ASHRAE's BEST

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HONORABLE MENTION: HEALTH-CARE FACILITIES, NEW

Similar rooms within major departments are served by the same air-handling unit, eliminating unnecessary overcooling and reheating.

MEDICAL CENTER Rx

By **Matt Volgyi, P.E.**, Member ASHRAE

The Kaiser Downey Medical Center in Downey, Calif., provides health care in a low income neighborhood in the Los Angeles metro area. It includes a new 657,800 gross ft^2 (61 112 m^2) acute care hospital and central utility plant. A six-story patient tower and adjacent three-story diagnostic and treatment building have full basements that house hospital services.

The central plant serving the hospital is 48,000 ft^2 (4459 m^2). It has a 3,300 ton (11 606 kW) chiller plant, expandable to 5,500 tons (19 343 kW) to serve future buildings, a 1,500 bhp (14 715 kW) hot water boiler plant, expandable to 2,500 bhp (24 525 kW), and a 500 bhp (4905 kW) steam boiler plant.

Challenges

The most significant challenge of the project was the aggressive schedule for design, permitting and construction. The design-build team was asked to provide a complete mechanical and plumbing design submittal in six months, ready for review by the California state agency: Office of Statewide Health Planning and Development (OSHPD). This was possible, as the project already had a well-developed architectural and structural

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Read		Days	kWh	Maximum (kW)
2010	July 7	30	2,314,320	4,608
	June 7	32	2,268,120	4,416
	May 6	30	1,985,496	4,320
	April 6	28	1,819,368	4,032
	March 9	32	2,000,256	3,936
	February 5	29	1,818,216	4,032
	January 7	30	1,855,104	3,936
2009	December 8	33	2,105,928	3,936
	November 5	30	2,166,936	4,512
	October 6	32	2,600,616	4,416
	September 4	29	2,230,608	4,800
	August 6	29	2,172,744	4,608
Total		364	25,337,712	4,800
Average		30.33	2,111,476	4,296

Table 1: One year of electrical energy use.

Building at a Glance

Name: Kaiser Permanente Downey Medical Center

Location: Downey, Calif.

Owner: Kaiser Permanente

Principal Use: Acute care hospital

Includes: 352-bed patient tower with ICUs, isolation rooms, ORs, women services, nursery, emergency department, imaging, food service

Gross Square Footage: 657,800

Conditioned Space: 651,000

Substantial Completion/Occupancy: October 2009

Occupancy: 100%

design, but it also presented a challenge in designing the systems with minimal impact on other trades.

To meet this challenge, the designer used an approach considered unique in early 2005. The submitted plans were prepared as an integrated engineering and detailing effort with 3-D detailed ductwork and pipes from the project's inception. This allowed the completion of full detailing, support and seismic design, and final trade coordination during the plan check review period, and an early start for construction. The final result was the completion of project construction five months ahead of schedule.

Energy Efficiency Considerations

Hospital design in California is code driven, resulting in energy use in California hospitals that is well above the national average. In the past few years, hospital owners and code authorities have been working toward reducing the energy demand of these buildings, while not compromising the quality of health care and patient, physician, staff, and visitor safety (see sidebar "California Codes for Hospitals").

Energy Efficiency Solutions

To provide an energy-efficient design for this project, while meeting all regulatory requirements and budget, several design features were used.

The building is served by 18 air-handling units (AHUs), each major department is provided with a separate unit. This allows similar rooms with similar characteristics to be served by the same unit, eliminating unnecessary overcooling and reheating of spaces with diverse uses. All departments with humidification and dehumidification requirements are served separately from other zones for the same reason. During the commissioning process, the right temperature setpoints were established to achieve an energy-efficient operation.

Special attention was paid to right sizing the air-handling systems. The 18 air-handling units, with a combined 542,300 cfm (255 937 L/s), provide 0.825 cfm/ft^2 (0.389 L/s·m^2) on average, which is well below the average airflow rate in many hospitals. Note that some high-heat-producing areas were supplemented by fan coil units on this project, which is not included in this number.

Air-handling units and ducts were sized to allow a 10% airflow increase, if needed, mainly for future flexibility. After two years of operations, the airflow has not needed to be increased to meet comfort needs. Avoiding circulating, cooling and reheating more than the necessary air volume in a 24-hour constant volume system is a critical part of an energy-efficient design.

The air-handling units serving the hospital building are 100% outdoor supply air units with runaround heat recovery coils providing an efficient building HVAC system. To improve efficiency,

ASHRAE Standard 62.1							
Application	Estimated Occupancy (1 person/1,000 ft^2)	Outdoor Air Requirements		Typical Room (ft^2)	Occupancy Calculated (Person)	Occupancy Assumed (Person)	Required OSA (cfm)
		cfm/person	cfm/ft^2				
Patient Rooms	10	25	–	235	2.4	3	75
Medical Procedure	20	15	–	370	7.4	8	120
Operating Rooms	20	30	–	660	13.2	14	420
Recovery	20	15	–	100	2.0	3	45
ICU	20	15	–	220	4.4	5	75
Autopsy	–	–	0.5	313	–	–	157
Physical Therapy	20	15	–	314	6.3	7	105
Actual Design							
Application	Typical Room (ft^2)	Typical Ceiling Height (ft)	Typical Air Changes (ach)	Calculated Airflow (cfm)	Actual OSA (cfm)	Required OSA (cfm)	Percent Act/ Required
Patient Rooms	235	8	6.3	197	200	75	267%
Medical Procedure	370	9	12	666	700	120	583%
Operating Rooms	660	9.5	20	2090	2240	420	533%
Recovery	100	8.5	12	170	180	45	400%
ICU	220	8	10.5	308	320	75	427%
Autopsy	313	8	12	501	510	157	326%
Physical Therapy	314	8	16	670	680	105	648%

Table 2: Ventilation rate comparison per ASHRAE Standard 62.1 Appendix E and actual design.

all heat recovery coils and chilled water coils were provided with bypass dampers to significantly reduce the pressure drop across the coils when not in use. The air-handing unit coils were all selected at 450 fpm (2.29 m/s) maximum velocity, which is important to reduce the fan energy, especially in a constant volume, 24-hour system, as well as to provide future flexibility, which is a critical consideration for health-care design.

The operating rooms are provided with a VAV system, which offers significant energy savings. The code allows this by providing supply and tracking exhaust VAVs for the 14 operating rooms. Air change rates are reduced to 6 ach during non-use.

A significant energy saving component of the design is the use of fan coil units in high-heat-producing non-patient areas such as imaging equipment rooms and IT rooms. Providing fan coils for these areas significantly reduces building AHU fan energy use by reducing air provided at a significantly higher AHU system pressure and filtration and eliminates unnecessary overcooling of these spaces during low usage.

A direct digital control (DDC) system was installed with full visual mapping of installed building systems with readout and adjustment capabilities of all relevant setpoints and trending capabilities.

Full commissioning was performed to optimize energy-efficient operation of all air and water systems and determine the optimal pressure settings controlling fan and pump operations.

Indoor Air Quality

A 100% outdoor supply air building air-handling system serving all patient and staff support areas provides a great advantage regarding indoor air quality, with ventilation rates well in excess of the ASHRAE Standard 62.1-2004 minimum ventilation rates. *Table 2* compares typical hospital areas ventilation rates per ASHRAE Standard 62.1 Appendix E and the actual design.

The 100% outdoor supply air building HVAC system is also desirable for infection control, as there is no recirculation of air in the building with potential infectious contaminants.

Innovation

Air-Handling Unit Design. The air-handling unit design was the most significant innovation. The 100% outdoor air supply air-handling units were designed with down-shot supply and building exhaust ducts side-by-side at the middle

Advertisement formerly in this space.

of the unit to allow them to be placed directly above the building shafts they serve. This approach resulted in a clean roof, which was a project goal because of the windows in the patient tower facing the low roof of the diagnostic and treatment building.

Heat Recovery System Design. Each air-handling unit was provided with a dedicated heat recovery system installed within the enclosure of each unit to avoid heat recovery piping on the roof or outside the air-handling units. The heat recovery system is connected to the chilled water system to avoid an expansion tank at each unit and is flushed through weekly by the CHW system during the warmest time of the day to eliminate the need for additional water treatment.

Fire Alarm Shutdown Strategy. A critical component of hospital design is the air moving equipment fire alarm shutdown strategy, as patients are difficult to move. The design was developed with considerations to air-handling unit fan fire alarm shutdown and the strategy was developed with the fire alarm designers and electrical engineers. An important and innovative component of this system design was the addition of 12 smoke detectors in strategic locations to selectively control corresponding fire smoke dampers and fan equipment while the rest of the hospital can remain in normal operation. Note that the building otherwise was exempt from duct smoke detectors (other than the AHU supply air duct detectors) as full area smoke detection coverage was provided for the hospital.

Air Balancing. The size of the project (with more than 6,000 supply diffusers) meant that an air balancing report was needed to assist with keeping airflow within the acceptable range.

The format developed in Excel included the necessary calculations for code compliant air changes, pressurization, and acceptable deviations from plans, which provided a quick turnaround time getting the necessary approvals from the state inspector. The third-party air balancing contractor prepared the air balancing report using this spreadsheet to automatically calculate deviations and color code grilles outside of acceptable tolerances.

Maintenance and Operation

The facility operators are stationed in the central plant. With the control system provided and visual mapping of all the system operations, the entire hospital and central plant can be monitored from this location, and alarms, warnings readily addressed.

The facility operators were actively involved during the design and commissioning of the systems, which allowed a high level of familiarity with the installed systems and controls by the time of the project turnover.

As part of the design-build delivery, a one-year warranty period was provided, during which time the design builder and control system provider assisted the facilities engineers with any potential problems with operations. This warranty period ended with a relatively small number of issues and warranty calls for a facility of this size.

California Codes for Hospitals

Probably the most significant code requirement in California resulting in high energy use is the requirement for constant volume air systems for the entire building. The system cools the total airflow, meeting the code required air changes, and reheats the air in most zones to meet comfort conditions. The only exception currently is to provide supply and return side VAVs, which is cost prohibitive on most projects and has a poor payback, as maintaining the code minimum air changes does not allow enough turndown to realize significant savings.

This requirement combined with the required minimum two air changes per hour of outside air for all areas within the building results in extremely high energy use for cooling, heating, and fan energy.

Recent code changes, such as updating the codes to only include pressurization requirements for rooms where infection control is a concern is a step in the right direction, but further steps are needed, such as reducing outside air requirements and allowing variable air volume (VAV) systems in non-patient areas to realize significant energy savings. Departments within the hospital buildings can be maintained at the right pressurization relatively easily and cost effectively in relationship to each other, even with VAV systems in the less sensitive departments.

Another significant code change expected in the near future is changing the operating room humidity requirements from 30% to 60% RH to 20% to 60% RH, which will significantly reduce the energy-intensive humidification requirements. In coastal climates, the steam humidification systems are potentially completely eliminated.

Changes such as these will not only improve the energy use in California hospitals, but can also significantly reduce the construction cost, which is also well above national average. Note that the 60% maximum relative humidity requirement will remain a major source of energy consumption with the demand for overcooling rooms with humidity controls, especially in operating rooms (where the desired temperature is often below the code minimum 68°F [20°C]).

Cost Effectiveness

Cost effectiveness was one of the key drivers for this project. Cost was monitored from the beginning of the design. All major design decisions and owner requests were reviewed and approved with actual cost information.

The project was virtually free of contractor generated change orders. Almost all change orders were owner requested changes during the design and construction of the project. The project was completed five months ahead of schedule presenting significant value to the owner, as well as the design and construction team.●