For new construction or renovation involving roofs and/or exterior walls, design and construction at all Navy locations in humid areas must comply with the following:

6-1.3.1 Continuous Air Barrier. Provide a continuous air barrier (vapor retarder, the least permeable material) on the exterior side of the building insulation and place only more-permeable materials on the interior side of the building insulation. For double-wythe walls, place the continuous air barrier on the exterior side of the inner wythe. Provide drainage from the continuous air barrier to the exterior (i.e., weep holes in the base of the exterior brick veneer wythe, protected from accumulation of mortar droppings).

6-1.3.2 Moisture Seal. Seal all seams in the continuous air barrier, and seal all openings around doors and windows, lintels, utility penetrations, and at intersections of walls, roofs, floors, and foundation walls. Install non-permeable sill gaskets between floors and the bottom plate of exterior walls. Flash all windows and exterior doors with corrosion-resistant flashing to prevent water intrusion into the wall cavity. Provide design details in design drawings for these requirements. Provide details to minimize thermal bridging, especially at door and window frames and the intersections of walls and roofs. Refer to *Humidity Control Design Guide for Commercial and Institutional Buildings,* Chapter 2, "Humidity Control Basics" for more information.

6-1.3.3 Provide roof/ceiling/insulation systems complying with the following principles:

6-1.3.3.1 Install the continuous air barrier (vapor retarder) in accordance with guidance in the *NRCA Roofing and Waterproofing Manual* (fifth edition).

6-1.3.3.2 Ventilate spaces created outside the roof/ceiling continuous air barrier (vapor retarder). For sloped roofs, ventilation must comply with the *International Building Code 2003* (IBC), Section 1202.2. Ensure that moisture transfer from ventilated attics into the building is minimized the same as for walls.

6-1.3.3.3 Prohibit entry of unconditioned outside air into all spaces inside the thermal envelope. Ventilation of such spaces, if required, must use air from conditioned spaces.

Exception: Mechanical, Electrical, Elevator Machine, and similar rooms, provided with louvers or other intended means of outside air entry, shall have all the interior surfaces provided with a continuous air barrier, except the interior face of the exterior walls. Walls and ceilings may be painted with vapor retardant paint, and above-grade floors may be seal-coated concrete.

6-1.3.3.4 On the interior face of exterior walls, use only interior wall finishes that allow water vapor within the wall to escape into the conditioned space, such as latex paint. Vinyl wall coverings, oil-based paint, and other vapor-resistant materials will not be used as interior finishes for exterior walls.

6-1.3.4 Envelope Design Analysis. For swimming pool enclosures, museums, and other highly-humidified buildings, the designer must perform a moisture/vapor diffusion analysis for exterior walls and roof structures, using the dew point method as shown in American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) *Fundamentals Handbook* (Fundamentals), 2001, Chapter 23 using design weather conditions as stated in paragraph 6-1.4.1.1 of this document. The wall analysis must indicate any planes of condensation. Acceptable wall design shall either NOT contain any planes of condensation or the walls SHALL have the capability to drain/vent the moisture to the exterior (i.e., weep holes). Corrective action (i.e., redesign) must occur if the design fails to meet these requirements.

6-1.4 HVAC Systems:

6-1.4.1 HVAC System Cooling/Dehumidification Capability. For facilities authorized air conditioning, HVAC system cooling/dehumidification capacity must be designed to meet the following:

6-1.4.1.1. Outside Design Conditions for all locations. Refer to UFC 3-400-02 and utilize the Design Criteria Data available from the referenced Air Force Combat Climatology Center website. For Design/Build projects, the data may be defined in the RFP documents.

6-1.4.1.1.1. Cooling Systems:

Humid Area Facilities, Specialized De-humidification Systems, and 100% Outside Air Systems: For design, use the "1% Occurrence" value of outside air "Dry Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Wet Bulb Temperature (°F)" for the Design Cooling Day. Also, design for Maximum Humidity conditions, using the "1.0% Occurrence" value of outside air "Humidity Ratio (HR)" "Design Value (gr/lb)" and the "Mean Coincident (Average) Values" "Dry Bulb Temperature (°F)." For Mission-Critical Facilities in Humid Areas, use the "0.4% Occurrence" values instead of the "1% Occurrence"values above.

Mission-Critical Facilities (not HA), where equipment failure due to high heat would be unacceptable: For design use the "0.4% Occurrence" value for outside air "Dry Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Wet Bulb Temperature (°F)" for the Design Cooling Day.

Other Typical Facilities and Systems (not HA): For design, use the "1% Occurrence" value of outside air "Dry Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Wet Bulb Temperature (°F)" for the Design Cooling Day.

Cooling Towers or Evaporative Cooling Equipment: For sizing, use the "0.4% Occurrence" (for Mission-Critical Facilities) or the "1.0% Occurrence" (for Other Typical Facilities) value for outside air "Wet Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Dry Bulb Temperature (T)" for the Design Cooling Day.

6-1.4.1.1.2 Heating Systems:

Mission-Critical Facilities: For design, use the "99.6% Occurrence" value for outside air "Dry Bulb Temperature (T)" "Design Value (°F)."

Other Typical Facilities: For design, use the "99.0% Occurrence" value for outside air "Dry Bulb Temperature (T)" "Design Value (°F)."

6-1.4.1.2 Inside Design Conditions for Bachelor Housing, Administrative Spaces, and Family Housing:

6-1.4.1.2.1. Cooling Systems:

Space Design conditions shall be 76 Fdb (24.4 Cdb) & 50% RH, during the Design Cooling Day outside air conditions. At all other than design day, occupied times, maintain the space within the "Summer" conditions shown in ASHRAE *Handbook of Fundamentals – 2001*, Chapter 8, Figure 5, but not less than 76 Fdb (24.4 Cdb). Space thermostat typically set at 76 Fdb +/- 2 Fdb dead band (24.5 Cdb +/- 1 Cdb). 100% Outside Air systems shall operate continuously in Humid Areas, to prevent mold growth.

Admin spaces with Process cooling; Space Design conditions are to be determined by the requirements of the respective processes to be utilized within.

Note: Spaces authorized comfort cooling shall be designed for inside temperatures no lower than 76 Fdb (24.4 Cdb). During unoccupied hours, cooling systems shall be secured where appropriate. [IAW OPNAVINST 4100.5D]

6-1.4.1.2.2. Heating Systems:

Space Design conditions shall be 70 Fdb (21.1 Cdb) during the Design Heating Day outside air conditions. At all other than design day, occupied times, maintain the space within the "Winter" conditions shown in ASHRAE *Handbook of Fundamentals – 2001*, Chapter 8, Figure 5, but not more than 70 Fdb (21.1 Cdb). Space thermostat typically set at 70 Fdb +/- 2 Fdb dead band (21.1 Cdb +/- 1 Cdb).

Admin spaces with Process heating; Space Design conditions are to be determined by the requirements of the respective processes to be utilized within.

Note: Spaces requiring comfort heating shall be maintained at temperatures no higher than 70 Fdb (21.1 Cdb). During unoccupied hours, temperatures shall be set no higher than 55 Fdb (12.8 Cdb). [IAW OPNAVINST 4100.5D]

6-1.4.1.3. Inside Design Conditions for Laboratories, Shops, Warehouses, etc:

Space Design conditions, during the Design Heating Day outside air conditions, shall be 65 Fdb (18.3 Cdb) for areas with moderate activity employment, 60 Fdb (15.5 Cdb) for areas with heavy activity employment, and 50 Fdb (10 Cdb) for storage areas.

Spaces with Process heating; Space Design conditions are to be determined by the requirements of the respective processes utilized within.

Note: Temperatures shall be maintained to minimize energy consumption, with 55 Fdb (12.8 Cdb) being the maximum for heating purposes in storage spaces. [IAW OPNAVINST 4100.5D]

6-1.4.2. System Design. Provide HVAC systems to separately dehumidify and precondition ventilation air if the latent cooling load at the design weather condition causes a system reheat requirement to maintain space conditions (if total dehumidification were to be accomplished by the system cooling coil). The HVAC systems must provide the capability to condition ventilation air and maintain space relative humidity less than 60 percent over the full range of cooling load. Where a separate system is provided to treat outdoor air, the system must comply with 6-1.4.8.1.2 below.

6-1.4.3 Psychrometric Design Analysis. The HVAC design analysis for new facilities or renovation of existing facilities must include a psychrometric analysis of each system, documenting that the system design meets the criteria in paragraph 6-1.4.1. The analysis must provide calculations of system cooling loads (sensible and latent); coil selections; fan selections; chiller or refrigeration system selections; and a system psychrometric diagram and table, indicating state point conditions of dry bulb, wet bulb, and dew point temperatures, humidity ratios, enthalpy, and relative humidity of outside air, mixed air, supply air, and return air flow streams.

6-1.4.4 Equipment Compliance. Construction specifications will require HVAC equipment submittals documenting that proposed equipment is in compliance with the design.

6-1.4.5 Ventilation Air. Supply ventilation air to satisfy ASHRAE 62-2004, *Ventilation for Acceptable Indoor Air Quality*, for the number of occupants, or as required to meet exhaust air requirement plus 15 percent for pressurization, whichever is larger. Ventilation air must be 115 +/- 5 percent of exhaust air for all spaces with direct mechanical exhaust.

Exception: Ventilation for military family housing is normally satisfied by infiltration or natural ventilation, and is designed per Energy Star requirements.

6-1.4.6 Filtering. Filter ventilation air before it enters an air handler, heat recovery equipment, or preconditioning equipment. Use extended media filters with a Minimum Efficiency Reporting Value (MERV) of 7 or greater, in accordance with ASHRAE 52.2-1999, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.*

6-1.4.7 Duct Seal. Seal all ducts to SMACNA Seal Class B, and leak test in accordance with UFGS 15950N, *Duct Air Leakage Testing (DALTS).* Ducts shall also be sealed at all penetrations through the building enclosure and continuous air barrier, and at all connections to equipment, louvers, registers, and grills. Registers and grills shall also be sealed to the space interior wall surfaces. Louvers shall be sealed to exterior wall surfaces. Seal all seams within the air paths, including within air moving equipment. Where units or ducts penetrate the exterior wall, seal all thru-wall sleeves between the exterior wall and the sleeve at both the exterior and interior wall surfaces. Also, seal all thru-wall sleeves between the units and ducts and the sleeve, at the exterior end of the sleeve. Seal all curb-mounted rooftop HVAC equipment to the roof curbs, and seal the roof curbs to the roofing membrane. Seal all HVAC equipment mounted within the building envelope to the supply and return ducts, to prevent leakage from or into the building cavities. Duct insulation must be external; duct board or internal duct liner are not allowed. Use only metal ductwork for the central ventilation and exhaust systems.

Supply air duct leakage into the building cavities causes condensation, leading to mold growth within the cavities, and reduced cooling to the spaces. Exhaust air duct leakage depressurizes the building cavities, increasing infiltration of moisture laden outside air into the building cavities, leading to mold growth within the cavities, and reduced removal of moisture laden or pollution laden air intended to be exhausted.

6-1.4.8 Bachelor Housing and Navy Lodge Facilities.

6-1.4.8.1 New Facilities. The design must provide sufficient floor-to-floor height, vertical distribution space, and mechanical equipment space to accommodate ducted systems to supply preconditioned ventilation air, and ducted systems for exhaust air. **In these types of facilities, do not use the space above the ceiling as an HVAC plenum.**

6-1.4.8.1.1 Within bathrooms, the substrate beneath ceramic tile, plastic tile, or plastic finished wall panels in areas exposed to water (e.g., tub and shower enclosures) must be made of cement, fiber cement, or composite materials manufactured specifically for use in high-moisture locations.

6-1.4.8.1.2 Ventilation Air Supply (VAS) Systems. New facilities must employ separate, dedicated, constant-volume, central ventilation air supply systems that continuously supply dehumidified and reheated (tempered) 100 percent outside air to all occupied spaces. The design intent of these systems is not to provide total space heating and cooling, but to provide total ventilation load and space latent load cooling, and to capture any available VAS sensible cooling to meet a portion of the space sensible cooling load; systems must continuously condition and deliver ventilation air to each occupied space. The ventilation air must be dehumidified to maintain a 55 F dew point (Fdpt) (12.8 C dew point (Cdpt)) and reheated (tempered) enough to maintain ventilation air supply relative humidity less than 70% within VAS ducts. This reheat is to reduce potential for mold growth within the VAS ducts due to moisture carryover from the cooling coil. VAS supply air temperature must not be at or below room design dew point temperature, to avoid condensation on the supply air registers. VAS supply air dew point temperature must be below room design dew point temperature, in order to meet the room latent load. Humidification of ventilation air during periods of low ambient humidity is not required, unless otherwise indicated. Facility central VAS systems must not be subject to intermediate season (no-heat/no-cool) shutdown, or any other non-emergency shutdown. Individual room heating/cooling equipment must have occupant control, but may be subject to intermediate season heating/cooling curtailment as directed by local command. Systems must be designed to minimize the transmission of sound between apartments. The designer will provide a psychrometric analysis documenting that the system is designed to properly maintain the space temperature and relative humidity, at the required "0.4% or 1 % Occurrence" Outside Design Conditions. The system must provide the capability to condition ventilation air and maintain space relative humidity less than 60 percent over the full range of cooling load.

Note: Conditioning of ventilation air is not required for facilities not otherwise air-conditioned.

6-1.4.8.1.3 Exhaust Systems. A central ducted bathroom exhaust system will be used instead of individual exhaust fans for each space. The exhaust system must run continuously and be interlocked with the building supply air system. The exhaust duct for each space must have a manual volume damper accessible from the space for proper balancing. Install an exhaust grille, constructed of corrosion-resistant material, just outside each shower stall and bathtub. Exhaust systems must be designed to minimize the transmission of sound between apartments. Exhaust from moisture-producing equipment (i.e., clothes dryers) must be vented to the exterior. Take advantage of the ASHRAE allowed reduced bathroom (toilet) ventilation requirements due to provision of continuous operation; see 2001 ASHRAE Handbook Fundamentals, Chapter 26, Table 3.

Note: Vent-less Clothes Dryers are not acceptable in Humid Area locations.

6-1.4.8.1.4 Air Balance for Bachelor Housing. Continuous VAS of 15 cfm (0.007 cms) per person for 4 persons (maximum) wartime loading will be 60 cfm (0.0028 cms). Continuous bathroom exhaust of 20 cfm (0.009 cms) (ASHRAE recommendation) will allow the remaining 40 cfm (0.019 cms) to pressurize the spaces to reduce infiltration. The bathroom will dry a little more slowly with the continuous exhaust airflow, but the VAS at 55Fdpt (12.8 Cdpt) will ensure that it dries satisfactorily. Bedrooms and kitchen spaces will remain dry due to pressurization reducing infiltration loads from humid outside air during door openings. Clothes dryer operation (if provided) will temporarily create an additional 150 cfm (0.071 cms) exhaust flow, which will be satisfied by the 40 cfm (0,019 cms) VAS pressurization air flow plus 110 cfm (0.052 cms) of infiltration, during the approximately one hour drying cycle. The other 23 hours of 40 cfm (0.019 cfm) exfiltration of VAS will transport the infiltrated moisture back outside the space, thereby protecting these spaces from moisture accumulation and resultant mold growth.

6-1.4.8.1.5 Heat Recovery. Use heat recovery from exhaust air, or from VAS refrigeration equipment, to provide the VAS reheat and reduce the energy consumption necessary to condition ventilation air, where savings from heat recovery results in a life cycle cost payback for the heat recovery equipment.

6-1.4.8.1.6 Economizer Cycle. Economizer cycle will not be used in Navy construction, unless required by ASHRAE Standard 90.1 (STD 90.1). Full use of the STD 90.1 Economizer Requirements Exceptions shall be taken, to avoid economizer use, where allowed. These exceptions are detailed in the 90.1 User's Manual, Section 6.3.1. They include the weather & capacity exception (Table 6.3.1); the residential exception, the envelope-dominated exception; the High efficiency exception, and others. STD 90.1, Table 6.3.1, lists 1% Cooling Design Wet Bulb Temperature (CDwbt) ranges and the Number of Hours the Outside Air Design Dry Bulb Temperature is between 55 Fdb (12.8 Cdb) and 69 Fdb (20.5 Cdb), during the time period of 8 AM to 4 PM. The tabulated value is the minimum system size that **will** require an economizer. STD 90.1, Appendix D-1, lists values for the 1% CDwbt and No. of Hours for many locations. Engineering Weather Data (EWD) lists the 1% Cooling Wet Bulb Temperature, on page 1 of 18, and lists the Dry Bulb Temperature Hours For An Average Year, on page 9 of 18. The column labeled "Hour Group (LST) 09 to 16" may be used to obtain the number of hours for use in STD 90.1, Table 6.3.1. The difference between the STD 90.1, Appendix D-1 data and the EWD is small, and is due to the difference in hours included in the data. STD 90.1 uses 0800 through 1559; EWD uses 0900 through 1659. Use the EWD data where available.

6-1.4.8.1.7 Storage Spaces. Closets and storage or utility rooms smaller than 4.64 square meters (50 square feet) of floor space within conditioned spaces must have undercut and overcut doors allowing airflow through these spaces. Closets and storage or utility spaces larger than 4.64 square meters of floor space must be supplied with conditioned air.

6-1.4.8.2 Existing Facilities. Existing facilities being renovated must incorporate ventilation air supply systems as described for new facilities in paragraph 6-1.4.8.1.2. Where the facility structure (i.e., floor-to-floor height) prohibits dedicated central ventilation air systems, alternative system (package unit) designs must have separate, dedicated, and continuous conditioning of ventilation air. The designer will perform a psychrometric analysis documenting that the system is designed to maintain space humidity with entering ventilation air at the 1 percent humidity ratio design weather condition. The system must provide the capability to condition ventilation air and maintain space relative humidity over the full range of cooling load.

6-1.4.9 HVAC Equipment Selection.

6-1.4.9.1 For VAS cooling coils, typically with a depth of 4 or more rows, indicate the design coil fin density on the equipment schedules, not to exceed a maximum of 8 fins per inch (8 fins per 25.4 millimeters), to ensure a cleanable coil and competitive bidding. For other than VAS cooling coils, with typical depth of less than 4 rows, indicate the cooling coil fin density on equipment schedules at a maximum of 14 fins per inch (14 fins per 25.4 millimeters). To preclude moisture carryover, coil face velocities must not exceed 550 feet per minute (167.6 meters per minute). Ultraviolet lights may be considered to control growth of mold within the coil, air-handling unit, and ductwork, and may be especially suitable for use with deep (4 row or more) cooling coils.

6-1.4.9.2 Specify the minimum number of cooling coil rows in the equipment schedules. The number of rows will be based on a comparison of data from at least three manufacturers and must ensure that latent cooling loads can be met or exceeded.

6-1.4.9.3 Cooling coil design entering and leaving air conditions must be specified (wet and dry bulb temperatures) at the design airflow rate.

6-1.4.9.4 Select equipment with a cooling capacity closest to the design load (no safety factors) meeting the conditions of paragraph 6-1.4.1. Over-sizing the cooling equipment inhibits dehumidification capability. (Heating equipment capacity SHOULD INCLUDE appropriate safety factors.)

6-1.4.9.5 Several options for equipment types are available to accomplish dehumidification. Select equipment that will meet the design requirements and provide the lowest life cycle cost and energy consumption.

6-1.4.10 HVAC System Layout.

6-1.4.10.1 To the maximum extent possible, chilled water piping must be routed through pipe chases and hallways. Avoid concealing piping in the walls or ceilings of occupied spaces. Provide access for maintenance.

6-1.4.10.2 Insulate piping with an operating temperature below dew point with jacketed insulation meeting the cold piping requirements of UFGS 15080, *Thermal Insulation for Mechanical Equipment*. The insulation jacket must be sealed to provide an exterior vapor barrier.

6-1.4.10.3 Sufficiently sized, safe access must be provided for the maintenance of valves, variable air volume (VAV) boxes, dampers, controls, and other HVAC components.

6-1.4.10.4 Ductwork must not be installed within or beneath slab-on-grade floors.

6-1.4.11 Design Analysis Submittal. The designer shall provide a single submittal package, for approval of the Contracting Officer, including each of the following applicable Design Analysis (DA):

ITG Paragraph 6-1.3.4.	Envelope DA
ITG Paragraph 6-1.4.3.	Psychrometric DA
ITG Paragraph 6-1.4.8.1.2.	VAS Psychrometric DA
ITG Paragraph 6-1.4.8.2	Existing Facility Alternative System Psychrometric DA

7-1 Testing, Adjusting, and Balancing (TAB). HVAC systems will be tested, adjusted, and balanced to verify and document actual performance of the systems and evaluate conformity with the design intent. UFGS 15950N will be used to develop the contract requirements for TAB.

8-1 Point of Contact. Recommendations for improvements to this ITG are encouraged and should be furnished to:

Commander, Naval Facilities Atlantic,
Engineering and Criteria Office (Code CI),
6506 Hampton Blvd., Norfolk, Virginia 23508-1278,
Attn: Mr. Thomas J. Harris

Or contact Mr. Harris at DSN 262-4206, (757) 322-4206, Fax (757) 322-4416

Or email to thomas.j.harris@navy.mil

BACHELOR HOUSING
1 + 1 E Apt
Example

Design Space Conditions: 76 Fdb, 50%RH, 56 Fdpt, 67 grHR (Design values underlined)

Occupancy: 2 + 2 persons, per UFC 4-721-10, Chap. 4-6 and 10-33.

Minimum Outside Air = 4 persons X 15 CFM/person = 60 CFM, per ASHRAE STD 62

Exhaust Air (EA) Reqmts: Bathroom – 20 CFM continuous, per ASHRAE Fund C26, Table 3
Or Bathroom – 50 CFM intermittent, per ASHRAE Fund C26, Table 4
And Clothes Dryer – 150 CFM intermittent, per ASHRAE Fund C26.18

Ventilation Air Supply (VAS) = greater of Minimum Outside Air for occupants (60 CFM)
Or 115% of Exhaust Air (20 CFM X 115% = 23 CFM), per UFC 4-721-10, Chap. 6.4.5
Or 115% of Exhaust Air (50 CFM X 115% = 57.5 CFM), per UFC 4-721-10, Chap. 6.4.5

Choose VAS = 60 CFM and Continuous Bathroom Exhaust = 20 CFM

This leaves 40 CFM available for pressurization, to reduce infiltration, and to dissipate, during 23 hours per day of exfiltration, the moisture infiltrated when the clothes dryer operates for say 1 hour per day.

Calculate Space Latent Load and Sensible Load due to occupants; all other sensible loads to be taken by the space cooling and heating equipment:

Male seated typing 4 persons X 255 BTUHL = 1020 BTUHL
4 persons X 255 BTUHS = 1020 BTUHS

Latent Load (BTUHL) = 0.68 X CFM X Δ grHR; rearranging to Δ grHR = BTUHL/ 0.68 CFM

Therefore: Δ grHR = 1020 BTUHL / (0.68 X 60 CFM) = 25 grHR

VAS HR Conditions must be Space HR (67 gr) – (25 gr) = 42 grHR

Therefore: The VAS cooling coil leaving conditions are about 47.7 Fdb, 46.3 Fwb, 45.1 Fdpt, & 42 grHR.

To maintain the VAS 70% RH in ductwork requirement of the ITG, Encl. (1), 6.4.7.1.1, reheat is needed to obtain a VAS reheat coil leaving conditions of 54.6 Fdb, 70 %RH, 49.5Fwb, 45.1 Fdpt, & 42 grHR.

Sensible Load (BTUHS) = 1.08 X CFM X Δt Fdb; rearranging to Δt Fdb = BTUHS/1.08 X CFM

Therefore: Δt Fdb = 1020 BTUHS / (1.08 X 60 CFM) = 15.75 Fdb

Therefore: Space temperature without other sensible loads would be VAS reheat coil leaving conditions of 54.6 Fdb + 15.75 Fdb = 70.35 Fdb.

Adding in the estimated sensible load from the refrigerator of 375 BTUHS raises the room temperature as follows:

Δt Fdb = BTUHS/1.08 X CFM = 375 BTUHS / (1.08 X 60 CFM) = 5.75 Fdb

Therefore: Space temperature with the 4 persons and the refrigerator will be 70.35 Fdb + 5.75 Fdb = 76.1 Fdb.

All other sensible loads will be taken by the space HVAC equipment, such as the outside wall load, the interior corridor or mechanical chase load, the fenestration load, and the various internal loads, such as lights, cook-top, microwave, ceiling fan motor, washer/dryer, and personal items such a televisions, computers, etc.

Consider now only 2 persons in the apartment:

VAS still 60 CFM; Space Latent Load = 510 BTUHL, Space Sensible Load = 510 BTUHS

Δ grHR = BTUHL/ 0.68 CFM = 510 BTUHL / (0.68 X 60 CFM) = 12.5 grHR

Δt Fdb = BTUHS/1.08 X CFM = 510 BTUHS / (1.08 X 60 CFM) = 7.9 Fdb

VAS HR Conditions must be Space HR (67 gr) – (12.5 gr) = 54.5 grHR

Therefore: The VAS cooling coil leaving conditions are about 52.8 Fdb, 51.4 Fwb, 50.4 Fdpt, & 54.5 grHR.

To maintain the VAS 70% RH in ductwork requirement of the ITG, Encl. (1), 6.4.7.1.1, reheat is needed to obtain a VAS reheat coil leaving conditions of 62.4 Fdb, 70 %RH, 55.4 Fwb, 50.3 Fdpt, & 54.5 grHR.

Therefore: Space temperature without other sensible loads would be VAS reheat coil leaving conditions of 62.4 Fdb + 7.9 Fdb = 70.3 Fdb; with refrigerator heat added, it will be 70.3 Fdb + 5.75 Fdb = 76.1 Fdb.

Therefore, the VAS/Exhaust systems need to sense the building room average conditions, and reset the VAS cooling coil and VAS reheat coil-leaving conditions, based upon occupancy.

Consider a Relative Humidity or Dew point sensor sensing the building total bathroom EA airflow dew point, and averaging it over several hours, and controlling the VAS cooling coil control valve to open upon a rise in EA dew point, and to close upon a fall in EA dew point. By averaging over a long period of time, the influence of showers, and clothes washing are damped out, and the system responds to the long-term building occupancy driven latent load. This will maintain the VAS cooling coil-leaving dew point at the desired value to maintain the space conditions.

Consider a Thermostat sensing the building total bathroom EA temperature, and averaging it over several hours, and controlling the reheat coil control valve to close upon a rise in EA temperature, and to open upon a fall in EA temperature. By averaging over a long period of time, the influence of showers, and clothes washing are damped out, and the system responds to the long-term building occupancy driven sensible load. This will maintain the VAS reheat coil leaving temperature at the desired value to avoid overcooling the spaces under low load conditions.

This control scheme attempts to minimize the VAS cooling use of new energy while protecting the building and contents from mold. It also attempts to use the reheat to minimize new energy use in the space cooling equipment, while not over-cooling the spaces under low load.

Both the VAS and EA Systems must run continuously in order to protect the building from mold and mildew growth. Even if the building is to be vacated, these systems still need to run continuously. However, with no occupancy, it may be possible to slow down the VAS and EA system fan speeds, so as to deliver less airflow to the building, without losing control of the space dew point.

BUILDING AIR LEAKAGE:

From UFC 4-721-10, Design: Navy and Marine Corps Bachelor Housing, Chapter 4, Para. 4-3, the Gross Building Area per Apartment = 710 sq. ft. Assuming a minimum height of 9 feet from top of floor to top of floor, and a three-floor building, the volume of the building may be approximated by the following:

Bldg. Volume = Area x Height = 710 sq. ft. x 100 units x 9 ft. high = 639,000 cubic feet.

The design VAS (outside air) volume to be delivered is 60 cubic feet per minute (CFM) per unit. Therefore, the total VAS is as follows:

VAS vol. = 60 CFM x 100 units x 60 min. per hour = 360,000 cubic feet per hour (CFH)

The design Exhaust Air (EA) volume to be removed by the toilet exhaust is 20 CFM per unit. Therefore, the total EA is as follows:

EA vol. = 20 CFM x 100 units x 60 minutes per hour = 120,000 CFH

Therefore, the design air change rate, available to offset building air leakage, is the (VAS volume minus EA volume) divided by the building volume, as follows:

(VAS – EA) / Bldg. Vol. = (360,000 – 120,000) CFH / 639,000 cubic feet
= 0.38 Air Changes/ hour

Per the ASHRAE *Humidity Control Design Guide for Commercial and Institutional Buildings,* Chapter 16, Building Pressure Management, based upon a field investigation survey of 70 commercial buildings in the southern U. S., these buildings leaked an average of 0.4 AC/hr when the HVAC systems were OFF, and an average of 0.9 AC/hr when the HVAC systems were ON. It is easy to see that the available 0.38 AC/hr will not be enough to positively pressurize the building with properly dehumidified VAS, unless and until we construct a building envelope tighter than the average, and we construct the HVAC system ductwork tighter than average. Additionally, the 60 CFM per unit was based upon 4 persons per unit, not the normal 2 persons per unit, therefore, the design VAS volume is ample, and the design EA volume is as low as allowed by ASHRAE.

The only other means to keep the moisture that leads to mold and mildew out of the building is to increase the VAS CFM enough to offset the leakage. This requires larger, more expensive HVAC equipment, greater energy consumption, and greater maintenance costs, for the life of the building.

Investing in sealing the building enclosure, and sealing the HVAC system, will avoid these increased life cycle costs.