CHAPTER 7

APPLICATIONS SOFTWARE

1. GENERAL DESCRIPTION.

a. Applications software includes programs which monitor and control the operations of various HVAC, mechanical, and electrical utility systems, as well as other site specific programs providing building support functions. Examples of specific applications programs include energy conservation programs, equipment selection programs, and utility demand limiting programs. The designer will select the appropriate instrument inputs and control outputs to be used with selected applications software as defined in the database table.

b. Depending on the requirements of the application, applications programs may use adaptive control techniques that allow the UMCS to monitor its own past performance and automatically adjust its parameters for optimum performance.

c. The applications software programs discussed in this section are not listed in the order of the highest potential energy or cost savings. The determination of cost effective programs for each building or system is made after the savings and economic calculations are completed. The amount of cost savings depends on factors such as existing building type, equipment condition, equipment performance and operating schedules.

d. Most applications software programs apply to both direct digital control (DDC) and supervisory control implementation. Depending on the system sequence of operation, the specific programs selected, the site-specific implementation, and the configuration of the controlled equipment, UMCS outputs based on the operation of applications programs may be binary (or change of state) control signals, analog signals to directly modulate final control elements such as valves or dampers, control point adjustment (CPA) signals or software adjustment to a sequence of operations.

e. For supervisory control implementation, CPA will be implemented by using an AO or a pair of DOs in conjunction with an AI signal from sensors to achieve changes in operating setpoints through the CPA port on a local loop controller.

2. SCHEDULED START/STOP PROGRAM. The scheduled start/stop program consists of starting and stopping equipment based on the time of day and day of week. Scheduled start/stop is the simplest of all UMCS functions to implement. This program provides the best potential for energy conservation by turning off equipment or systems during unoccupied hours. In addition to sending a start/stop command, it is mandatory to have a feedback signal indicating the status (on-off or open-closed) of the controlled equipment. The feedback signal verifies that the command has been carried out and provides the UMCS operator with an alarm when the equipment fails or is locally started or stopped. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS input from utility system. Equipment status from pressure switch, auxiliary contacts, flow switch or current sensing relay/transducer.

(2) UMCS output to utility system. Start/stop control signal from UMCS to interposing relays (momentary or maintained signal as required by the equipment control circuit configuration and failure mode) - one for each piece of equipment.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Day of week/holiday.

(b) Time of day.

(c) Cooling and heating high low alarm limits.

(d) Cooling and heating start/stop schedules.

(e) Equipment status.

(f) Equipment constraints.

(g) Consecutive start time delay.

(2) Program outputs.

(a) Start signal.

(b) Stop signal.

c. Application notes. The scheduled start/stop program operates in conjunction with optimum start/stop, demand limiting, and ventilation-recirculation programs.

3. OPTIMUM START/STOP PROGRAM. The scheduled start/stop program is refined by automatically adjusting the equipment operation schedule in accordance with space temperatures and outside air (OA) temperature. In the scheduled start/stop program, HVAC systems are started prior to occupancy to cool down or heat up the space on a fixed schedule independent of space and OA conditions. The optimum start/stop program automatically starts and stops the system on a sliding schedule. The program will adjust start/stop times by taking into account the thermal inertia of the structure, the capacity of the HVAC system to either increase or reduce space temperatures, OA conditions, and current space temperatures, using prediction techniques. These techniques determine the latest time for starting HVAC equipment to satisfy the space environmental requirements at the beginning of the occupied cycle, and determine the earliest time for stopping equipment at the day's end. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Equipment status from pressure switch, auxiliary contact, flow switch or current sensing relay/transducer - one for each piece of equipment

(b) Space dry bulb temperature (minimum of one per zone).

(c) OA dry bulb temperature.

(2) UMCS outputs to utility system. Start/stop control signal from UMCS to interposing relays (momentary or maintained signal as required by the equipment control circuit configuration and failure mode) - one for each piece of equipment.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Day of week/holiday.

(b) Time of day.

(c) Cooling and heating operation.

(d) Equipment status.

(e) Cooling and heating building occupancy schedule.

(f) Space temperature(s).

(g) Building heat constant (operator adjustable).

(h) Building cooling constant (operator adjustable).

(i) OA temperature.

(j) Required space temperature at occupancy (heating).

(k) Required space temperature at occupancy (cooling)

(l) Equipment constraints.

(m) Cooling and heating high-low alarm limits.

(2) Program outputs

(a) Start signal.

(b) Stop signal.

c. Application notes. The optimum start/stop program operates in conjunction with the scheduled start/stop, demand limiting, and ventilation-recirculation programs.

4. ECONOMIZER PROGRAM. The use of an economizer cycle in air conditioning systems can be a cost effective conservation measure, depending on climatic conditions and the type of mechanical system. The economizer cycle utilizes OA to reduce the building's cooling requirements when the OA dry bulb temperature is less than the required changeover temperature. At optimum conditions, the space temperature is maintained at setpoint without the addition of mechanical cooling.

a. Changeover Temperature. The changeover temperature is equal to the return air (RA) temperature minus a fixed differential temperature. The fixed differential shall be determined site-to-site depending on local weather conditions, to minimize periods when the OA enthalpy would be greater than the RA enthalpy.

b. Cold Deck Type Systems. For cold deck type systems (such as Reheats, Multizones, Dual Ducts, and Variable Air Volume systems), the UMCS shall modulate the OA, RA, and relief air dampers based on the conditions shown in Table 7-1.

Table 7-1. Damper Modulation for Cold Deck Systems.

Condition No.	Description	Control
1	OA temperature < SA temperature < Changeover temperature	Modulate OA, RA, and relief dampers to maintain mixed air temperature at cold deck supply temperature setpoint minus 2 degrees F.
2	SA temperature < OA temperature < Changeover temperature	Set OA and relief dampers at 100% open; RA dampers closed.
3	SA temperature < Changeover temperature < OA temperature	Set OA and relief dampers at their minimum positions, and set RA damper at its corresponding open position.

c. Single Zone Type Systems. For single zone type systems, the UMCS shall modulate the OA, RA, and relief dampers based on the conditions shown in Table 7-2.

Table 7-2. Damper Modulation for Cold Deck Systems.

Condition No.	Description	Control
1	OA temperature < Changeover temperature	Modulate OA and relief dampers open, and the RA dampers closed to maintain the space temperature cooling setpoint.
2	Changeover temperature < OA temperature	Set OA and relief dampers at their minimum positions, and set RA damper at its corresponding open position.

d. Damper Controls. The OA, return air and relief air dampers are positioned by the UMCS (for direct digital control implementation) or by local loop control (for supervisory control implementation) to maintain the required mixed air temperature. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

(1) Field hardware requirements. The hardware requirements are:

(a) UMCS inputs from utility system.

1/ OA intake damper position feedback - one per OA damper.

2/ OA dry bulb temperature.

3/ Mixed air temperature.

4/ Return air temperature.

(b) UMCS outputs to utility system.

1/ Proportional control signal to dampers (for direct digital control implementation).

2/ Minimum OA override of local loop mixed air temperature controls (for supervisory control implementation).

(2) Software I/O requirements. The software requirements are:

(a) Program inputs.

1/ Changeover dry bulb temperature.

2/ OA dry bulb temperature.

3/ Return air dry bulb temperature.

4/ Equipment constraints.

(b) Program outputs. Automatic/minimum OA damper control signal.

(3) Application notes. This program cannot be used where humidity control is required.

5. VENTILATION-RECIRCULATION PROGRAM. The ventilation-recirculation program controls the operation of the OA dampers when the introduction of OA would impose an additional thermal load during warm-up or cool down cycles prior to occupancy of the building. This program is particularly useful in those facilities which maintain environmental conditions (such as electronic equipment installations) during building unoccupied periods. During unoccupied periods, the OA dampers remain closed. During building occupied cycles, the OA, return and relief dampers are under normal UMCS control (for direct digital control implementation) or local loop control (for supervisory control implementation). During summer cool-down cycle operation, when the OA temperature is cooler than the space temperature, the OA and exhaust air dampers are opened, and the fans are energized. During winter warm-up cycle operation, when the OA temperature is warmer than space temperature, the OA and exhaust air dampers are opened and the fans are energized. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) OA dry bulb temperature - one per facility.

(2) UMCS outputs to utility system.

(a) Proportional control signal to dampers (for direct digital control implementation).

(b) Open/close damper override control signal to local loop controls - one per HVAC system (for supervisory control implementation).

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Day of week/holiday.

(b) Time of day.

(c) Cooling and heating operation.

(d) Cooling and heating start/stop schedules.

(e) Equipment status.

(f) Cooling and heating occupancy schedules.

(g) OA dry bulb temperature.

(h) Space temperature.

(i) Equipment constraints.

(2) Program outputs. Automatic or open/close override damper control signal.

c. Application notes. This program operates in conjunction with scheduled start/stop and optimum start/stop programs prior to building occupancy.

6. HOT DECK-COLD DECK TEMPERATURE RESET PROGRAM. The hot deck-cold deck temperature reset program is applied to dual duct systems and multizone HVAC systems. These systems utilize a parallel arrangement of heating and cooling surfaces, commonly referred to as hot and cold decks, for providing heating and cooling capabilities simultaneously. The hot and cold air streams are combined in mixing boxes or plenums to satisfy the individual space temperature requirements. In the absence of optimization controls, these systems mix the two air streams to produce the desired temperature. When the space temperature is acceptable, a greater difference between the temperatures of the hot and cold decks results in inefficient system operation. This program selects the areas with the greatest heating and cooling requirements, and establishes the minimum hot and cold deck temperature differentials which will meet the requirements, thus maximizing system efficiency. Zone space temperature sensors are used to determine the greatest cooling and heating space temperature requirements during the building occupied period and reset the corresponding deck temperature proportionately. Where humidity control is required, the program will prevent the cold deck cooling coil discharge temperature from increasing further when the maximum allowable space humidity setpoint is reached. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Hot deck heating coil discharge temperature.

(b) Cold deck cooling coil discharge temperature.

(c) Space dry bulb temperature - one sensor per zone.

(d) Space relative humidity - one per zone of humidity control.

(e) Mixing box damper position or proportional control signal feedback - one per zone.

(2) UMCS outputs to utility system.

(a) Hot deck heating coil control valve proportional control signal (for direct digital control implementation).

(b) Hot deck heating coil control valve CPA (for supervisory control implementation).

(c) Cold deck cooling coil control valve proportional control signal (for direct digital control implementation).

(d) Cold deck cooling coil control valve CPA (for supervisory control implementation).

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Zone space temperature set point.

(b) Zone space temperatures.

(c) Space humidity set point (where shown).

(d) Space relative humidities (where shown).

(e) Mixing box damper position or proportional control signal feedback.

(f) Hot deck temperature.

(g) Cold deck temperature.

(h) Minimum space temperature during occupied periods.

(i) Maximum space temperature during occupied periods.

(2) Program outputs.

(a) Hot deck temperature setpoint.

(b) Cold deck temperature setpoint.

c. Application notes. This program operates in conjunction with the chilled water temperature reset program.

7. REHEAT COIL RESET PROGRAM. Terminal reheat systems operate with a constant cold deck cooling coil discharge temperature. Air supplied at temperatures below the individual space temperature requirements is elevated in temperature by reheat coils in response to signals from individual space thermostats. The program then resets the cold deck discharge temperature upward until it equals the discharge temperature of the reheat coil with the lowest demand. Where humidity control is required, the program will prevent the cooling coil discharge temperature from increasing further when the maximum allowable space humidity setpoint is reached. For air conditioning systems, where reheat coils are not used, the program will reset the cold deck discharge temperature upward until the zone or space with the greatest cooling requirement is satisfied. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Cold deck cooling coil discharge temperature.

(b) Reheat coil valve position or proportional control signal feedback - one per reheat coil valve.

(c) Space dry bulb temperature - one per zone up to 40 percent of the zones per building exposure.

(d) Space humidity - one per zone of humidity control.

(2) UMCS outputs to utility system.

(a) Cold deck cooling coil control valve proportional control signal (for direct digital control implementation).

(b) Cold deck cooling coil control valve CPA (for supervisory control implementation).

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Zone relative humidity high limit.

(b) Zone temperature.

(c) Zone relative humidity (where shown).

(d) Cold deck cooling coil discharge temperature.

(e) Reheat coil valve positions or proportional control signal feedbacks.

(f) Minimum space temperature during occupied periods.

(g) Maximum space temperature during occupied periods.

(h) Equipment constraints.

(2) Program output. Cold deck temperature setpoint.

c. Application Notes. This program operates in conjunction with the chilled water temperature reset program.

8. BOILER MONITORING AND CONTROL PROGRAM. Steam and hot water boiler monitoring and control will allow for automatic central reporting of alarms, critical operating parameters, boiler selection, remote enabling and disabling permissives for boilers and calculation of boiler efficiency. The UMCS operator will be able to interrogate all monitored parameters for determining satisfactory boiler operation. The operator will be prompted when an alarm condition occurs, allowing corrective action to be taken by appropriate personnel, upon operator notification. Boiler operating data will be obtained from the manufacturer, or developed by monitoring fuel input as a function of the steam output. Determination of boiler efficiency also takes into account the heat content of the condensate return and make-up water. Based on the efficiency curves, fuel inputs vs. steam output, the boilers with the highest efficiency can be selected to satisfy the heating load. Boilers may be started manually by a boiler operator or automatically by UMCS depending on site requirements. Burner operating efficiency is monitored by measuring the oxygen or carbon monoxide and flue gas temperature in each boiler flue. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Steam supply pressure - one per boiler.

(b) Hot water supply pressure - one per boiler.

(c) Steam temperature - one per boiler.

(d) Hot water temperature - one per boiler.

(e) Steam flow - one per boiler.

(f) Hot water flow - one per boiler.

(g) Fuel flow - one per boiler.

(h) Fuel pressure - one per boiler (with natural gas).

(i) Fuel temperature - one per boiler (with heated fuel oil).

(j) Feed water or make up flow - one per boiler.

(k) Feed water temperature - one per boiler.

(l) Boiler drum level - one per boiler.

(m) Furnace draft - one per boiler.

(n) Flame status - one per boiler.

(o) Flue gas analyzer - one per boiler (oxygen and carbon monoxide)

(p) Flue gas temperature - one per boiler.

(q) Common steam supply pressure - one per steam plant.

(r) Common steam supply temperature - one per steam plant.

(s) Common condensate return total flow - one per steam plant.

(t) Common condensate return temperature - one per steam plant.

(2) UMCS outputs to utility system. Boiler Enable/Disable control signals or permissives to boiler operator for manual control.

b. Software input requirements.

(1) Program Inputs.

(a) Fuel type.

(b) Fuel flow.

(c) Fuel pressure (for natural gas)

(d) Fuel temperature (for heated fuel oil)

(e) Flame status

(f) Flue gas oxygen

(g) Flue gas carbon monoxide (over 20,000 lb/hr)

(h) Flue gas temperature

(i) Makeup or feed water flow

(j) Furnace draft

(k) Hot water flow (hot water boilers)

(l) Hot water pressure (hot water boilers)

(m) Hot water supply temperature (hot water boilers)

(n) Hot water return temperature (hot water boilers)

(o) Hot water BTUs (hot water boilers)

(p) Steam flow (steam boilers)

(q) Steam pressure (steam boilers)

(r) Steam temperature (steam boilers, superheat only)

(s) Steam BTUs (steam boilers)

(t) Feedwater temperature (steam boilers)

(u) Boiler drum level (steam boilers)

(2) Program Outputs.

(a) Boiler enable/disable control signal

(b) Boiler enable/disable permissive to boiler operator for manual control

(c) Boiler efficiency

c. Application Notes. The hardware and software inputs described are not necessarily required in every case. The designer will study the existing or new system to determine which of the parameters are necessary. Extreme care will be observed when providing automatic start/stop of boilers in lieu of operator supervised startups.

9. CHILLER SELECTION PROGRAM. The chiller selection program is implemented in chilled water plants with multiple chillers. Based on chiller operating data and the energy input requirements obtained from the manufacturer for each chiller, the program will select the chiller or chillers required to meet the load with the minimum energy consumption. When a chiller or chillers are started, chiller capacity must be limited (prevented from going to full load) for a predetermined period to allow the system to stabilize in order to determine the actual cooling load. Comparison of equipment characteristics vs. the actual operating chiller characteristics makes it possible to determine when heat transfer surfaces need cleaning to maintain the highest efficiency. The program must follow the manufacturer's startup and shutdown sequence requirements. Interlocks shown between chilled water pumps, condenser water pumps, and chiller will be in accordance with the chiller manufacturer's requirements. Chillers may be started automatically by the UMCS or manually by the chiller operator depending on the site's operating requirements. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Chiller status (auxiliary contacts) - one per chiller.

(b) Chilled water supply temperature - one per chiller.

(c) Chilled water return temperature - one per chiller.

(d) Chilled water flow - one per chiller (for variable flow systems only)

(e) Entering condenser water temperature - one per chiller.

(f) Leaving condenser water temperature - one per chiller.

(g) Condenser water flow - one per chiller (for variable flow systems only).

(h) Instantaneous kW to chiller - one per chiller.

(i) Instantaneous kW to chiller water pump(s) - one per CW pump (if variable).

(j) Instantaneous kW to condenser water pump(s) - one per condenser water pump (if variable).

(k) Instantaneous kW to cooling tower fan(s) - one per cooling tower fan (if variable).

(l) Common chilled water supply temperature - one per chilled water plant.

(m) Common chilled water return temperature - one per chilled water plant

(n) Total chilled water flow - one per chilled water plan.

(o) Chilled water pump status - one per chilled water pump.

(p) Condenser water pump status - one per condenser water pump.

(q) Solution pump status (absorption chillers only).

(r) Steam flow (for absorption chillers only).

(2) UMCS outputs to utility system. Start/stop control signal to interposing relays or start/stop signal to chiller operator for manual control - one for each chiller, chilled water pump, condenser water pump, cooling tower fan.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Efficiency curves.

(b) Chiller water supply temperatures.

(c) Chiller water return temperatures.

(d) Chiller water flows (for variable flow systems only).

(e) Entering condenser water temperatures.

(f) Leaving condenser water temperatures.

(g) Condenser water flows (for variable flow systems only).

(h) Instantaneous kW to chillers.

(i) Instantaneous kW to chilled water pumps (if variable).

(j) Instantaneous kW to condenser water pumps (if variable).

(k) Instantaneous kW to cooling tower fans (if variable).

(l) Common chilled water supply temperatures.

(m) Common chilled water return temperatures.

(n) Total chilled water flow.

(o) Chilled water pumps status.

(p) Equipment constraints.

(2) Program outputs.

(a) Start/stop signals for chillers (manual or automatic).

(b) Start/stop signals for chilled water pumps (manual or automatic).

(c) Start/stop signals for condenser water pumps (manual or automatic).

(d) Start/stop signals for cooling tower fans (manual or automatic).

(e) Chiller efficiency data.

c. Application notes. The hardware and software inputs described may not be required in every case. The designer will study the existing or new system to determine which of the parameters are necessary. Care will be observed when providing automatic start/stop of chillers in lieu of operator supervised startups.

10. CHILLED WATER TEMPERATURE RESET PROGRAM. The energy required to produce chilled water in a reciprocating or centrifugal refrigeration machine is a function of the chilled water supply temperature. The refrigerant suction temperature is also a direct function of the supply water temperature; the higher the suction temperature, the lower the energy input per ton of refrigeration. Chilled water supply temperature is selected for peak design times; therefore, the supply temperature can be reset upward during non-peak design operating hours to the maximum which will still satisfy space cooling requirements. The program resets chilled water temperature upward until the required space temperature or humidity setpoints can no longer be maintained. This determination is made by monitoring positions of the chilled water valves on various cooling systems or by monitoring space temperatures. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Chilled water valve position (analog position indicator, or fully open indicator on valve stem) - one per air conditioning chilled water valve.

(b) Space dry bulb temperature - one per zone.

(c) Chiller supply water temperature.

(d) Space relative humidity - one per zone (where required).

(2) UMCS outputs to utility system. Chilled water supply temperature CPA - one per chiller.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Chilled water valve position.

(b) High limit for space dry bulb temperature.

(c) High chilled water operating temperature.

(d) Low chilled water operating temperature.

(e) High limit for space relative humidity.

(f) Equipment constraints.

(2) Program outputs. Chilled water supply temperature setpoint.

c. Application notes. The chilled water temperature reset program will affect any system requiring chilled water.

11. CONDENSER WATER TEMPERATURE RESET PROGRAM. The energy required to operate refrigeration systems is directly related to the temperature of the condenser water entering the machine. Heat rejection systems are designed to produce a specified condenser water temperature such as 85F at peak wet bulb temperatures. Automatic controls are provided at some sites to maintain a specified temperature at conditions other than peak wet bulb temperatures. In order to optimize the performance of refrigeration systems, condenser water temperature is reset downward when OA wet bulb temperature will produce lower condenser water temperature. The reset schedule will incorporate the manufacturer's requirements governing acceptable condenser water temperature range. Design requirements for this applications program will be indicated by the letter X adjacent to the program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Condenser water supply temperature - one per condenser.

(b) OA dry bulb temperature.

(2) UMCS outputs to utility system. Condenser water supply temperature CPA - one per condenser.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) High condenser water operating temperature.

(b) Low condenser water operation temperature.

(c) Condenser water supply temperature.

(d) OA dry bulb temperature.

(e) OA relative humidity.

(f) Equipment constraints.

(2) Program output. Condenser water supply temperature setpoint.

c. Application notes. A dedicated local loop controller may be implemented.

12. DEMAND LIMITING PROGRAM. Demand limiting is accomplished by shedding electrical loads or starting sources of auxiliary power such as standby generators to prevent electrical demand from exceeding a peak value (target). This technique is used to reduce electrical costs where electric demand is a cost factor in the utility rate schedules. Peak demand values are established by the utility company using fixed demand intervals, sliding window intervals, and/or time of day schedules. The strategy to be utilized in UMCS is the sliding window interval. Many complex schemes exist for reducing peak demand billings; however, all schemes continuously monitor power demand and calculate the rate of change of the demand value in order to predict future peak demand using prediction techniques. When the predicted peak approaches preset limits, predetermined auxiliary power sources must be started and predetermined scheduled electrical loads within pre-established groups must be shut off or power-limited on a prescheduled priority basis to reduce the connected load before the peak is exceeded. Within a particular group, the order in which a load is shed must be changed by the program so that after a load has been the first to be shed in a group, it is moved to last in the group and another load becomes first. The most commonly shed loads are non-critical HVAC and other utility systems. Design requirements for this applications program will be indicated by the letter X adjacent to the demand limiting step listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system.

(a) Equipment status (differential pressure switch, auxiliary contact, flow switch, chiller current) - one for each piece of equipment

(b) Instantaneous kilowatts (kW) demand for each metered point.

(2) UMCS outputs to utility system.

(a) Start/stop control signal to each load to be shed.

(b) Analog control signal or set point adjustment.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Day of week/holiday.

(b) Time of day.

(c) Equipment status.

(d) Chiller percent capacity.

(e) Minimum cooling capacity.

(f) Peak demand limit target.

(g) Equipment priority schedules.

(h) Length of sliding window interval.

(i) Instantaneous demand.

(j) Maximum space temperature during occupied periods (cooling).

(k) Minimum space temperature during occupied periods (heating).

(l) Space temperatures.

(m) Equipment constraints.

(n) Cooling and heating operation.

(o) Demand limit setpoints

(2) Program outputs.

(a) Calculated percent load point.

(b) Demand signals.

(c) Start signals.

(d) Stop signals.

(e) Setpoint adjustments.

c. Application notes. The demand limiting program is used in conjunction with scheduled start/stop and optimum start/stop programs. Standard demand limiting steps appropriate to summer and winter operation have been established and listed in guide specification CEGS-16935. The designer will assign each sheddable load to electrical demand limiting steps based on installation requirements. The designer will consider the impact of demand limiting on building habitability, occupant comfort and productivity. In general, demand limiting actions having the least impact on operations will be scheduled to occur first. Demand limiting designs which include shutting off ventilation to occupied buildings shall incorporate air quality sensors or other features to prevent or alert occupants to potential discomfort.

13. CHILLER DEMAND LIMITING PROGRAM. One specific application of demand limiting is chiller capacity control. Centrifugal chillers are normally factory equipped with an adjustable control system which limits the maximum available cooling capacity; thus, the power the machine can use. An interface between the UMCS and the chiller controls allows UMCS to reduce the maximum available cooling capacity in a demand limiting situation, thereby reducing the electric demand without completely shutting down the chiller. The method of accomplishing this function varies with the manufacturer of the chiller. The chiller percent capacity is obtained by monitoring the chiller current input. When a chiller is selected for demand limiting, a signal is transmitted, reducing the chiller capacity. The chiller demand limit adjustment is performed by shunting out taps of a transformer in the control circuit or by resetting the control air pressure to the chiller compressor vane operator or by potentiometer adjustment at the chiller control panel. As further need arises, signals are transmitted until the demand limiting situation is corrected. Extreme caution will be exercised when applying this program to chiller demand, since incorrect control can cause the refrigeration machine to operate in a surge condition, potentially causing it

considerable damage. The chiller manufacturer's recommended minimum cooling capacity and temperature limits will be incorporated into the sequence of operation shown. In general, surges occur in chillers at loads below 20% of the rated capacity. Design requirements for this applications program will be indicated by the letter X adjacent to the demand limiting step listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS inputs from utility system. Chiller current - 1 per chiller.

(2) UMCS outputs to utility system.

(a) Step control signal - one per step per chiller.

(b) Or, analog control signal - one per chiller depending on chiller control interface.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Chiller percent capacity.

(b) Minimum cooling capacity.

(c) Equipment priority schedules.

(d) Equipment constraints.

(2) Program output.

(a) Calculated percent load point

c. Application notes. This program is used in conjunction with the demand limiting program.

14. DAY/NIGHT SETBACK PROGRAM. The energy required for heating or cooling during unoccupied hours is reduced by lowering the heating space temperature setpoint or raising the cooling space temperature setpoint. This applies only to facilities that do not operate 24 hours a day. Space temperature can be reduced from the normal winter inside design temperature to a lower space temperature during the unoccupied hours. In spaces that require air conditioning during unoccupied hours, the normal temperature setting is reset upwards to a temperature that is compatible with space requirements. Design requirements for this applications program will be indicated by listing of default occupied and unoccupied cooling and heating space temperature setpoints on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are :

(1) UMCS inputs from utility system.

(a) Equipment status (differential pressure switch, auxiliary contact, flow switch) - one for each HVAC systems.

(b) Space dry bulb temperature (minimum of one per zone)

(2) UMCS outputs to utility system.

(a) Day/night control signal to interposing relays (momentary or maintained signal as required by the equipment control circuit and failure mode) - one for each HVAC system.

(b) Control signal to close OA damper (as required by equipment control circuit) one per OA damper.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Day of week/holiday.

(b) Time of day.

(c) Summer or winter operation.

(d) Summer and winter occupancy schedules.

(e) Equipment status.

(f) Space temperature

(g) Maximum space temperature during unoccupied periods (cooling).

(h) Minimum space temperature during unoccupied periods (heating).

(i) Equipment constraints.

(2) Program output.

(a) Day/night control signal.

c. Application notes. The day/night setback program operates in conjunction with the scheduled start/stop and optimum start/stop programs. Space temperature instruments will be located to preclude freezing during the night setback period.

15. HOT WATER OA RESET. Hot water heating systems, whether the hot water is supplied by a boiler or a converter, are designed to supply hot water at a fixed temperature. Depending on the system design, the hot water supply temperature may be reduced as the heating requirements for the facility decrease. A reduction in hot water supply temperature results in reduction of heat loss from equipment and piping. To implement this program, the temperature control setpoint for the hot water supply is reset as a function of OA temperature. Design requirements for this applications program will be indicated by inclusion of an OA temperature reset schedule on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) System inputs from DE.

(a) Hot water supply temperature - one per boiler or converter.

(b) OA dry bulb temperature.

(2) UMCS outputs to utility system. Hot water supply temperature CPA - one per boiler or converter.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Reset schedule.

(b) OA dry bulb temperature.

(c) Maximum HW supply temperature.

(d) Equipment constraints.

(2) Program output. HW temperature setpoint.

c. Application notes. A dedicated local loop controller may be implemented, depending on site specific requirements.

16. LIGHTING CONTROL. Time scheduled operation of lighting consists of turning lights off based on the time of day and the day of the week. Additional off commands may be generated at regular intervals to ensure that lights are off (relay operated zoned lighting only). Emergency lighting is not to be controlled by this program. Design requirements for this applications program will be indicated by the letter X adjacent to the scheduled start/stop program listing on the appropriate database table, as shown in Chapters 8 and 9.

a. Field hardware requirements. The hardware requirements are:

(1) UMCS outputs to utility system. Start/stop control signal to interposing relays - typically one for each lighting circuit to be controlled.

b. Software I/O requirements. The software requirements are:

(1) Program inputs.

(a) Day of week/holiday.

(b) Time of day.

(c) Summer and winter start/stop schedules.

(d) Equipment status.

(e) Times of day for additional off commands (where applicable).

c. Application notes. The lighting control program is used in conjunction with the scheduled start/stop program.

17. UNITARY CONTROLLER APPLICATIONS PROGRAMS. A number of application-specific unitary controllers are available with applications programs for specific types of equipment. Examples are heating and ventilating units, air volume control, and air distribution terminal unit control programs. Design requirements for these applications programs will be indicated in the sequence of operations as shown in Chapter 8.

18. UTILITY CONTROL FUNCTIONS AND SEQUENCES OF OPERATION.

a. In addition to the pre-established applications programs listed in this chapter, the UMCS utilizes several basic control functions in combination for control of utility systems. These control functions include event-driven control, two position control, floating point control, and proportional-plus-integral-plus derivative (PID) control. Structured combinations of these basic control functions applied to specific utility systems are referred to as sequence of operation.

b. Event-driven control is a function allowing the UMCS to activate a control output in response to a specific event or state of the monitored utility system. For example, UMCS control of a swimming pool filtration system may provide for backwashing of the filter when the filter DP exceeds a specified limit. Implementation of event-driven control requires that the UMCS monitor the parameters related to the event (in the example, filter DP).

c. Two position control is a function allowing the UMCS to activate a two-state device to control utility system parameters within specified limits. For example, UMCS control of a steam-to-hot water heat exchanger may provide for opening the steam valve when the hot water temperature falls 2 degrees F below the setpoint and closing the valve again when the hot water temperature reaches 2 degrees F above the setpoint.

d. Floating point control is a function allowing the UMCS to change the position of a final control element (such as a valve) by increments in response to deviation of a utility system parameter from its setpoint. As long as the value of the utility system parameter is within a specified deadband around the setpoint, the final control element maintains its current position. Floating point control is normally used when changes in utility system load are gradual.

e. PID control (or proportional-plus-integral or proportional-only control) is a function of feedback controllers allowing the UMCS to continuously modulate a final control element in response to deviations of a utility system parameter from its setpoint. PID control is normally provided for utility system parameters requiring close control or experiencing rapid load swings. Proportional (gain), integral (reset), and derivative (rate) values must be selected for specific control applications and are not all applicable for every control loop.

f. Sequences of operation are combinations of applications programs and these other basic control functions to describe all operational requirements for specific utility systems. Sequences of operation will address different operational modes such as system startup, normal occupied operation, unoccupied operation, heating and cooling modes and failure modes. Typical sequences of operation for utility systems commonly found on Government installations are provided in Chapters 8.