DISTRICT ENERGY

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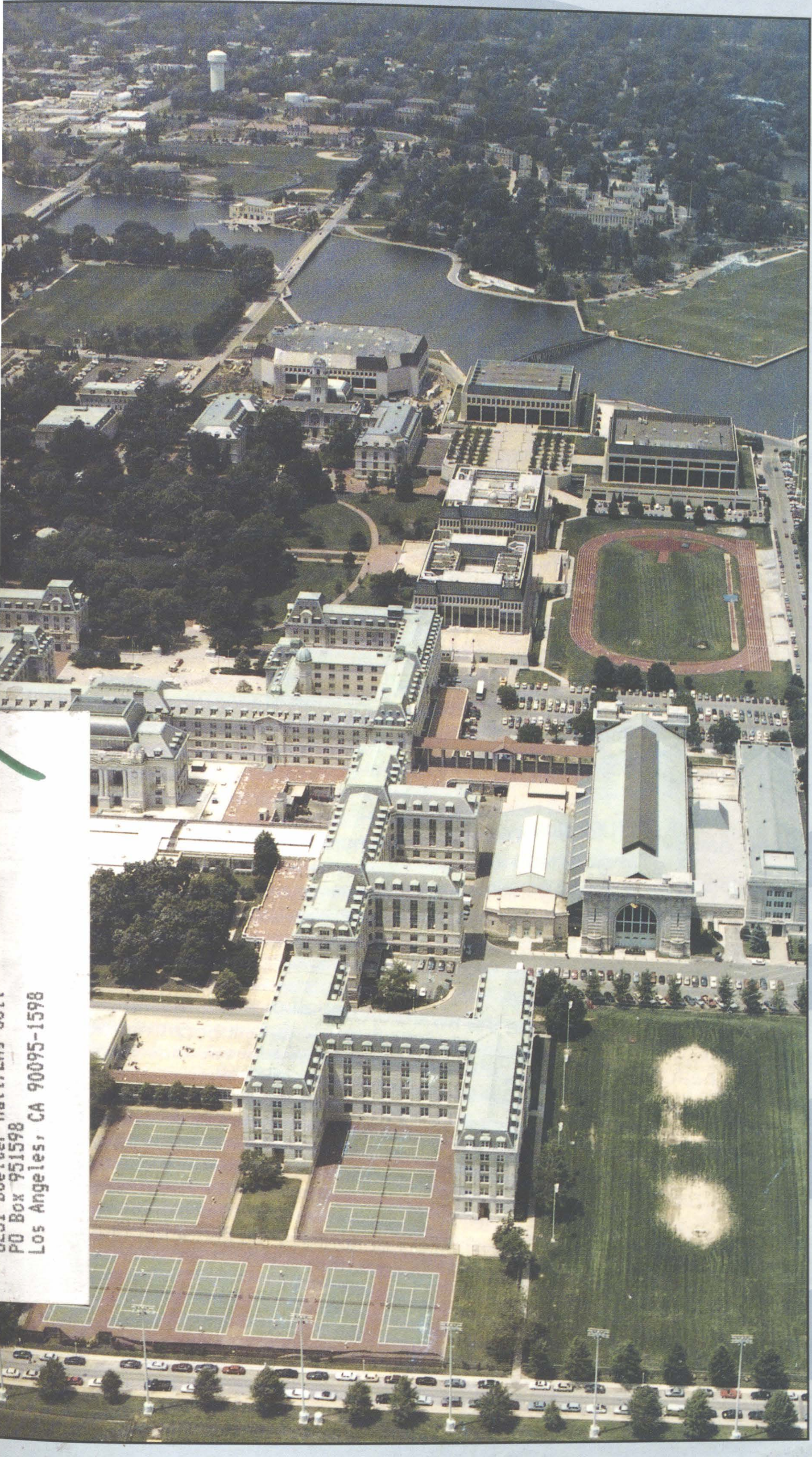

U.S. Naval Academy Serves as Energy Showcase

Featuring

University Teams With Private Sector for Heat and Power

Energy Concerns Bridge Atlantic

Proper Amine Use Means Quality and Compliance

Major Campus Connects to Downtown Cooling System

New System Debuts on Suburban Campus

District Energy Buyers' Guide

and more...

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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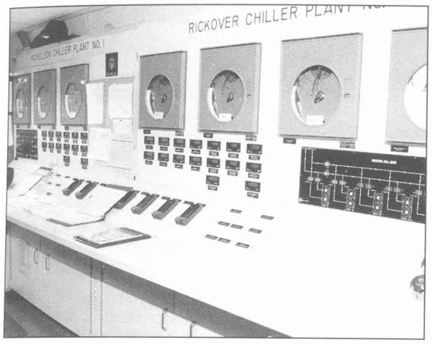
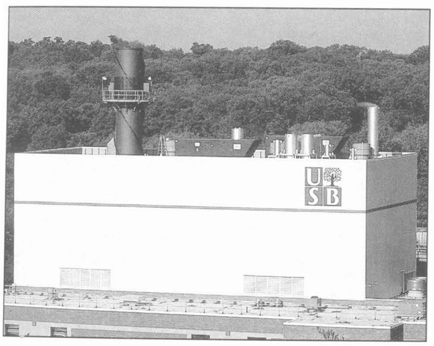


26

COVER STORY

Eight years after its founding, the United States Naval Academy built the first true district heating system in the United States in 1853. Today the Naval Academy's district heating system is the oldest continuously operating system in the world, save only a small geothermal system in France. Fifty-seven people now operate and monitor the 338-acre campus's heating, cooling and water distribution systems. Designated as the Navy's "Energy Showcase" base, the Naval Academy demonstrates and publicizes new advanced technologies in energy and water conservation to more than 1 million visitors annually.

FEATURES



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To combat shrinking public funds and escalating utility costs, the State University of New York turned to the private sector to develop a heat-and-power production facility at its campus in Stony Brook, Long Island. The new 40 MW cogeneration facility began serving all of the University's electrical and thermal energy needs in 1995 with CEA Stony Brook Operators at the helm. Designed with excess capacity, Stony Brook's new plant is ready for the campus's planned growth.

Controlling corrosion in condensate-return systems is an ongoing challenge for physical plant administrators. Amines, typically used to prevent corrosion, have recently been subject to environmental health and safety concerns. Today, plant operators must not only seek better methods of feeding and controlling amines for corrosion protection, but also ensure that amine use meets regulatory requirements.

Indiana University Purdue University at Indianapolis (IUPUI) became Mid-America Energy Resources' (MAER) largest customer when it signed a contract for district cooling service with MAER in 1994. The new service allowed IUPUI to decommission its old self-operated, electric-driven campus district cooling system that used chlorofluorocarbons and was unable to provide sufficient cooling during the hottest summer days. The University sees definite benefit in its new outsourcing arrangement.

Located in the northern Baltimore suburb of Towson, Goucher College is now home to a brand-new district heating and cooling system. After a master-planning effort in 1992 recommended heating and cooling system upgrades, the college agreed on a new central plant to generate and distribute hot water for heating during the heating season; for the cooling season, the plant's chillers would be paired with an ice-storage system. The initial phase of the project, which included connecting two of the college's largest buildings, was completed in September 1995.

In the article "District Cooling Flattens Load Profiles" in the third quarter 1996 issue of *District Energy*, graphs were used to illustrate the impact of district cooling on the electricity profile of a customer building. The month axis for each graph, however, was incorrect. The article has been reprinted in this issue as corrected.

DEPARTMENTS

On the Cover: Long recognized as one of the most beautiful of the historic landmarks along the eastern seaboard, the Naval Academy was designated a National Historic Site in 1963. It is home to the nation's first true district heating system. *Courtesy of U.S. Naval Academy.*

U.S. NAVAL ACADEMY UTILITIES IN SHIP-SHAPE: SERVING AS ENERGY SHOWCASE

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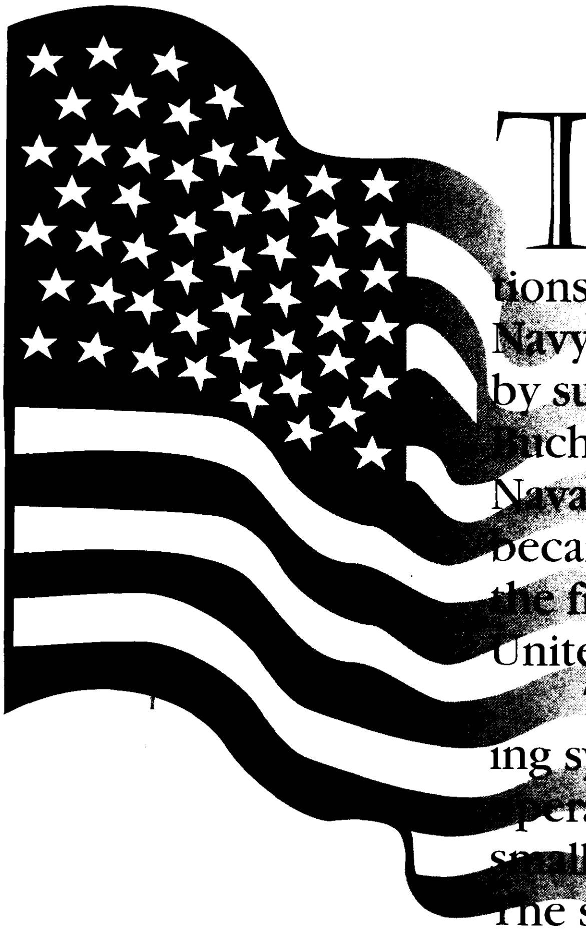
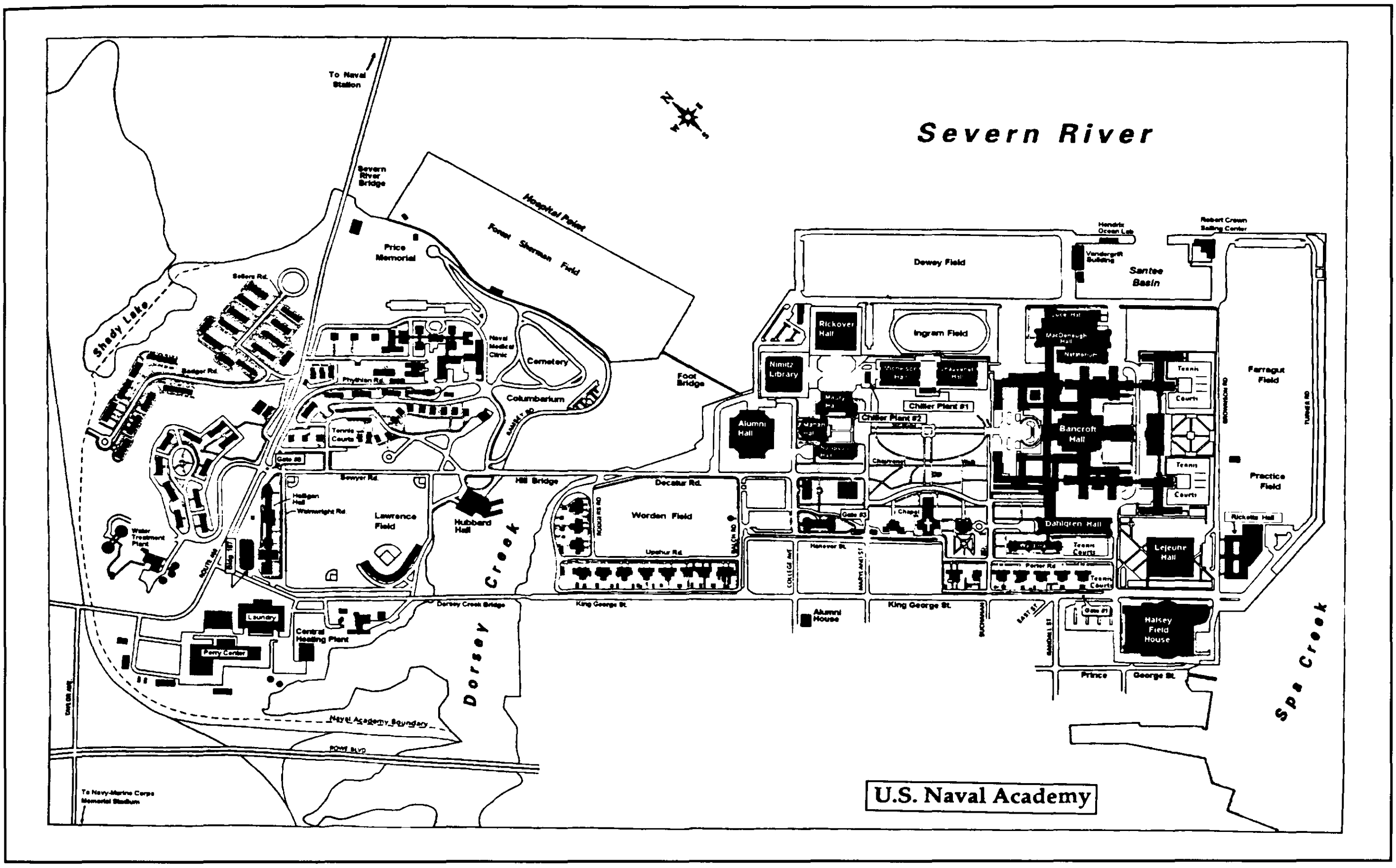


The United States Naval Academy in Annapolis, Md., is one of America's most venerated and historic institutions. Founded in 1845 by Secretary of the Navy George Bancroft, and formally opened by superintendent Commander Franklin P. Buchanan, it was originally established as a Naval School on 10 acres of land. In 1850, it became the U.S. Naval Academy, which built the first true district heating system in the United States in 1853.

Today the Naval Academy's district heating system stands as the oldest continuously operating system in the world, save only a small geothermal system in southern France. The system's construction marks a significant historic milestone, as not even electric lights were introduced at the Academy until 1900. (Pierce, Morris A., University of Rochester, "The Evolution of Heat, Light, and Power Systems at the U.S. Naval Academy: 1845-1995.")



Courtesy of U.S. Naval Academy.

Located on land originally known as Fort Severn, the U.S. Naval Academy lies on the banks of the Severn River in Annapolis, Md.

Today the Naval Academy's district heating system stands as the oldest continuously operating system in the world, save only a small geothermal system in southern France.

Since the mid-1800s, the Academy's campus has expanded significantly, today comprising 338 acres. The growth of the campus has stemmed largely from the increase in students. From its first class of 58 midshipmen, the Academy's student body has grown to a brigade of more than 4,000 midshipmen and 600 faculty and staff.

More than 300 maintenance people and engineers serve the Academy campus in its Public Works Department. This includes the 57 people in the Energy and Utilities Division who operate and monitor the campus's heating, cooling and water distribution systems.

Keeping the Academy's utilities distribution systems operating at the highest-possible efficiency levels is crucial, especially given the Annapolis campus's high profile. In 1994, it was designated the Navy's "Energy Showcase" base. This appointment resulted from the President's Executive Order 12902 requiring each component of the Department of Defense to identify one base as a model for conservation technologies. As the Navy's chosen site, the Academy will highlight, demonstrate and publicize new advanced technologies in energy and water conservation to more than 1 million visitors each year.

Since 1995, the Naval Academy has demonstrated the state-of-the-art, energy-efficient T8 lamps and electronic ballasts, low-flow shower heads and low-flow faucets. Fuel-cell installation is scheduled to be completed in 1997. The fuel cell will demonstrate the high technology of using natural gas in a non-combustion process to provide high-quality electricity and hot water recovery.

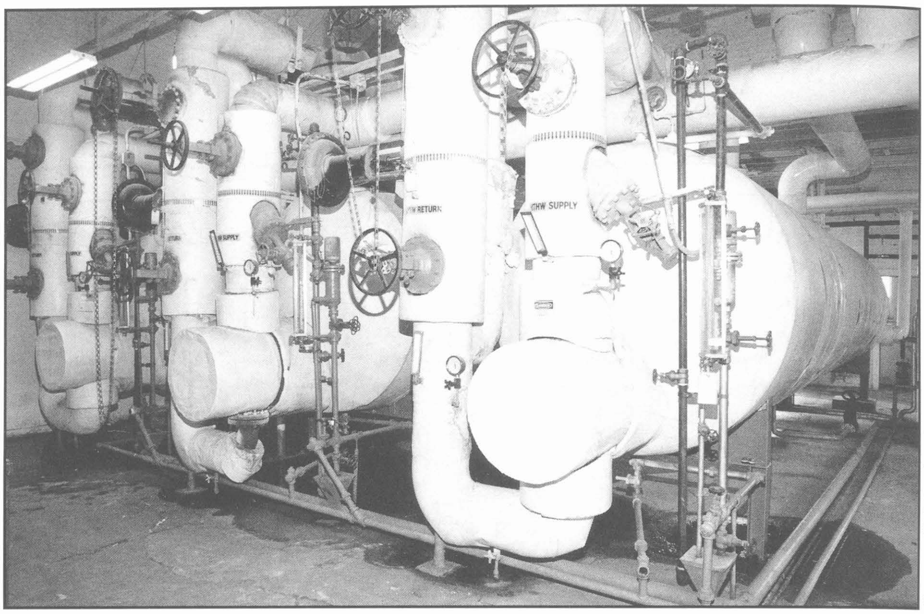
As the Navy's Energy Showcase, the Academy is expected to meet aggressive energy-reduction goals. The Academy must cut energy consumption 30 percent by the year 2005 (using 1985 consumption as the baseline). This will yield a total energy savings of 55 MMBtu per thousand sq ft.

Heating Distribution System

Each facility is heated by the Academy's Central Heating Plant, constructed in the mid-1960s and rebuilt in 1989. It consists of three high-temperature-hot-water (HTHW) generators, each with a nominal input rating of 95 MMBtu/hr. The total output capacity of the heating plant is approximately 228 MMBtu/hr, based on 80 percent generator efficiency.

The Central Heating Plant has dual fuel capability. The primary fuel is natural gas, supplied by Baltimore Gas & Electric on an interruptible basis; the secondary fuel is No. 2 fuel oil. The plant delivers high-temperature hot water at 420-430 degrees F at a pressure of 525 psig. It is pumped through a two-zone distribution system to the various buildings in the main Academy complex.

All distribution pumps are located in the Central Heating Plant. There are two 50-HP and two 40-HP circulation pumps and four 125-HP distribution pumps for the secondary HTHW circulation system. All of the pumps have mechanical seals that are cooled with water at an estimated flow rate of 3 to 5 gpm per pump. The HTHW circulation rate of each boiler is 620,000-680,000 lb/hr.



Three 20,000 lb/hr steam generators are located in Building 187.

Courtesy of U.S. Naval Academy.

The Academy's Central Heating Plant operates 24 hours a day, 365 days a year, with plant operators working around the clock in two 12-hour shifts. Each shift includes one supervisor, two plant operators and two staff persons on a roving patrol, who oversee and record the operation of various mechanical, electrical and sewage equipment located in buildings throughout the campus. One general foreman supervises all plant operations and maintenance. The Central Heating Plant's uninterruptible operation is vital to accomplishing the Academy's mission. Approximately every three years, the Central Heating Plant will shutdown for major plant repair or maintenance. Temporary boilers will be installed in various locations to provide heating service during the Central Heating Plant's shutdown.

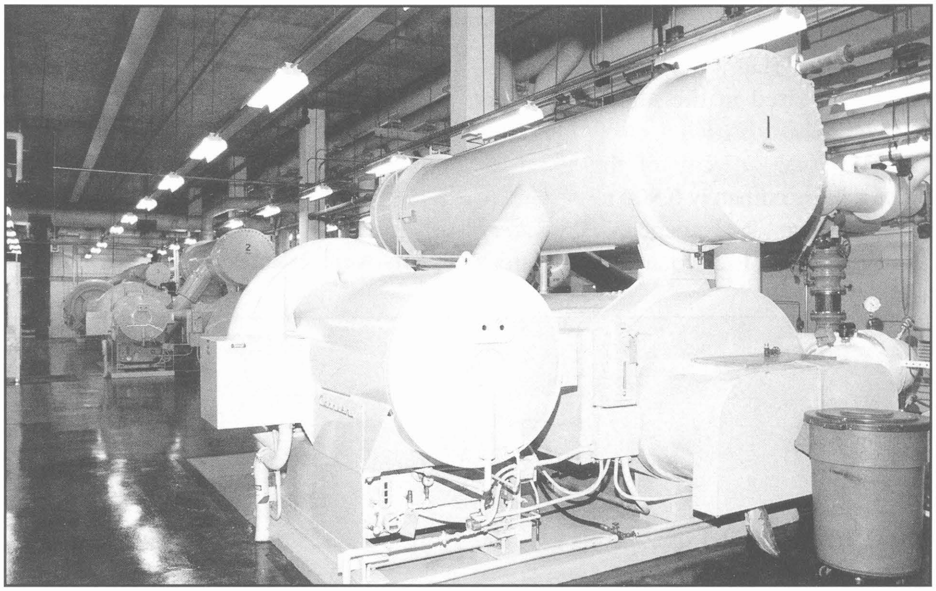
Before the HTHW heating plant was constructed, nearly all buildings on the main campus were served by a steam-heating facility built in 1939 adjacent to the existing plant. As HTHW became more available, most of the steam-heating systems in the main campus buildings switched to low-temperature-hot-water (LTHW) heating and equipped with HTHW-to-LTHW converters. (Information taken in part from "HTW/Steam/Condensation Return Utility Systems at the United States Naval Academy" by Hayes, Seay, Mattern & Mattern Inc.)

Now, steam and lower-temperature hot water are produced by hot water heat exchangers throughout the main campus and distributed to other buildings not served by the HTHW distribution system. The steam provided by the heat exchanger is primarily used for space heating. The majority of domestic hot water is heated by steam-to-hot-water heat exchangers located in each building.

The secondary distribution system was constructed in segments during the 1930s, '40s and '60s. Some of the steam and condensate lines have recently been replaced; however, many still operate with original components.

Zone One is the largest Academy distribution zone. It has a 14-inch HTHW supply-and-return line serving almost 80 percent of the buildings in the main Academy complex. The piping leaving the heating plant is directly buried underground until it reaches Dorsey Creek, where it comes above ground. After crossing Dorsey Creek, it enters into the walk-through utilities tunnels and shallow trenches leading to the mechanical rooms of Maury Hall and Bancroft Hall. Steam, LTHW or domestic hot water is produced by mostly shell-and-tube heat exchangers, with the high-temperature hot water in the tubes.

Soon steam-heating systems in many officer quarters on the main campus will be replaced with natural gas furnaces. The conversion of the housing units served by Bancroft Hall's steam distribution system is slated for 1996; in addition more than 20 units are scheuled for renovation by 1997.



Courtesy of U.S. Naval Academy.

One of the two refrigeration equipment rooms that comprise the Central Chilled-Water Plant is located in Michelson Hall.

With one of the largest loads on campus, the Academy Laundry uses large amounts of steam and domestic hot water.

Rehabilitation of the 1.4 million-sq-ft dormitory Bancroft Hall is currently under way and should be complete by 2002. At that time, steam will be required for the galley equipment in King Mess Hall only. Located in the center of Bancroft Hall, this dining area currently receives steam from the generators in the center section of the building. It is supplied with domestic hot water from Bancroft Hall Wing No. 4. In King Mess Hall's galley, where an average of 4,000 meals are served three times daily, the estimated domestic hot water load is approximately 22,800,000 Btu per day.

Zone Two, equipped with 12-inch supply-and-return piping, serves Building 187, Perry Center and the Academy Laundry. In Building 187, there are three steam generators with an output rating of 20,000 lb/hr each. Throughout the year, they supply steam at a pressure of 50 psig to the Naval Hospital, apartments, administration buildings and houses located northwest of Dorsey Creek.

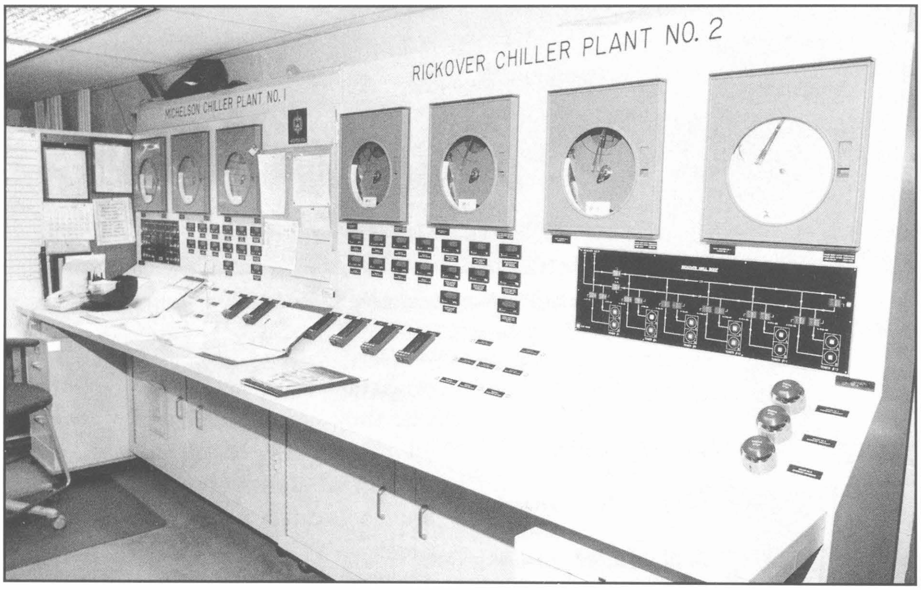
The steam distribution lines connected to the steam plant are installed in tunnels and shallow trenches. The steam piping in the shallow trench, previously comprised of 3-inch winter distribution line and 2-inch summer distribution line, has recently been upgraded. Individual buildings are now fed by a 1-1/2-inch steam line and a 2-1/2-inch condensate-return line.

With one of the largest loads on campus, the Academy Laundry uses large amounts of steam and domestic hot water. Its domestic hot water consumption varies with the number of washer loads run each day. The average laundry process load is approximately 900,000 lb of steam per month – and as high as 2,242,000 lb of steam per month during peak times. This high-volume process load indicates its significant utility demand.

Cooling Distribution System

The Academy's Central Chilled-Water Plant was constructed in the 1960s and '70s. It cools more than 1.3 million sq ft of floor space on the main campus. This plant consists of two large refrigeration equipment rooms – one beneath the plaza between Michelson Hall and Chauvenet Hall and the other in Rickover Hall. The central control room is located in the Michelson Hall refrigeration room.

The total capacity of the existing plant is approximately 6,500 tons, with a total of five R-11 centrifugal water chillers and one R-22 rotary-screw water chiller; seven horizontal split-cased circulation/distribution chilled-water pumps; one expansion tank; 10,833-ton, induced-draft steel-counterflow cooling towers; local control panels; central control system; and an automation system.



The central control room for the Academy's chilled-water system is located in Michelson Hall.

Courtesy of U.S. Naval Academy.

Two separate cooling-tower installations serve the Academy's chillers. One group – four two-cell cooling towers – is located on the roof of Rickover Hall. A second group with six two-cell cooling towers is situated on the roof of Chauvenet Hall. Each has a capacity of approximately 2,500 gpm. The primary operator controls for the cooling towers are found on the cooling-tower panel on the main console in the Michelson main control room. Additional operator controls, local gauges and automatic controls are also located adjacent to each cooling tower and in the penthouse remote-control panels.

In 1994, a study investigated how the existing chiller plant could be retrofitted and/or expanded to meet future cooling-load requirements. Per the study's recommendations, all three chillers in the Michelson refrigeration plant were scheduled to be replaced in fall 1996; those in Rickover Hall will be replaced by 2000. At that time, all refrigeration units using R-11 will be retrofitted with HCFC-22. (Information obtained from "Chilled Water Study and Master Plan" by James Posey Associates Inc.)

Beyond the refrigerant retrofit, two plans were evaluated to determine the most economical and efficient cooling system: one to construct a thermal-storage system and the other to build a new plant. The study recommended a chilled-water thermal-storage system. The system being considered consists of an insulated tank storing 1.7 million gal of 45 degree F chilled water, which will be produced during off-peak hours to save electric energy. The estimated thermal-storage-capacity requirement is approximately 16,500 ton-hours. The location of the thermal-storage site has not yet been determined.

The Academy's chilled-water distribution system is a closed-loop system. The chillers produce 45 degree F water and pump it to the chilled-water headers. The headers in Michelson Hall have a diameter of 18 inches; those in Rickover Hall, 20 inches. The chilled-water mains connect the two refrigeration rooms to provide chilled water through a distribution system to the various buildings on the main campus.

The chilled-water distribution system consists of two loops serving the east and west sides of the complex. They are tied into each other at Stribling Walk. Both loops can be supplied with chilled water by any one chiller or combination of chillers in the two refrigeration rooms. The chilled water is returned to the Central Chilled-Water Plant through a parallel pipe network. Since the chillers are not directly interlocked with any particular chilled-water pump, the chiller flow interlocks are accomplished through differential-pressure switches. These are located at each chiller and controlled by the local energy management control system. Condenser-water pumps and towers may be used with any chiller in the same location. The chilled-water distribution system is equipped with centrifugal separators and a filter feeder system for each pump, which removes any rust and dirt contaminating the circulating chilled water. Chiller-plant maintenance and repairs are accomplished through a service contract.

Chilled-water service to the east side of campus is provided by 16-inch lines that cross under the street, traverse the full length of Bancroft Hall's basement and terminate at Ricketts Hall. The upper floors of Bancroft Hall currently are not served with chilled water.

The west side of the loop consists of 16-inch supply-and-return lines branching off the 18-inch header that comes from the Michelson and Chauvenet Hall refrigeration rooms. It serves the academic buildings, Nimitz Library and Brigade Activities Center, terminating at Dahlgren Hall. An additional 250-ton chiller was installed in the Rickover Hall refrigeration room to provide air conditioning for the computer main frames in Chauvenet Hall and Rickover Hall during the winter. This dedicated winter chiller will be removed when the thermal-storage system becomes available in the future.

Since the chillers are not directly interlocked with any particular chilled-water pump, the chiller flow interlocks are accomplished through differential-pressure switches.

Water Distribution System

The Academy's Water Treatment Plant was constructed in 1971 to supply its own potable water to the entire Annapolis complex. It serves a population of approximately 6,000 residents and 2,000 transients. An average of 1.2 million gal of raw water is used throughout the campus each day. The water is pumped to the Water Treatment Plant from two wells, ranging from 650 to 750 ft deep. It is filtered and chemically treated at the plant, then stored in two 1 million-gal ground-level tanks. Three 125-HP centrifugal pumps distribute the water from these tanks to a 750,000-gal elevated storage tank and then on to the campus.

Potable water is distributed through more than 10 miles of water main. The water-distribution-system piping varies from four to 20 inches in diameter, and system pressure ranges between 54 and 95 psi. Though part of the piping at the plant and main distribution system is made of concrete-lined ductile iron, the majority is constructed of unlined cast iron. In addition to this piping system, another 21,000 ft of mains distribute nonpotable water for use in firefighting.

Conclusion

As Morris Pierce writes in "The Evolution of Heat, Light, and Power Systems at the U.S. Naval Academy: 1845-1995," the "vast majority of naval history is written about ships and sailors, but the Navy's large (and largely invisible) supporting cast should not be forgotten. One such area of support is the supply of heat, light, and power to shore facilities. . . ." Today, district energy engineers and maintenance workers provide a vital service to the Navy – whether on ship or at shore. And many of these well-trained engineers and maintenance workers subsequently move on to serve district energy systems throughout the country – a fitting tribute to the system that started it all.

The author thanks the following individuals for their contribution to this article: LTJG Scott Allen, Academy's Public Affairs; Ramin Hatef, mechanical engineer, Hayes, Seay, Mattern & Mattern Inc.; Stephen K. Mamakos, director, Energy and Utilities Division; Rick Serfass, supervisor, Central Chilled-Water Plant; Bob Hemming, general foreman, Central Heating Plant; Frank Mills, supervisor, Environmental Controls; Al Myers, foreman, Water & Reclamation Plant.

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