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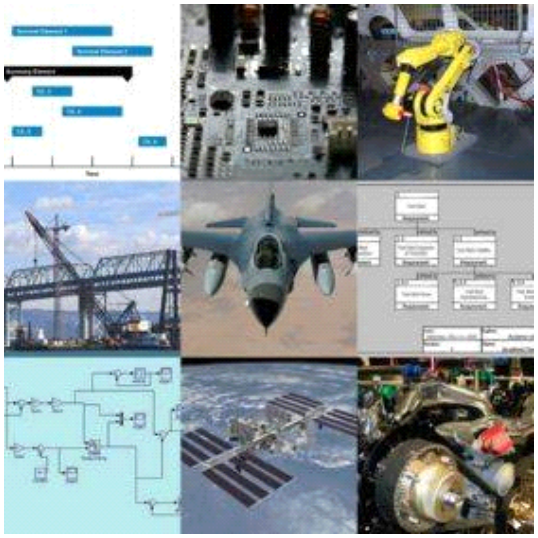

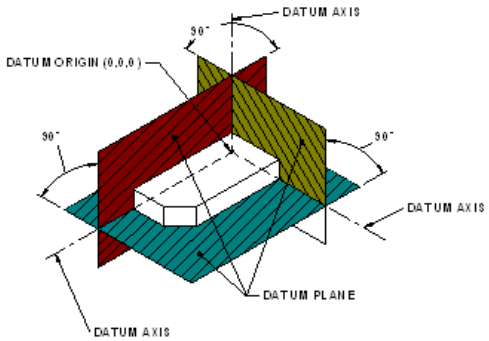

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Paul Guyer is a registered civil engineer, mechanical engineer, fire protection engineer, and architect with over 35 years experience in the design of buildings and related infrastructure. For an additional 9 years he was a senior-level advisor to the California Legislature. He is a graduate of Stanford University and has held numerous national, state and local positions with the American Society of Civil Engineers and National Society of Professional Engineers.

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1. GENERAL.

The primary requirement of the heating, ventilating and air conditioning (HVAC) systems in a medical facility is the support of medical function and the assurance of occupant health, comfort, and safety. The HVAC system functions not only to maintain minimum requirements of comfort and ventilation, but is an essential tool for the control of infection, removal of noxious odors, dilution and expelling of contaminants, and establishment of special environmental conditions conducive to medical procedures and patient healing. Subject to the above, appropriate consideration shall be given to the HVAC design to ensure system maintainability, economics and energy efficiency, and adaptability to future facility modification or expansion.

This presentation is intended to provide an introduction to heating, ventilating and air conditioning systems in medical facilities. It is not intended as a definitive treatise or design manual.

7.1 Applicability. This criteria applies to new and existing medical facilities including hospitals, medical and dental clinics, veterinary clinics, medical supply warehouses, medical training facilities, and medical research laboratories. Applicability to existing facilities is restricted to upgrade or replacement projects, and for those specific systems or services included in the scope of the project authorization. For existing facilities, when complete compliance with the technical criteria of this section is not economically practicable, consideration shall be given to substitution of other recognized industry standards or criteria. All facilities shall comply with the applicable standards of the National Fire Protection Association (NFPA).

2. DESIGN CONDITIONS.

2.1 Weather Data. Weather data shall be obtained from a recognized source. A recommended source is Unified Facilities Criteria 3-400-02 available without charge at www.wbdg.org.

2.2 Interior Design Conditions. Interior design conditions shall be in accordance with Unified Facilities Criteria 4-510-01 (available without charge at www.wbdg.org) or other recognized source such as ASHRAE publications.

2.3 Space Ventilation. Minimum total and outside air change rates shall be as indicated in UFC 4-510-01; Computed on a per-occupant basis, minimum outside air ventilation shall meet the worst-case requirements of either UFC 4-510-01, or ASHRAE Standard 62.1. Higher air change rates may be required to meet air conditioning or makeup air requirements as supported by engineering calculations.

2.4 Ambient Design Dry and Wet Bulb. The HVAC cooling design for facilities housing critical care and other inpatient services shall be based on the 0.4% Dry Bulb (DB), and corresponding Mean Coincident Wet Bulb (MCWB) temperatures, and winter heating design shall be based on the 99.6% DB. Cooling towers shall be designed on the basis of the 0.4% dew point temperature. Clinical facilities shall in general be designed to the 1.0% DB/MCWB temperature for cooling, and 99% level for heating. Cooling towers shall be designed on the basis of the 1.0% Wet Bulb temperature.

2.5 Critical Care Spaces. NFPA-99 and 70 discuss various minimum safe practices, and safety requirements for "General Care", "Critical Care" and "Wet Locations." The following patient care areas for hospitals have been identified by reputable authority as "Critical Care Areas" where patients may be subjected to invasive procedures and connected to line-operated electro-medical devices:

a. Operating rooms.

b. Delivery rooms and Labor and delivery rooms.

c. Cystoscope rooms.

d. Oral Surgery Maxillofacial surgery, Perodontics, and Endodontics.

e. Recovery (surgery, and labor recovery beds).

f. Coronary care units (patient bedrooms).

g. Intensive care unit (patient bedrooms).

h. Emergency care units (treatment/trauma/urgent care rooms and cubicles).

i. Labor rooms (including stress test and preparation).

j. Intensive care and isolation care nursery.

k. Cardiac catherization.

l. Angiographic exposure room.

m. Hemodialysis (patient station).

n. Surgery suite preparation and hold.

o. Hyperbaric chamber.

p. Hypobaric chamber.

q. Radiation Therapy (including simulator room).

r. Nuclear medicine (camera room).

2.6 Sensitive Spaces. Sensitive areas include Automated Data Processing (Computer) rooms, Radiology and MRI computer rooms, selected laboratories (see below), and Telephone Switch Room. Other rooms housing sensitive electronic or other equipment or processes may be designated as Sensitive Areas on an individual project basis. Design ambient temperatures shall generally be the 0.4% DB/0.4% MCWB (summer), and 99.6% DB (winter). Each application should consider using 1.0% DB/1.0% MCWB (summer), and 99% DB (winter) design conditions for less critical equipment/process air conditioning requirements.

2.6.1 Laboratories. Space design temperatures for laboratories are indicated at UFC 4-510-01, generally 26ºC (78.8ºF). However, designers shall be responsible to coordinate with the equipment designer and user to establish whether temperature-sensitive equipment is expected to be utilized in a laboratory space. When such equipment requires, for proper operability or to meet warranty limitations, an ambient temperature lower than can be maintained by the HVAC/Control System when set at 26ºC (78.8ºF), the designer shall coordinate with the user to establish a reasonable lower design temperature for that space.

2.7 Temperature during Smoke Control Operation. When a supply air system is required to operate on 100% outside air during smoke mode operation, the system shall be designed with sufficient heating capacity to maintain a minimum of 45 degrees at the air handling unit discharge under the 99.6% winter design conditions.

2.8 Mechanical Equipment Rooms. In general, mechanical equipment rooms shall be designed with ventilating systems which will maintain temperatures within 5.5C of summer ambient design temperature. However when these equipment rooms house temperature-sensitive electronic components, such as microprocessor based controls, electronic circuit breakers, etc., designers shall confirm the ambient requirements of such equipment and design accordingly. In humid climates, mechanical rooms which are contiguous with the occupied building shall be conditioned to a humidity level equivalent to the occupied areas, to minimize transfer of moist, unconditioned air to the interior of the building.

2.9 Humid Climate Definition. A humid climate, as referenced here, is a region with 4,500 or more cooling degree days (50ºF basis) that receives 20” or more of annual precipitation.

3. REFRIGERANTS.

Refrigeration equipment shall utilize refrigerant having an Ozone Depletion Potential (ODP) of not greater than 0.0 (refer to the EPA Significant New Alternatives Program (SNAP) for acceptable refrigerants). Refrigeration room design shall include the safety features, such as sensing devices, purge ventilation system, etc., as required for the particular refrigerant in accordance with ASHRAE Standards 15.

4. LIFE-CYCLE-COST/ENERGY ANALYSIS.

Life cycle cost and energy analysis required in conformance with this Section, or necessary for the evaluation of building sustainability features or performance, shall be in accordance with appropriate criteria.

5. APPROPRIATE SPACES FOR AIR CONDITIONING.

5.1 Total Air Conditioning. Air conditioning is required in all normally occupied facilities and spaces in which the interior conditions listed in UFC 4-510-01 cannot be met through natural ventilation alone. “Normally occupied spaces” will include such spaces incidental to medical facilities as corridors and circulation areas. Normally unoccupied, or intermittently occupied, spaces such as restrooms, locker rooms, soiled linen rooms, janitors closets, and similar spaces accessible to medical staff or the public and having exterior exposure shall be air conditioned (in addition to being provided with the required ventilation) to maintain reasonable conditions.

5.2 Food Service Area. Air conditioning of the kitchen areas shall be designed to avoid the waste of energy. Designs shall consider utilizing dining room transfer air or tempered make-up air for vented equipment exhaust, spot cooling, exhaust system heat recovery, and other energy saving strategies to minimize energy costs while providing a *reasonably* comfortable environment for kitchen staff.

5.3 Not Air Conditioned Spaces. In non-humid climates, the following areas are generally not provided with air conditioning. Heating and/or ventilation shall be provided as required to meet criteria.

a. Motor Vehicle Storage Area

b. Energy (Boiler/Chiller) Plants

c. Mechanical Equipment Rooms, unless containing sensitive electronic equipment requiring temperature control.

d. Toilets/Showers and Locker Rooms not located with outside exposure. Note that locker rooms which do not include a shower room or toilet may be recirculated.

5.4 Medical Warehouses. HVAC design shall be based upon the environmental requirements of the stored materials. Spaces within medical warehouses which will be normally occupied, including Administrative or Break rooms, shall be air conditioned as required to provide the design conditions listed in Appendix A. Air conditioning will also be required for any warehouse spaces housing computer or other environmentally sensitive equipment.

6. MECHANICAL EQUIPMENT SPACE.

6.1 Mechanical rooms for major air handling equipment, heat exchangers, prime movers, medical gas supplies, vacuum/air compressors, and other major mechanical equipment shall generally be located within the facilities with access to the outside of the building. Exceptions to locate equipment in penthouse equipment rooms may be considered by the designer if justified from a cost or functionality standpoint and if properly coordinated with the base/post engineers. Rooftop mounted air handlers should be avoided due to the difficulty of maintenance access, and consideration of safety and working conditions for O&M personnel. Mechanical room location and layout shall consider:

a. Sufficiency of space to enable access for operation, maintenance, and replacement of equipment.

b. Minimization of distribution runs.

c. Relative location to electrical equipment rooms: NEC vertical clearance/dedicated space requirements for electrical equipment will restrict or preclude the routing of piping and ductwork through these locations.

d. Relative location to communication rooms: adjacency of fan and communications rooms will create congested above-ceiling conditions where cable trays and ductwork converge.

e. Adjacency to corridors, as a path for the routing of ductwork.

f. Adjacency to spaces having stringent noise control requirements, or spaces with high ceilings which may restrict duct distribution space.

g. Potential future expansion of mechanical system capacity.

6.2 Chilled water and steam/hot water generators may be located in a separate energy plant. Utility lines connecting the energy plant to the facility shall be installed in a tunnel or other *accessible* enclosure providing maintenance access and protection from the elements.

7. HVAC SYSTEM DESIGN FOR FUNCTIONAL AREAS

For HVAC design, a medical facility can be considered to contain six general areas including Critical, Sensitive, Clinic, Administrative, Support areas, and Patient Bedroom areas. The primary considerations of the HVAC design are to provide the environmental conditions required to meet the functional requirements. Multizone, dual-duct, terminal reheat, variable air volume, and combinations of such air distribution systems may be considered for application in appropriate areas. If utilized, VAV systems will be of the minimum air quantity type. Furthermore, Direct Expansion (DX) coils shall not be used in Variable Air Volume systems. All-water, unitary, and fan-powered VAV systems will generally not be acceptable in medical facilities, due to their limitations in meeting ventilation requirements, increased contamination source potential, or increased maintenance requirements.

7.1 Critical Care Spaces. These spaces will normally be served by single duct terminal reheat or double duct systems. Simultaneous temperature, humidity, *and pressurization* control requirements for these spaces preclude the use of other types of systems.

7.1.1 Operating & Delivery Room (OR and DR) Air Systems. The room air supply system for Operating Rooms, Delivery Rooms, Cardiac Catheterization (hospital) Rooms, and Cystoscopy (hospital) Rooms shall be a ceiling supply type, located over the operating table or treatment area, using non-aspirating "low velocity" (0.2 - 0.41 m/s)(40-90 fpm) diffusers that isolate the air over the operating or treatment area. Room exhaust/return provisions shall consist of a minimum of two exhaust or return registers, located at diagonally opposing corners of the room, mounted with bottoms of registers between 150 mm (6 in) and 230 mm (9 in) above finished floor. The HVAC system for anesthetizing locations, including operating and delivery rooms, shall be designed in accordance with NFPA 99 to (a) prevent recirculation of smoke originating within the surgical suite and (b) prevent the circulation of smoke entering the system intake, without in either case interfering with the exhaust function of the system.

7.1.2 Continuity of Service. The design for the HVAC systems serving Critical Care spaces shall include the following:

a. The Air Handling Unit(s (AHUs) serving Operating or Delivery Room suites shall be separate, independent units serving only the respective Surgical or Obstetrical Department or portions thereof, to enhance the reliability of these systems and minimize demand on the emergency power system. The air handling unit(s) serving each suite may also provide service to other Patient Care or support areas outside the respective Surgical or Obstetrical Department. A maximum of four ORs or four DRs should be served by any single AHU. Where a facility has four or fewer ORs, these should be served by at least two separate air handling systems, to enhance reliability; a similar consideration should apply for DRs.

b. HVAC equipment, including controls, which serve Critical Spaces (including ventilation and pressure controls for isolation bedrooms) shall be connected to the emergency electrical power system. This shall include a

sufficient number of chillers and boilers, with necessary supporting equipment, to meet critical design loads. Boilers shall have dual-fuel burners that are not solely dependent on one source of fuel for ignition.

c. Designs shall include features to minimize HVAC service interruptions to Critical Care spaces, without the provision of redundant air handling units or distribution systems. Provisions shall be such that service interruption to any Critical Care space, as a result of failure of an air handling unit component or its supporting electrical or controls systems, shall be minimized. Such features may include the provision of multiple, isolatable, heating and cooling coils, spare stock of replacement motors, drive belts, and bearings in the immediate vicinity of the equipment room, dual fan units, "manifolded" ductwork connections between AHUs, or other measures providing for continuity or expeditious restoration of service.

d. Air Handling Units, with associated controls, which serve critical care spaces and patient bedrooms shall be connected to the electrical emergency power system.

7.2 Sensitive Areas. These are spaces or areas in which equipment or processes may require special environmental control, including continuous (24 hours per day, year-round) air conditioning and individual room temperature and/or humidity control. Economic or operational considerations normally dictate provision of independent air conditioning systems for Sensitive Areas, to enable continuation of air conditioning when main building systems are shut down for repairs, or are operating in night setback or economizer mode. Minimum outside air ventilation shall be provided in normally occupied areas. For those sensitive spaces critical to continued hospital function and which require continuous cooling to remain in operation, appropriate backup or redundant features shall be provided to assure continuity of air conditioning in the event of primary air conditioning equipment failure. This may include the requirement for connection of air conditioning equipment to the emergency power system.

7.3 Administrative Areas. Administrative areas may be served by single duct reheat, multi-zone, VAV, or dual-duct systems, with perimeter radiation when required or advantageous.

7.4 Outpa t, dual-duct, VAV, f the following c 2) no large dispa ing or rearrangem

7.5 Suppc luct reheat, dua

7.6 Patien l duct, multi-zone, tain minimum v ation systems (ra ms. Fin-tube heatin

7.7 Patien w systems wl flow rates to ma nt spaces and for isolation be Isolation and Diseas al power system.

8. GENERAL DESIGN CONSIDERATIONS