Energy Conservation Methods in HVAC

Course No: M01-010

Credit: 1 PDH

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UNIFIED FACILITIES CRITERIA (UFC)

HEATING, VENTILATING, AIR CONDITIONING, AND DEHUMIDIFYING SYSTEMS

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

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HEATING, VENTILATING, AIR CONDITIONING, AND DEHUMIDIFYING SYSTEMS

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

Record of Changes (changes indicated by **1**\ ... /**1**/)

Change No.	Date	Location

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

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APPENDIX A
ENERGY CONSERVATION METHODS

A-1.00 Energy Conservation by Optimization of Controls

A-1.01 Intermittent Occupancy Controls. Classrooms, conference rooms, cafeterias, and other areas with intermittent occupancy shall have occupied/unoccupied switches. These switches shall function to eliminate conditioning of spaces when the room is not being used.

A-1.02 Space Temperature Requirements for Interior Zones. Refer to MIL-HDBK-1190.

A-1.03 Perimeter Radiation Heating Systems Control. Perimeter heating system controls shall have daytime, and a lower nighttime, reset schedule. During occupied periods, excessive internal heat gains are produced by internal loads (for example people, lighting, and equipment). Perimeter radiation systems shall be designed for the absence of these loads while maintaining night setback temperature. When used with VAV systems without reheat coils, provide radiation capacity to heat ventilation air to room setpoint during occupied cycle. Do not oversize but do add a 10 percent allowance for morning warm-up after night setback.

A-1.04 Energy Efficient Control System

A-1.04.1 Night Setback. A night setback allows the heating system to cycle automatically at the minimum allowable space temperature. These systems are generally provided with time clocks. Use electronic programmable time clocks or DDC programs for night, weekend, and holiday temperature setback (or cutoff) in the winter and set up (or cutoff) in the summer to reduce heating and cooling loads respectively. Normally, when unoccupied, air conditioning for personnel comfort will be cut off and heating will be reduced by approximately 15 degrees F.

A.1.04.2 Occupied/Unoccupied Hot Water Reset Schedule. An occupied/unoccupied hot water reset schedule is a dual setting system which allows for use of internal heat from equipment, lights, and people as part of the heat supply during occupied hours. See Figure A-1. During occupied hours, the setting is lower than during unoccupied hours, when there is not as much internal heat gain.

A-1.04.3 Direct Digital Control (DDC). DDC control systems provide the functions of a typical building automatic control system. Systems can also provide an effective operator interface

APPENDIX A (Continued)

to allow diagnostics of HVAC system operation from a remote location. Use care to provide and locate accurate sensors required by NFGS-15972.

There are many advantages of using DDC systems that make them preferred over conventional pneumatic, electric, or electronic systems. These include lower first cost, systems with fewer components, lower failure rate, greater accuracy of control, higher reliability, and lower maintenance cost. DDC systems may also incorporate remote monitoring and self-tuning to simplify operation and maintenance.

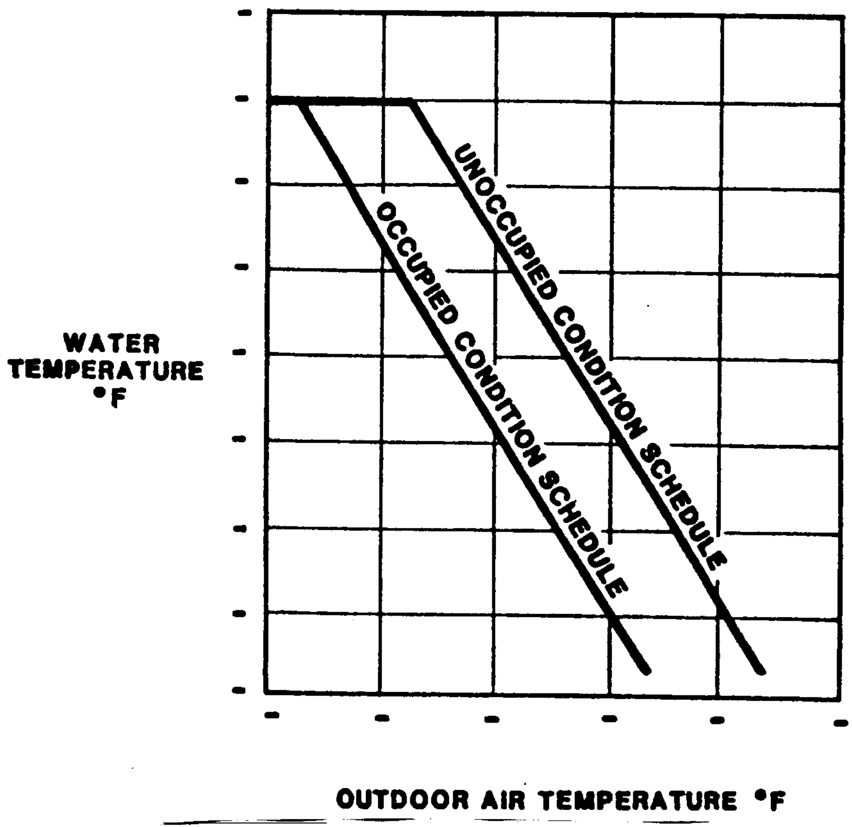

Figure A-1
Occupied/Unoccupied Hot Water Reset Schedule

APPENDIX A (Continued)

NFGS-15972 was prepared to take advantage of the many desirable features of a DDC system while minimizing anticipated problems by specifying appropriate hardware and software and by requiring adequate training for activity personnel. DDC systems should be specified for new projects and major renovations where operators and maintenance personnel are DDC qualified or are willing to accept DDC and receive proper training. Where these conditions are not met, use NFGS-15971 and provide pneumatic, analog electronic, or electric control systems.

DDC systems may be selected for repair or renovation of existing control systems to save energy and take advantage of the other features of DDC systems. Where existing pneumatic or electric valves and other actuators are proper and functional, they may work with the replacement DDC system with the appropriate interface.

EMCS is an outmoded concept and should be discouraged and avoided. EMCS added a computer based system to monitor existing pneumatic and analog electronic control systems and provided some energy saving strategies. Success of the EMCS depended on proper operation of the existing control system. When the existing control system failed, EMCS failed. If energy monitoring features are desired, a DDC system should be specified. If an operating EMCS is to be expanded and a DDC system will not be installed, refer to the Army Corps of Engineers, Architectural and Engineering Instructions, Design Criteria, Chapter 11, "Energy Conservation Criteria," and guide specification CEGS-15950, Heating, Ventilating, and Air Conditioning (HVAC) Control Systems for selection and application.

A-1.04.4 Thermostat Setpoints. Selective thermostat setpoints provide a temperature range in which no mechanical heating or air conditioning takes place. See Figure A-2. Deadband thermostats should not be used. Rather thermostats with separate control and setpoint for heating and cooling or DDC with separate control loops should be used. Strategies should control heating and cooling within one degree F of the respective setpoints.

A-2.00   Energy Conservation with Systems

APPENDIX A (Continued)

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A-2.00 Energy Conservation with Systems

APPENDIX A (Continued)

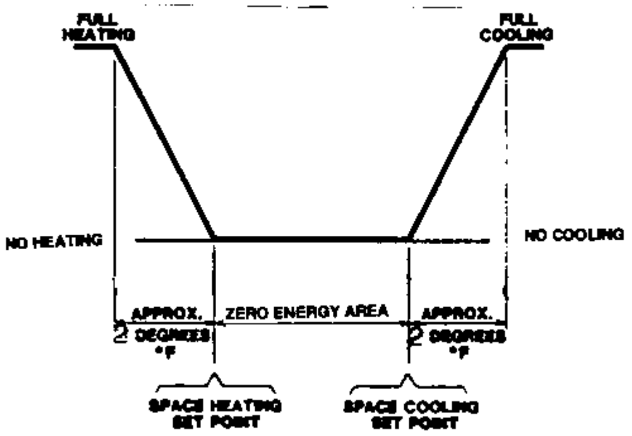

Figure A-2
Thermostat Setpoints Diagram

A-2.01 Energy Efficient Systems. Design factors such as reliability can have priority over energy efficiency. An energy saving feature that is unstable or not maintained may fail and actually consume more energy than a simpler stable HVAC system. Select the least complicated energy efficient system for the application. Energy efficient devices shall be specified when possible if they are life cycle cost effective.

A-2.02 Economizer Cycle Systems. Contact the individual NAVFACENGCOM EFD or EFA for exact guidance on the use of economizer cycles. In the absence of immediate guidance, systems larger than 10 tons shall be designed to use maximum outside air for cooling whenever the outdoor dry bulb temperature is lower than 60 degrees F more than 3000 hours per year. Operation shall be limited by an outdoor air dry bulb sensor. Do not use economizer cycle systems in humid climates.

A-2.03 Multiple Parallel Equipment Systems. Multiple parallel equipment systems, such as boilers, chillers, cooling towers, heat exchangers, air handlers, etc., provide superior operating efficiency, added reliability, and the operating capacity required at design conditions. Use multiple equipment systems when energy savings will offset higher first costs.

APPENDIX A (Continued)

A-2.04 Direct Exhaust Systems. Direct exhaust systems may reduce the cooling load in a space requiring high ventilation rates to remove high heat loads of a source. Evaluate the energy required for the extra makeup air.

A-2.05 Heat Recovery Systems (Cascading Energies). Consider the following economic factors when evaluating heat recovery systems:

a) Higher first costs,

b) Higher maintenance costs,

c) Additional building space requirements, and

d) Added complication to HVAC equipment.

A-3.00 Exhaust Air Heat Recovery. With the air exhaust heat recovery system in the heating mode, heat from exhaust air is recovered and used to preheat the outdoor air supply, domestic hot water, boiler combustion air, and boiler makeup water. In the cooling mode, exhaust air is used to pre-cool outdoor air. In addition to the economic factors cited above, system pressure is increased. The five methods available for exhaust air heat recovery air are as follows:

a) Rotary air wheel method,

b) Static heat exchanger method,

c) Heat pipe method,

d) Runaround system/closed loop method, and

e) Runaround system/open loop method.

The rotary air wheel, static heat exchanger, and heat pipe methods require supply and exhaust ducts to be adjacent ducts. Therefore, duct design should ensure that the outside air and exhaust air louvers are adequately separated to prevent cross contamination. Do not use rotary air wheel for industrial ventilating systems because of contamination carryover. For more information, refer to ASHRAE Equipment Handbook, the chapter entitled "Air-to-Air Energy Recovery Equipment."

APPENDIX A (Continued)

A-3.01 Rotary Air Wheel. With the rotary air wheel, heat transfer takes place as the finned wheel rotates between the exhaust and supply duct. See Figure A-3. There are two types of rotary air wheels - one transfers only sensible heat, the other transfers both sensible and latent heat. The wheel is 70 percent effective for an equal supply and exhaust mass flow rates, but a certain amount of unavoidable leakage will reduce this effectiveness. Closely investigate cross contamination effects on the application, especially when the exhaust air is from a process source. Give this system full consideration in air conditioning and ventilating systems where exhaust air is 4,000 cfm or greater.

A-3.02 Plate Heat Exchanger. With the plate heat exchanger method heat transfers across alternate passages carrying exhaust and supply air in a counterflow or crossflow pattern. See Figure A-4 and Figure A-5.

Plate heat exchangers are 40 to 80 percent efficient in recovering heat, depending on the specific system design, temperature differences, and flow rates. Crossflow methods are usually more convenient, but counterflow methods are more efficient. With the plate exchanger method, only sensible heat is transferred. Plate heat exchanger is a static device having no moving parts, allowing for only a minimal chance of cross contamination. It is a relatively simple method of heat recovery.

A-3.03 Heat Pipe Method. The heat pipe method involves a self-contained, closed system which transfers sensible heat. This method consists of bundles of finned copper tubes, similar to cooling coils, sealed at each and filled with a wick and working fluid. The working fluid may be water, refrigerant, or methanol.

For the most efficient system, the exhaust and supply air shall be counterflow. Performance also is improved by sloping the heat pipe so the warm side is lower than the cool side. See Figure A-6. For more information refer to ASHRAE Equipment Handbook, the chapter entitled "Air-to-Air Energy Recovery Equipment."

A-3.04 Runaround System (Closed Loop) Method. With the closed loop systems method, a hydronic system transfers sensible heat from the exhaust air to the outdoor air using water, glycol, or some other sensible heat fluid. See Figure A-7.

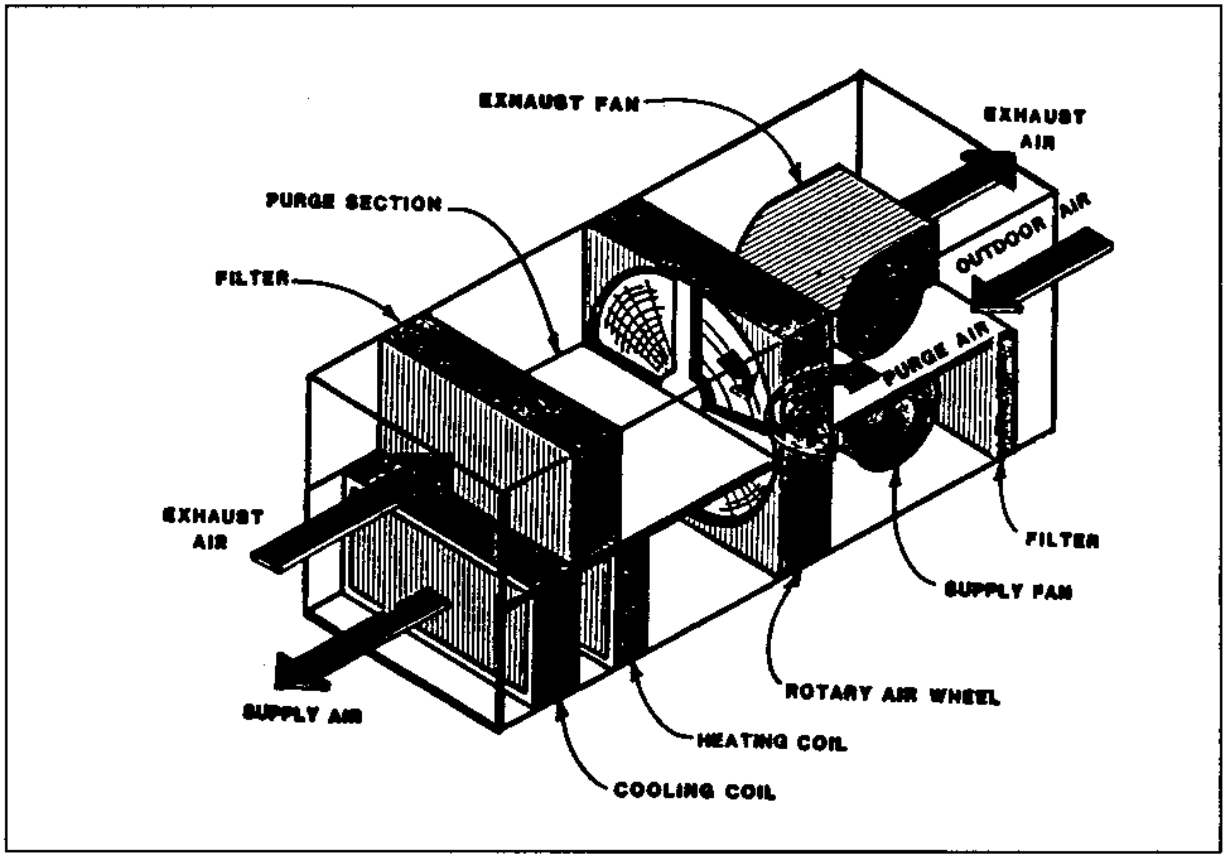

Figure A-3
Exhaust Air Heat Recovery With Rotary Air Wheel

APPENDIX A (Continued)

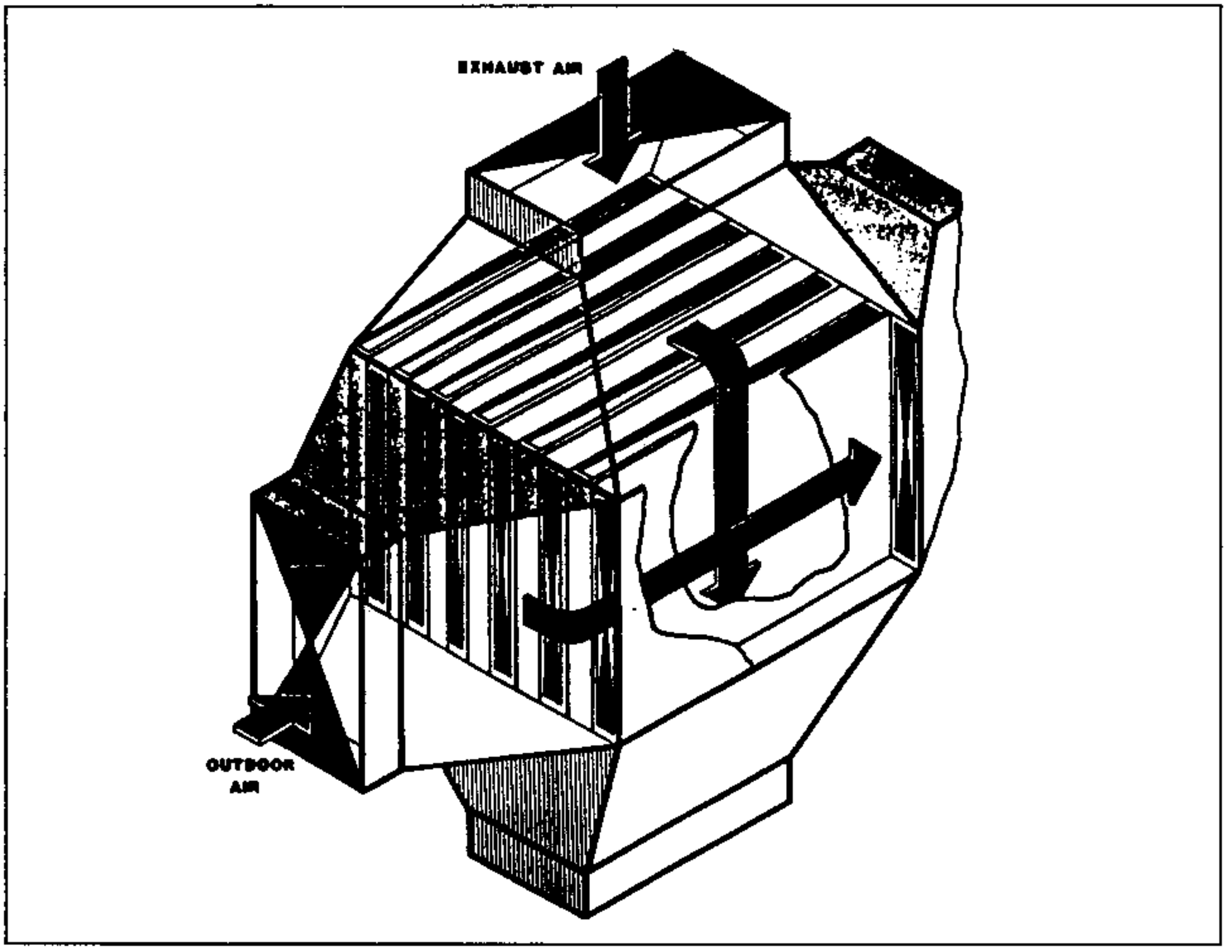

Figure A-4
Exhaust Air Heat Recovery With Counterflow Pattern
Static Heat Exchanger

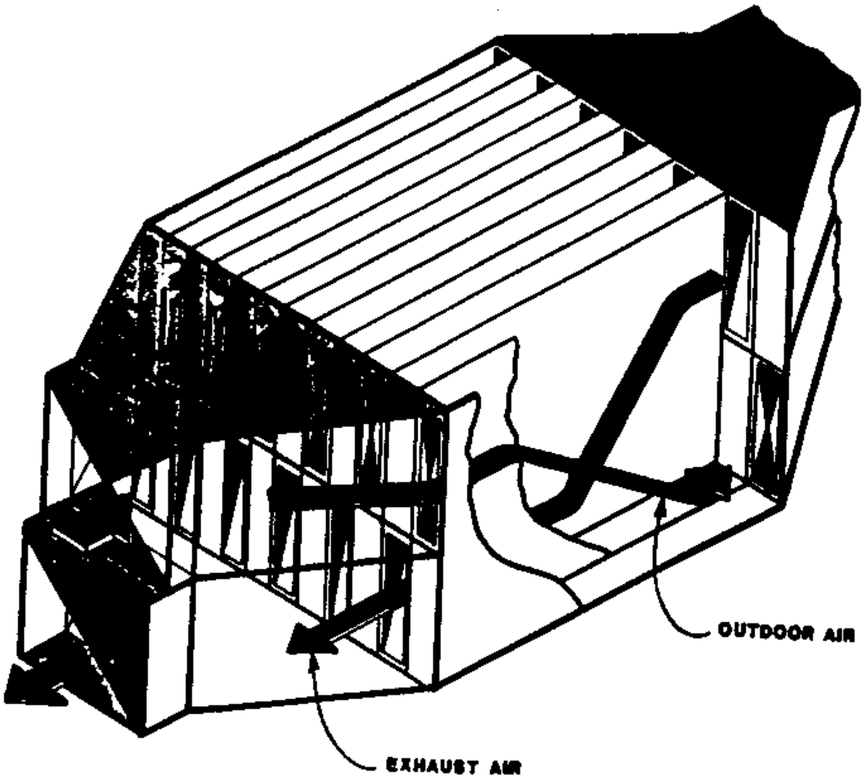

Figure A-5
Exhaust Air Heat Recovery With Crossflow Pattern
Static Heat Exchanger

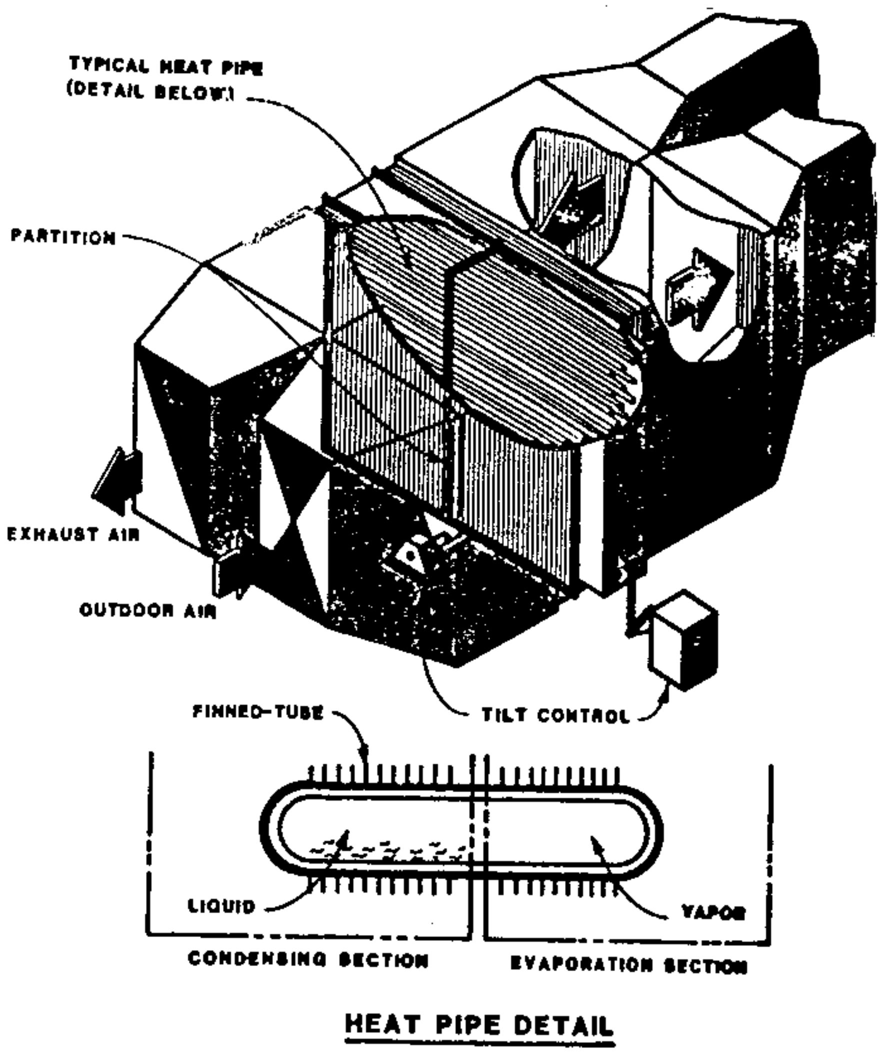

Figure A-6
Exhaust Air Heat Recovery Method With Heat Pipe

APPENDIX A (Continued)

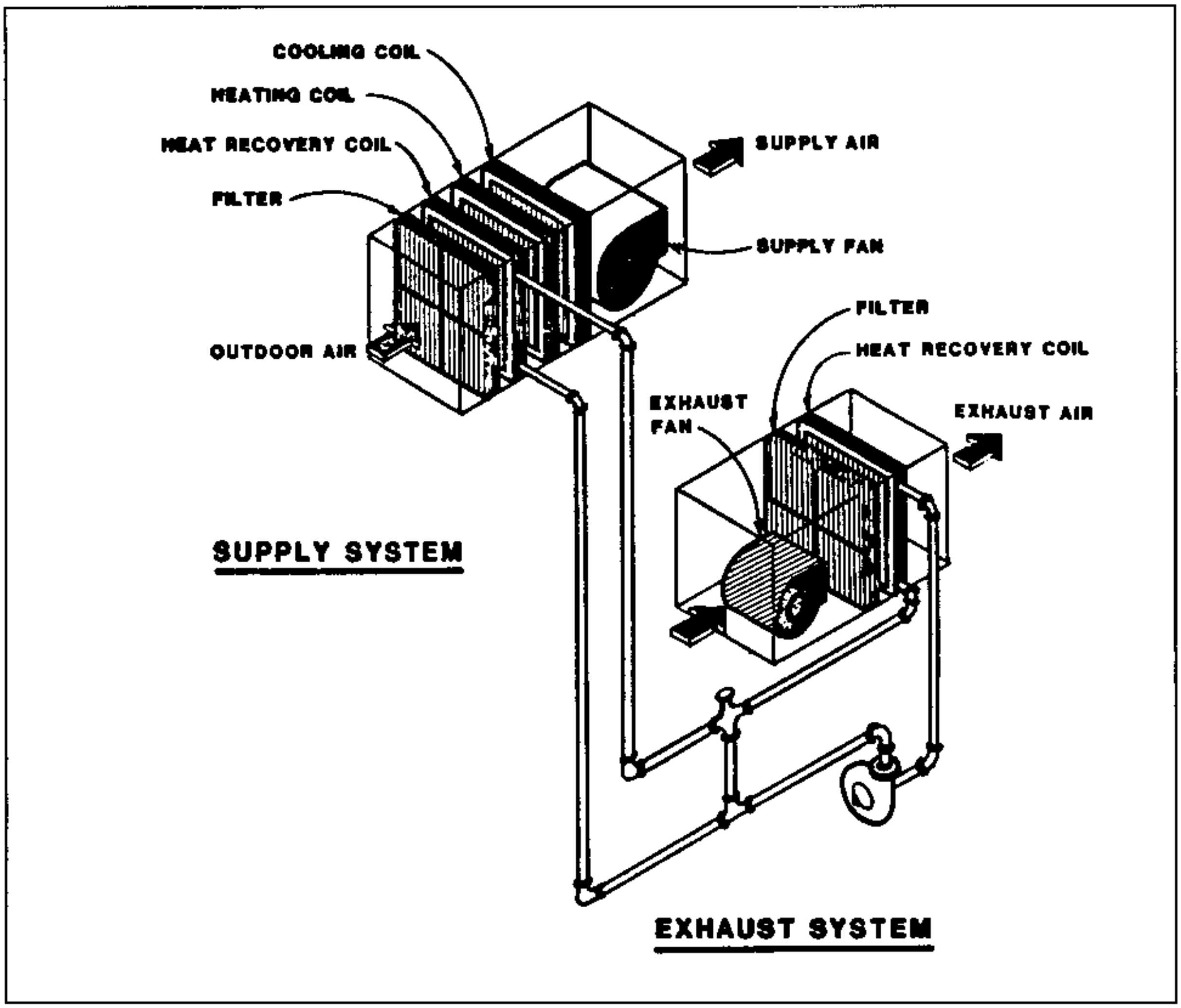

Figure A-7
Exhaust Air Heat Recovery Method
With Runaround (Closed Loop) System

The closed loop method consists of two coils (one in the supply system and one in the exhaust system), a pump, and a closed pipe loop. This method can be expected to increase the outdoor air temperature by 60 to 65 percent of the outdoor air and exhaust air temperature difference. If the winter design temperature is 32 degrees F or below, this system requires an antifreeze solution.

A-3.05 Runaround System (Open Loop) Method. The open loop method transfers sensible and latent heat. This is an air-to-liquid, liquid-to-air enthalpy recovery system where working fluid flows into each cell with the aid of a pump, in a manner similar to cooling tower flow. See Figure A-8. Sorbent liquid used with this system can be bacteriostatic, if necessary. The open loop method shall not be used for high temperature applications.

A-3.06 Ancillary Components. Ancillary components for exhaust air heat recovery methods include:

a) Energy recovery devices for supply/exhaust filters,

b) Preheat coils,

c) Backdraft dampers,

d) Exhaust dampers,

e) Recirculation dampers,

f) Face and bypass dampers, and

g) Drainage provisions.

Controls and ancillaries shall be shown on drawings and supplemented by specifications, as necessary. Select the minimum acceptable energy transfer effectiveness and the maximum acceptable cross-contamination.

A-3.07 Condensate Cooler/Hot Water Heat Recovery Method. The condensate cooler/hot water heat recovery method uses a heat exchanger, which removes heat from condensate not returned to the boiler. This recovered heat can be used to preheat domestic hot water, boiler makeup water, or low temperature water return to boiler or heat exchanger.

APPENDIX A (Continued)

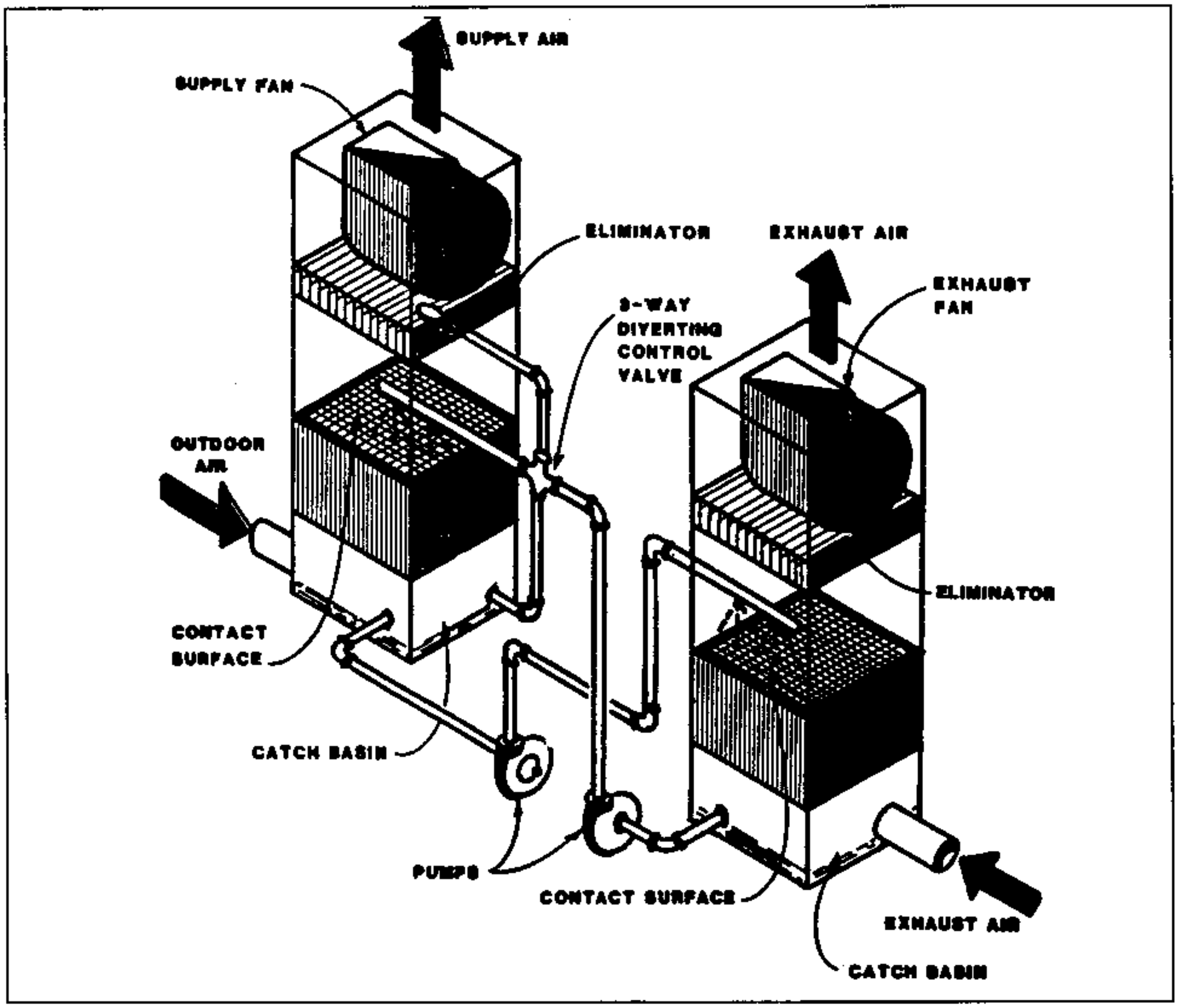

Figure A-8
Exhaust Air Heat Recovery Method
With Runaround (Open Loop) System

APPENDIX A (Continued)

A-3.08 Heat-of-Light Heat Recovery Method. The sensible heat given off by the lighting fixtures is a large portion of the total cooling load. Recovery of this heat reduces energy usage both by reducing the room cooling load and by recovering usable heat. In some instances, the efficient removal of heat-of-light that does not enter the room may reduce the air supply to the room below that which is desirable. Verify that effective air circulation is maintained. Recommended methods of heat-of-light recovery are the light troffer and induced air methods. Where life cycle cost effective, use heat-of-light recovery method in air conditioned spaces. Do not use for clean rooms, animal laboratories, and laboratories with toxic, explosive, or bacteriological exhaust requirements.

A-3.09 Light Troffer Method. The light troffer method removes space air by pulling it through a light troffer or through a light fixture, and transfers it into the ceiling plenum where it is routed into the return air system. See Figure A-9. With this system, the room cooling load is reduced. Also, less air is required to cool the room, making it possible to use smaller duct and fan systems. Do not use for VAV systems.

With this method, the total cooling load is substantially reduced for outdoor air supply systems, but not as significantly for systems not capable of providing 100 percent outdoor air. This technique also reduces the luminaire surface temperature and, therefore, increases ballast and lamp life.

A-3.10 Induced Air Method. The induced air method removes air from the space by pulling it through the light troffer or through a lighting fixture, and transfers it into the ceiling plenum, to be recirculated or discharged outdoors. See Figure A-10.

A-3.11 Refrigeration Heat Recovery Method. The refrigeration heat recovery method uses heat rejected from the refrigeration machine. This method uses four different techniques:

a) Conventional refrigeration machine method,

b) Heat pump method,

c) Single condenser water circuit method, and

d) Double condenser water circuit method,

APPENDIX A (Continued)

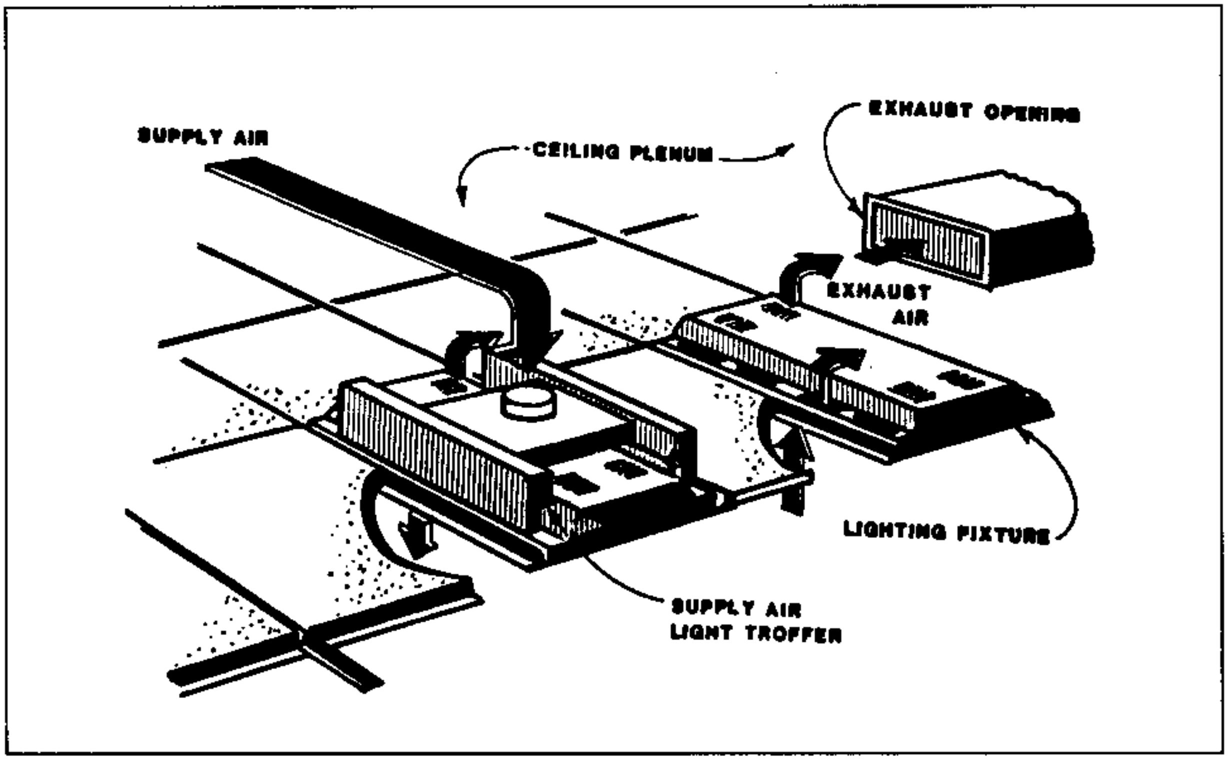

Figure A-9
Heat-of-Light Recovery Method With Light Troffer

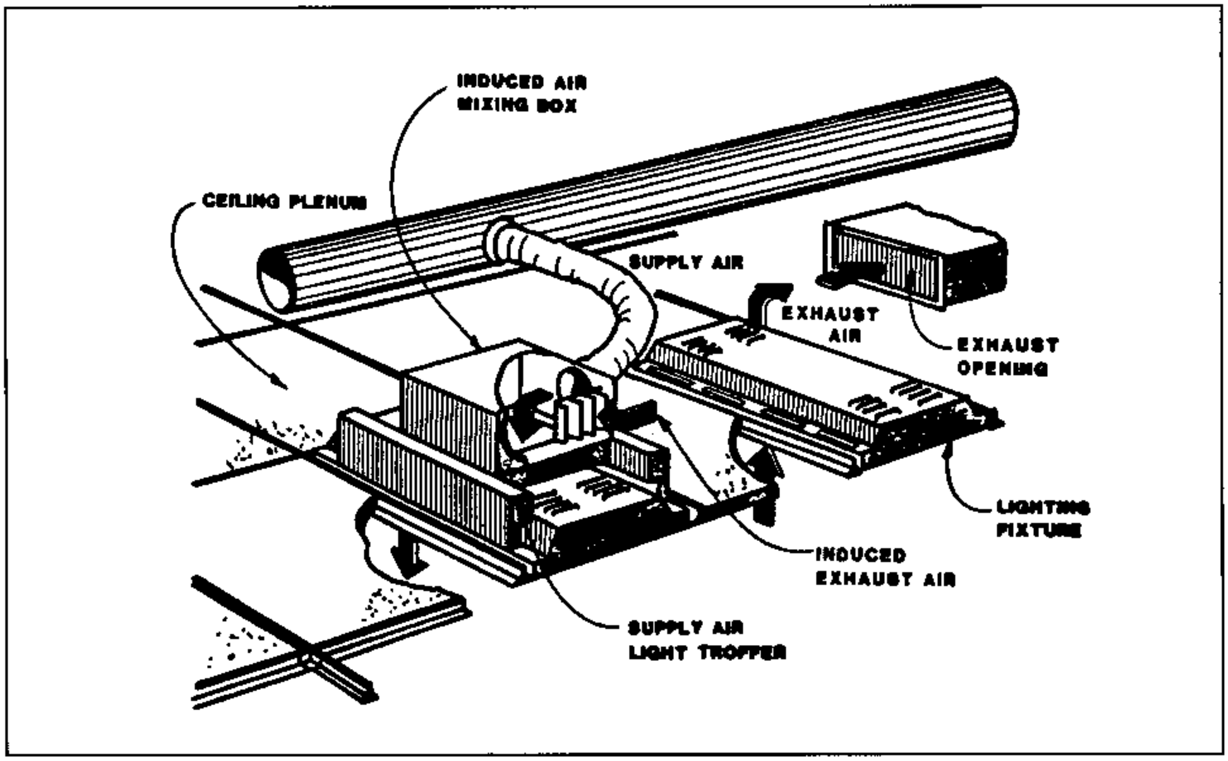

Figure A-10
Heat-of-Light Recovery Method With Induced Air

APPENDIX A (Continued)

The refrigeration heat recovery method is suitable when a refrigeration-type compressor is used, and when simultaneous heating and cooling of one or more spaces is required.

A-3.12 Conventional Refrigeration Machine Method. The conventional refrigeration machine method uses a direct expansion cooling coil in conjunction with either a hot water or refrigerant coil. See Figure A-11 and Figure A-12.

A hot water heating system extracts heat from the refrigerant through a heat exchanger. For direct air heating, a condensing refrigerant coil is used instead of a heat exchanger and water pump. This method is used for lower capacity systems with reciprocating compressors. An air-cooled condenser is used to reject heat when space heating is not required.

A-3.13 Internal Source Heat Pump Method. See Figure A-13.

A-3.14 Single Bundle Condenser Water Circuit Method. The single bundle condenser water circuit method uses a cooling coil in conjunction with a hot water system for heat recovery. When space heating is not required, heat is rejected through an evaporative cooler, a heat exchanger, and an open cooling tower.

Application of this system is limited to a maximum water temperature of 110 degrees F. This system can be used with any compressor type. See Figure A-14.

A-3.15 Double Bundle Condenser Water Circuit Method. The double bundle condenser water circuit method incorporates two separate condenser water circuits - one for the heating system and one for the cooling tower system. Water temperatures up to 125 degrees F can be obtained by using higher compressor speeds, larger impellers, or more than one stage. See Figure A-15.

Selection of a heat recovery machine is critical because relatively high condensing temperatures are required. To prevent surging of the compressor under operating load and required condenser water conditions, lower the condensing temperatures under partial load conditions. Units shall be selected to operate above 50 percent of full load at all times. Storage tanks may be incorporated into a double bundle condenser water circuit system.

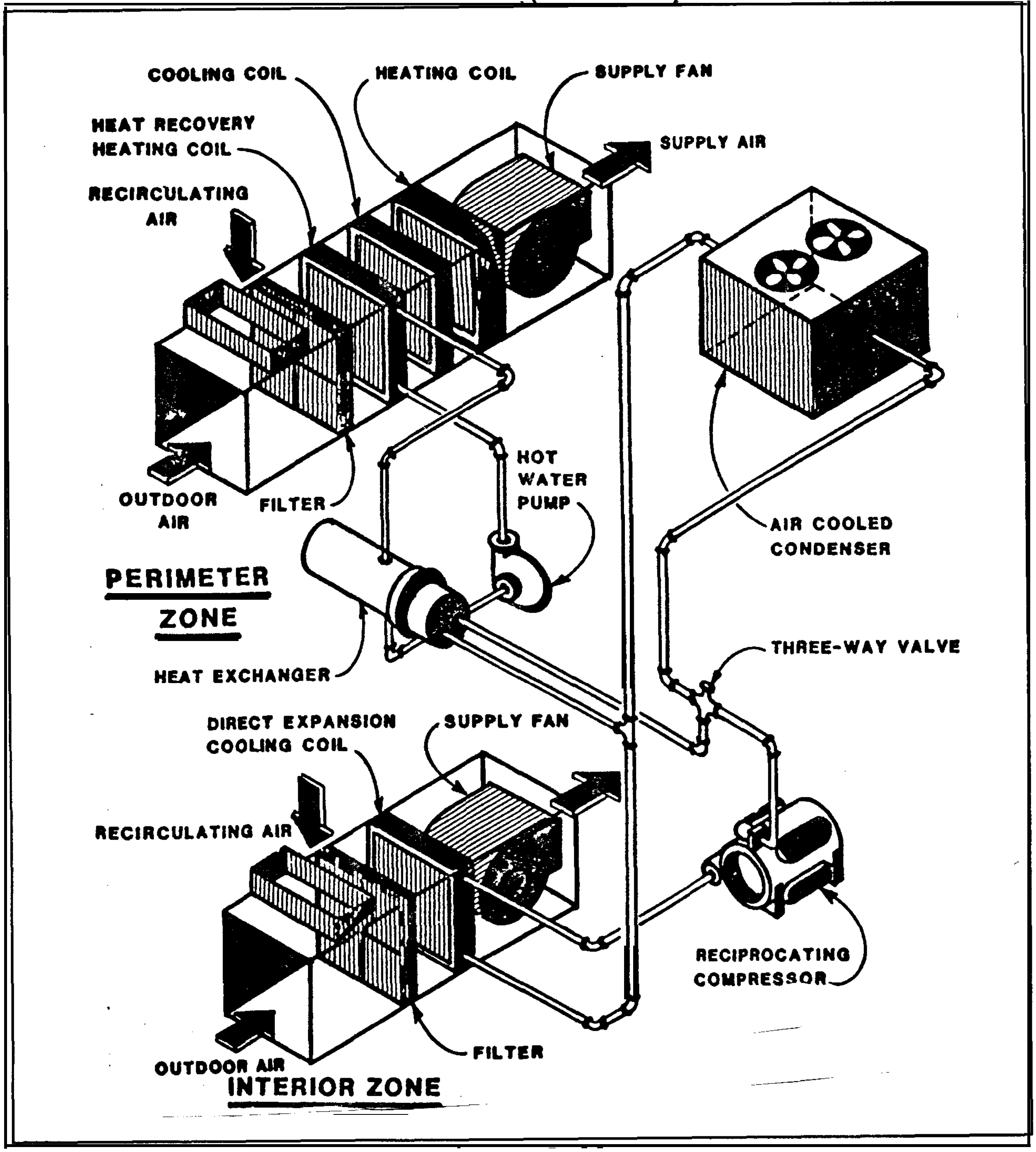

Figure A-11
Refrigeration Method Heat Recovery With Conventional Refrigeration Machine Using Hot Water Coil

APPENDIX A (Continued)

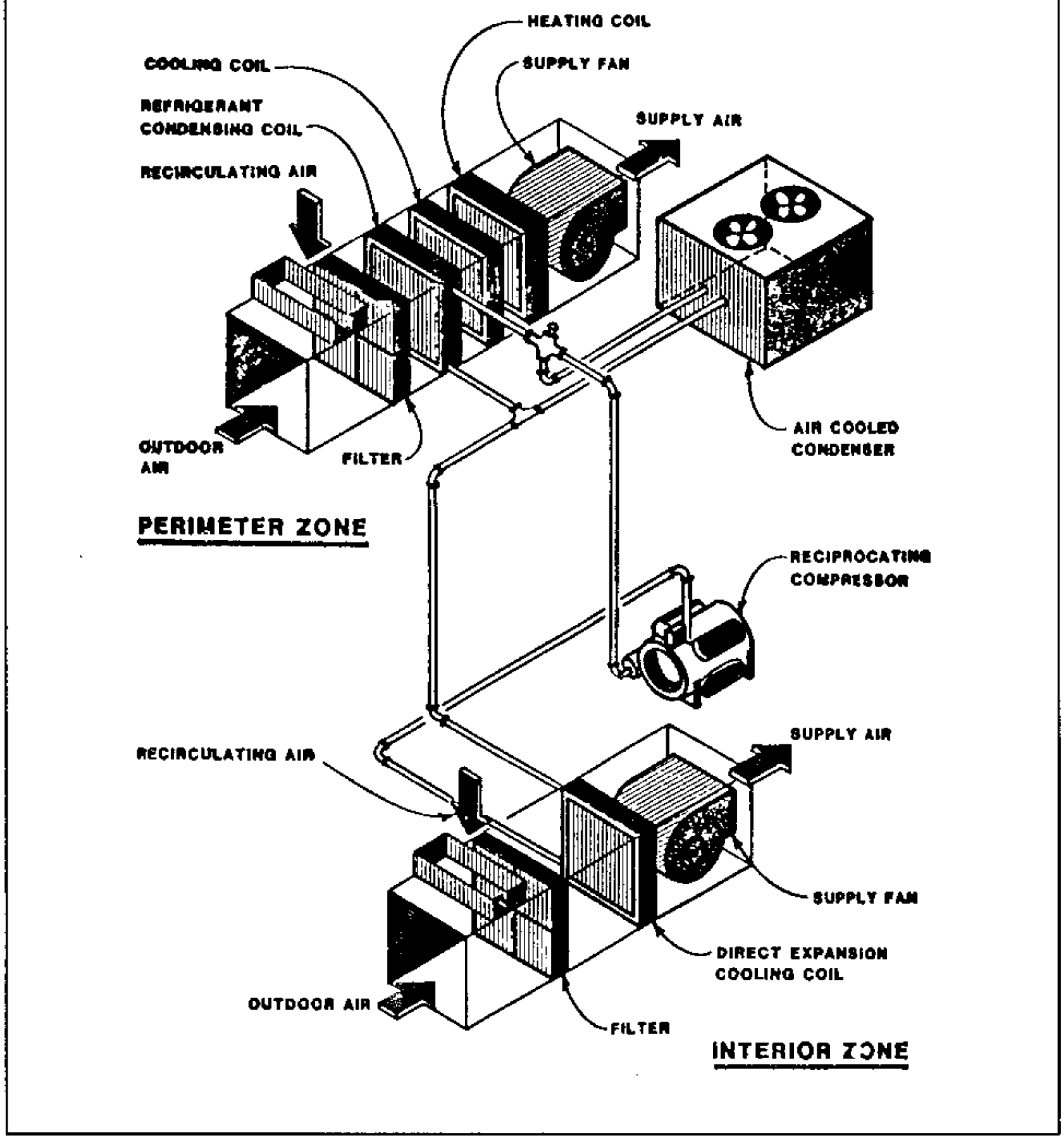

Figure A-12
Refrigeration Method Heat Recovery With Conventional Refrigeration Machine Using Refrigerant Coil

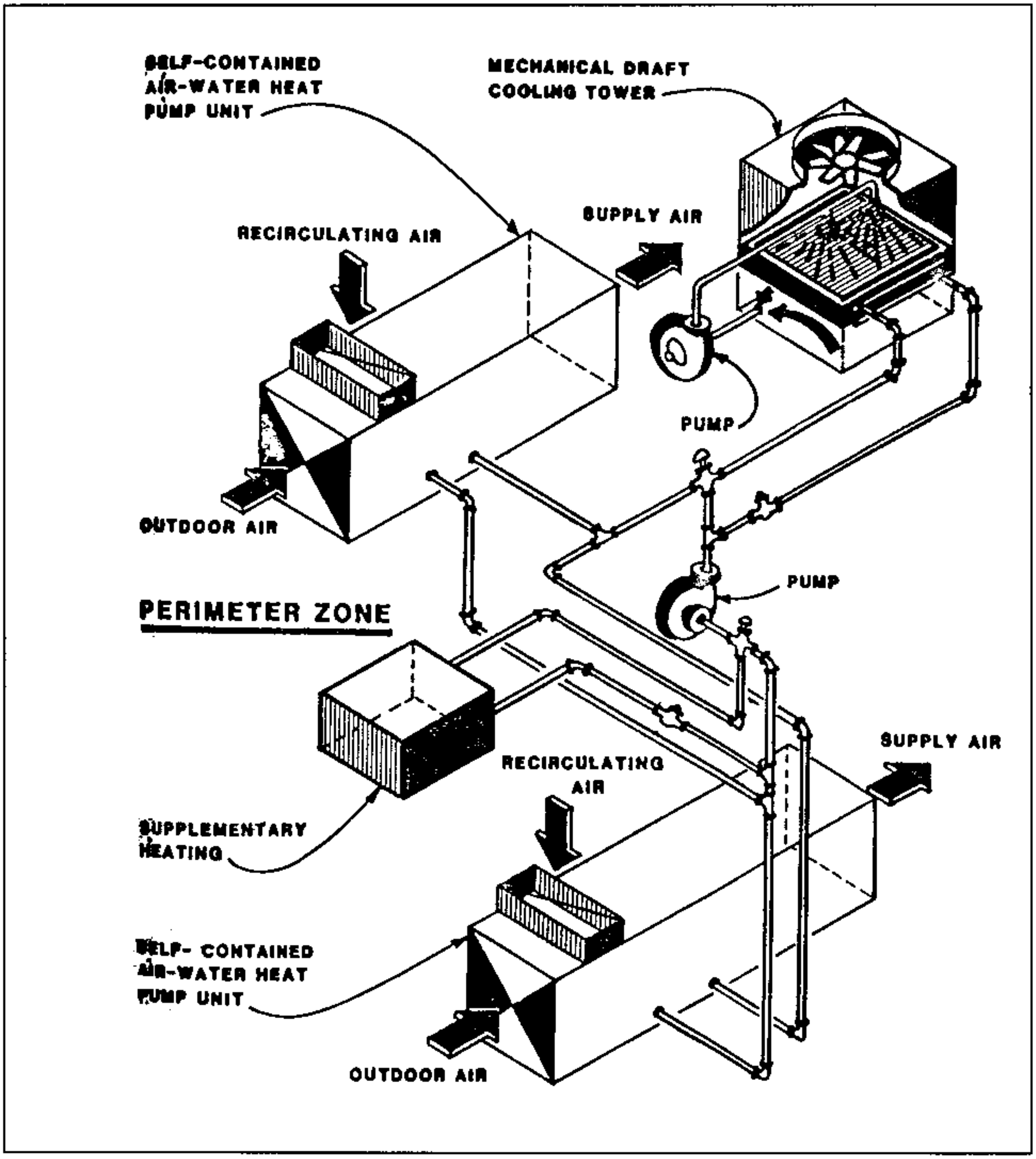

Figure A-13
Refrigeration Method Heat Recovery With
Internal Source Heat Pump

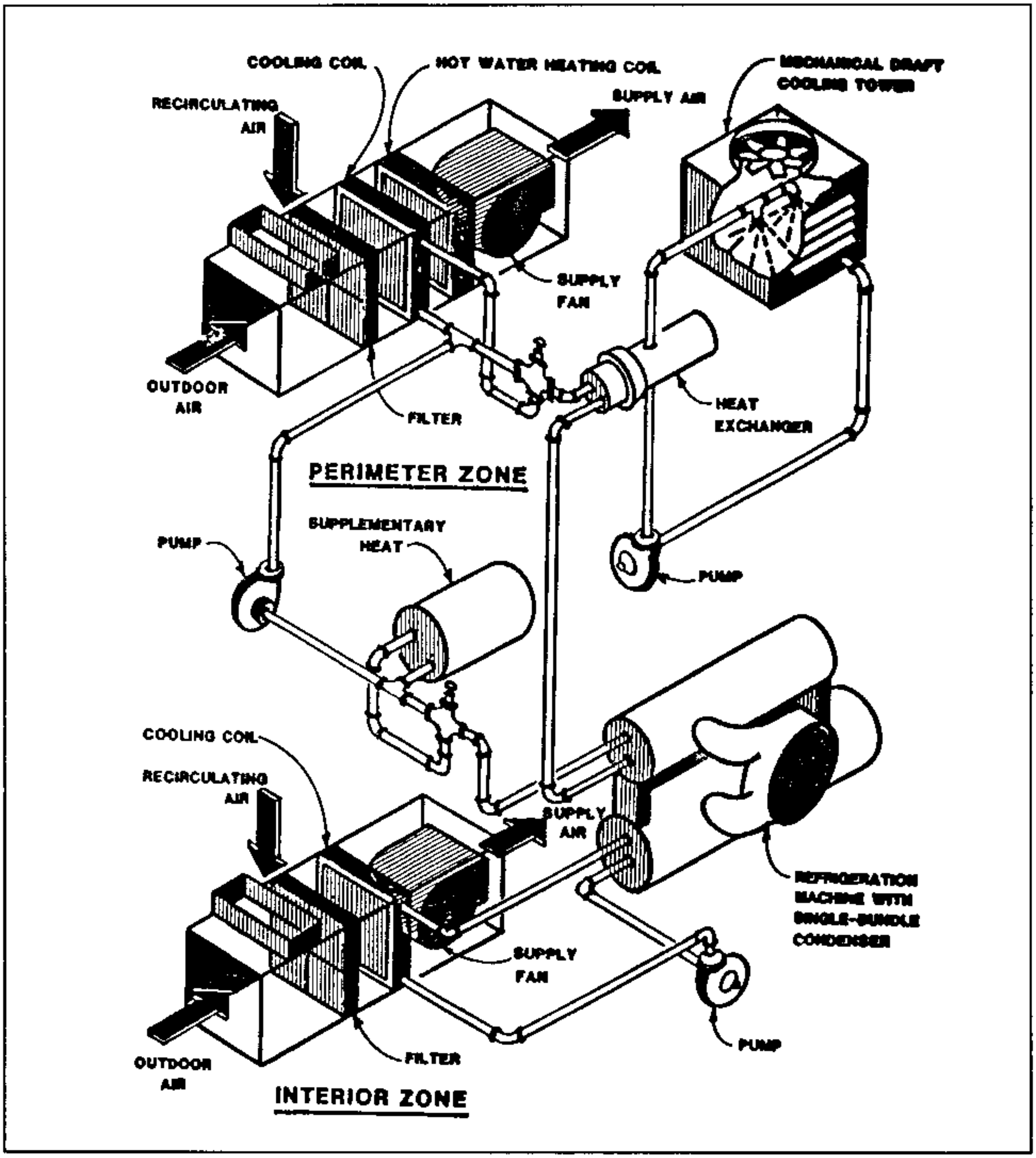

Figure A-14
Refrigeration Method Heat Recovery
With Single Bundle Condenser Water Circuit Method
and Open Cooling Tower

APPENDIX A (Continued)

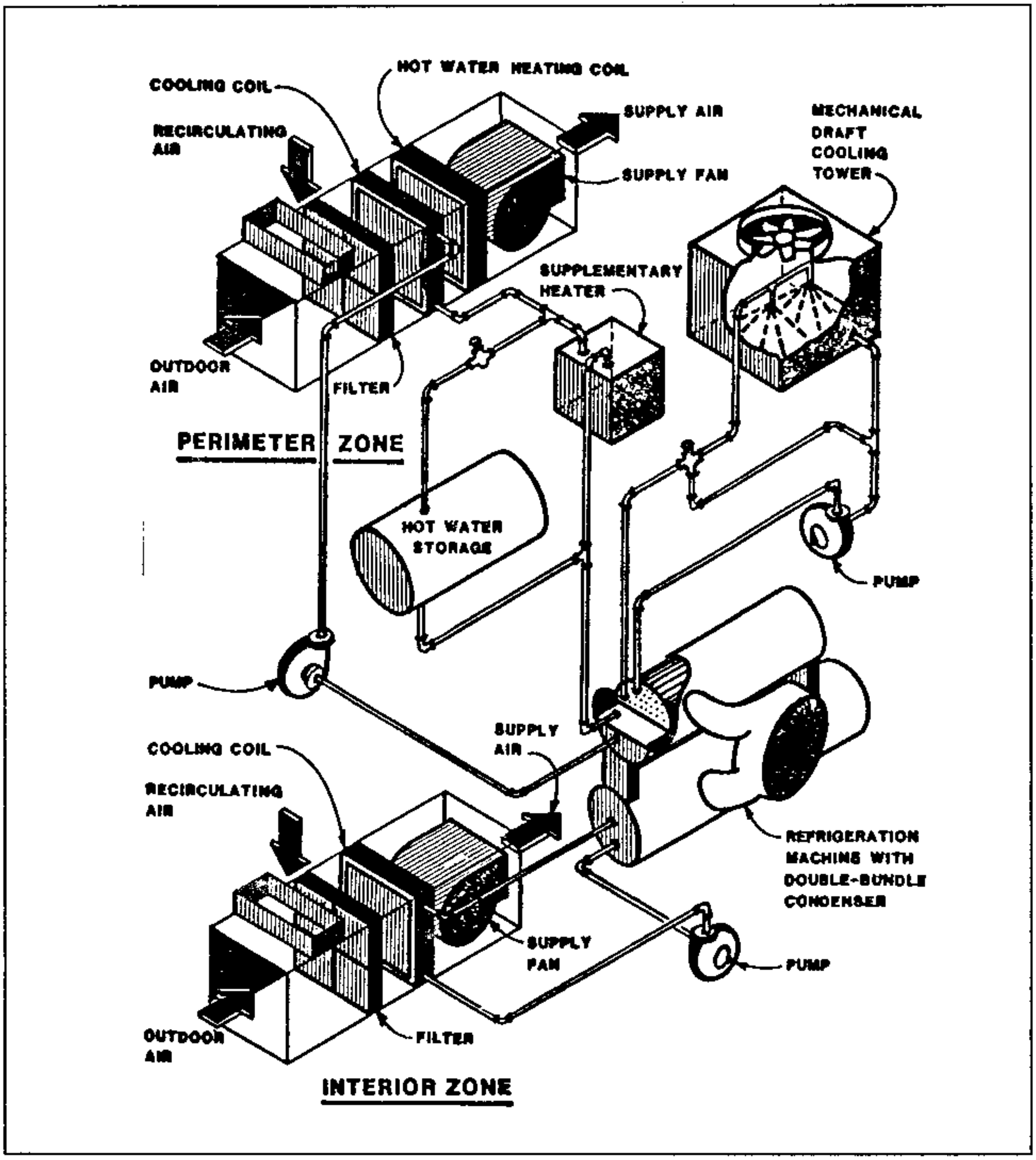

Figure A-15
Refrigeration Method Heat Recovery
With Double Bundle Condenser Water Circuit Method

APPENDIX A (Continued)

Complete an economic evaluation for use of heat recovery machines in large systems. If economically justified, the large system can be designed for multiple machine installations by using conventional machines in conjunction with heat recovery machines. The selection of a double tube bundle machine is a design function where standby low-grade demand exists. Where this cannot be justified, use a single tube bundle machine.

A-4.00 HVAC System Management. Cycling the boiler and refrigeration chiller in a pattern responsive to the time of day and prevailing weather conditions reduces energy consumption by reducing excess heating and cooling capacity during operating hours. For large buildings, a computerized energy management system may be justified. These systems can analyze weather conditions, building and system characteristics, and HVAC operating conditions. Energy management systems then adjust various controls to provide optimum energy use.