DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

AUG 12 2003

FROM: HQ AFCESA/CES
139 Barnes Drive
Tyndall AFB FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 03-2: Design Criteria for Prevention of Mold in Air Force Facilities**

1. Purpose. This ETL provides design criteria for preventing mold inside Air Force facilities.

2. Summary of Revisions. This ETL supersedes ETL 93-2, *Dormitory Criteria for Humid Areas*, and ETL 97-13, *Dormitory Ventilation and Exhaust System Design Criteria*. This ETL changes the definition of humid areas and expands application to all conditioned facilities.

3. Application. This ETL applies to the design of new or renovated Air Force facilities that are less than 35 percent designed. The ultimate recipients of this ETL are major commands (MAJCOM), installations, and Air Force design and construction agents.

3.1. Authority: Air Force Instruction (AFI) 32-1023, *Design And Construction Standards and Execution of Facility Construction Projects*.

3.2. Effective Date: Immediately.

3.3. Ultimate Recipients:
- Installation civil engineer (CE) personnel
- Project managers (PM)
- Design consultants
- Design agents

3.4. Coordination:
- Office of the Air Force Civil Engineer, Engineering and Environmental Divisions (HQ USAF/ILEC/ILEV)
- MAJCOM/CE points of contact (POC) for heating, ventilating, and air conditioning (HVAC)
- Air Force Center for Environmental Excellence, Design/Construction Division (HQ AFCEE/DCD)
- Air Force Services Agency, Directorate of Plans and Force Management (HQ AFSVA/SVXFB)

4. Referenced Publications:

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4.1. Air Force:

- AFI 32-1023, *Design and Construction Standards and Execution of Facility Construction Projects*, http://www.e-publishing.af.mil/
- *Air Force Enlisted Dormitory Design Guide*, http://www.afcee.brooks.af.mil/dc/DCD/arch/enlisteddormitories/index.html
- *Temporary Lodging Facilities Design Guide*, http://www.afcee.brooks.af.mil/dc/dcd/arch/tlfdg/tlf/index.html

4.2. Unified Facilities Criteria (UFC):

- UFC 3-400-02, *Design: Engineering Weather Data*, http://65.204.17.188//report/doc_ufc.html
- UFC 4-724-01, *Air Force Visiting Quarters Facility Design Guide*, http://65.204.17.188//report/doc_ufc.html

4.3. Unified Facilities Guide Specifications (UFGS):

- UFGS 02621A, *Foundation Drainage System*, http://www.ccb.org/ufgs/ufgs.htm
- UFGS 15080A, *Thermal Insulation for Mechanical Systems*, http://www.ccb.org/ufgs/ufgs.htm
- UFGS 15995A, *Commissioning of HVAC Systems*, http://www.ccb.org/ufgs/ufgs.htm

4.4. 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 55-1992, *Thermal Environmental Conditions for Human Occupancy* and addendum ANSI/ASHRAE 55a-1995
- ASHRAE 62-2001, *Ventilation for Acceptable Indoor Air Quality*
- *ASHRAE Fundamentals Handbook*

4.5. Other Industry:

- National Roofing Contractors Association (NCRA) *Roofing and Waterproofing Manual* (fifth edition)
- International Code Council (ICC) *International Building Code 2000* (IBC)

5. Acronyms:

AFI	- Air Force Instruction
ANSI	- American National Standards Institute
ASHRAE	- American Society of Heating, Refrigeration and Air Conditioning Engineers
C	- Celsius
CE	- civil engineer
CFM	- cubic feet per minute
CONUS	- continental United States
ER	- Engineer Regulation

F - Fahrenheit
HVAC - heating, ventilating, and air conditioning
ICC - International Code Council
MAJCOM - major command
MERV - Minimum Efficiency Reporting Value
NCRA - National Roofing Contractors Association
PM - project manager
POC - point of contact
UFC - Unified Facilities Criteria
UFGS - Unified Facilities Guide Specification
VAV - variable air volume

6. Definitions:

6.1. Humid Climate: Geographic locations where the latent cooling load per cubic feet per minute (cfm) of outside (ventilation) air equals or exceeds the ventilation sensible cooling load for months of the year when cooling degree days (base 18 °C [65 °F]) exceed heating degree days (base 18 °C [65 °F]), from data available through UFC 3-400-02, *Design: Engineering Weather Data*.

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

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

7. Requirements.

7.1. Introduction. Air Force facilities have experienced damage from moisture and/or mold, especially in locations with humid climates. The high ambient moisture and temperature common in high-humidity areas reverse vapor flow through building components and increase the latent cooling load on HVAC equipment when compared to the design conditions for most other continental United States (CONUS) locations. These unique conditions require design criteria differing from the conventional wisdom used in other areas.

7.2. Building Envelopes. For new construction or renovation involving roofs and/or exterior walls, design and construction at all Air Force locations must comply with the following:

7.2.1. Site Drainage. Grade/slope building sites to drain away from buildings. Provide foundation drainage systems in accordance with Unified Facilities Guide Specification (UFGS) 02621A, *Foundation Drainage System*.

7.2.2. Moisture Seal. Seal all openings around doors and windows, lintels, utility penetrations, seams in vapor retarders and air barriers, 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.

7.2.3. Design Analysis. The designer will perform a moisture/vapor diffusion analysis for exterior walls and roof structures (American Society of Heating, Refrigeration and Air Conditioning Engineers [ASHRAE] *Fundamentals Handbook*, 2001, Chapter 23) using design weather conditions of 99 percent dry bulb and 1 percent humidity ratio based on UFC 3-400-02. The wall analysis will 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 moisture to the exterior (i.e., weep holes). Corrective action (i.e., redesign) must occur if the design fails to meet these requirements.

7.2.4. Dormitories, Visitor Quarters, and Temporary Lodging Facilities.

7.2.4.1. The design must provide sufficient floor-to-floor height, vertical distribution space, and mechanical equipment space to accommodate a ducted system to supply preconditioned ventilation air. **In these types of facilities, do not use the space above the ceiling as an HVAC plenum.**

7.2.4.2. 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.

7.3. Design for Humid Locations. In locations where the wet bulb temperature is equal to or greater than 19 °C (67 °F) for more than 3,000 hours per year, the building envelope design and construction must:

7.3.1. Place the least permeable material or vapor retarder on the exterior side of the building insulation and place more permeable materials inside the building insulation. For double-wythe walls, place the vapor retarder on the exterior side of the inner wythe. Provide drainage from the vapor retarder to the exterior (i.e., weep holes at the base of the brick veneer).

7.3.2. Provide roof/ceiling/insulation systems complying with the following principles:

7.3.2.1. Install air/vapor retarder in accordance with guidance in the *NCRA Roofing and Waterproofing Manual* (fifth edition).

7.3.2.2. Ventilate spaces created outside the roof/ceiling vapor retarder. For sloped roofs, ventilation must comply with the *International Building Code 2000* (IBC), Section 1202.2. Ensure that moisture transfer from ventilated attics into the building is minimized the same as for walls.

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

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

7.4. HVAC Systems. Air Force facility HVAC systems must comply with the following:

7.4.1. HVAC System Cooling/Dehumidification Capability. For facilities authorized air conditioning, HVAC system cooling/dehumidification capacity will be designed to meet the greater of the following:

7.4.1.1. Maintain space dry bulb temperature setpoint and 50 percent relative humidity with ambient weather design condition of 1 percent dry bulb temperature and the corresponding 1 percent mean coincident wet bulb temperature.

Note: Ambient design conditions for spaces with specialized technical requirements should be based on 0.4 percent dry bulb temperature and the corresponding 0.4 percent mean coincident wet bulb temperature.

7.4.1.2. Maintain space dry bulb temperature setpoint with conditioned space relative humidity of 60 percent or less at ambient conditions at the 1 percent humidity ratio design weather condition.

7.4.2. System Design. Equip HVAC systems to separately dehumidify and precondition ventilation air if the latent cooling load at the 1 percent humidity ratio 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 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.

7.4.3. Design Analysis. The HVAC design analysis for new facilities or renovation of existing facilities must include a psychrometric analysis documenting that the system design meets the criteria in paragraph 7.4.1.2. The analysis must provide calculations of system cooling load, energy/mass transfer through conditioning equipment and fans, and a system schematic indicating state point dry bulb and wet bulb temperatures (or humidity ratios) of outside air, mixed air, supply air, and return air flow streams. The cooling load for this analysis must be based on the 1 percent humidity ratio design condition.

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

7.4.5. Ventilation Air. Supply ventilation air to satisfy ASHRAE 62-2001, *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 110 to 120 percent of exhaust air for all spaces with direct mechanical exhaust. Ventilation for military family housing is normally satisfied by infiltration or natural ventilation.

7.4.6. 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*.

7.4.7. Dormitories, Visitor Quarters, and Temporary Lodging Facilities.

7.4.7.1. New Facilities.

7.4.7.1.1. Ventilation Systems. New facilities must employ separate, dedicated, central ventilation air constant-volume supply systems that supply dehumidified and tempered 100 percent outside air to all occupied spaces. The design intent of these systems is not to provide total space heating and cooling; systems must continuously condition and deliver ventilation air to each occupied space. The ventilation air must be tempered to within room comfort conditions. Ventilation air room supply conditions must not be at or below room dewpoint. Humidification of ventilation air during periods of low ambient humidity is not required. Facility central ventilation air supply systems must not be subject to intermediate season (no-heat/no-cool) 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 quarters. The designer will perform a psychrometric analysis documenting that the system is designed to maintain space humidity with ambient condition of 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 less than 60 percent over the full range of cooling load. Use only metal ductwork for the central ventilation systems. Duct insulation must be external, and duct board or internal duct liner are not allowed.

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

7.4.7.1.2. 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 quarters. Exhaust from moisture-producing equipment (i.e., clothes dryers) must be vented to the exterior.

7.4.7.1.3. Heat Recovery. Use heat recovery from exhaust air to 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.

7.4.7.1.4. Economizer Cycle. Economizer cycle will not be used in Air Force construction.

7.4.7.1.5. 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 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.

7.4.7.2. Existing Facilities. Existing facilities being renovated must incorporate ventilation air supply systems as described for new facilities in paragraph 7.4.7.1.1. Where the facility structure (i.e., floor-to-floor height) prohibits dedicated central ventilation air systems, alternative 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.

7.4.8. HVAC Equipment Selection.

7.4.8.1. To ensure a cleanable coil and competitive bidding, the cooling coil fin density will be indicated on equipment schedules at a maximum of 8 fins per 25.4 millimeters (8 fins per inch). To preclude moisture carryover, face velocities must not exceed 167.6 meters per minute (550 feet per minute).

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

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

7.4.8.4. Select equipment with a cooling capacity closest to the design load (no safety factors) meeting the conditions of paragraph 7.4.1. Oversizing cooling equipment inhibits dehumidification capability. (Heating equipment capacity SHOULD INCLUDE appropriate safety factors.)

7.4.8.5. 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.

7.4.9. HVAC System Layout.

7.4.9.1. 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.

7.4.9.2. Insulate piping with an operating temperature below dewpoint with jacketed insulation meeting the cold piping requirements of UFGS 15080A, *Thermal Insulation for Mechanical Systems*. The insulation jacket must be sealed to provide an exterior vapor barrier.

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

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

8. Commissioning. HVAC systems will be commissioned to verify and document actual performance of the systems and evaluate conformity with the design intent. UFGS 15995, *Commissioning of HVAC Systems*, will be used to develop the contract requirements for commissioning.

9. POC. Recommendations for improvements to this ETL are encouraged and should be furnished to: HQ AFCESA/CESM, 139 Barnes Dr., Suite 1, Tyndall AFB FL, 32403-5319, Attention: Mr Gerald Doddington, DSN 523-6343, commercial (850) 283-6343, FAX DSN: 523-6219, e-mail Gerald.Doddington@tyndall.af.mil.

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