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ENERGY MONITORING AND CONTROL SYSTEM (EMCS). ECONOMIC ANALYSIS --ETC(U)
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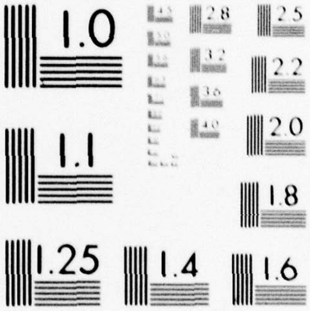
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CIVIL ENGINEERING LABORATORY

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NAVAL CONSTRUCTION BATTALION CENTER
Port Hueneme, California 93043

TITLE: ⑥ **ENERGY MONITORING AND CONTROL SYSTEM (EMCS),**

ECONOMIC ANALYSIS GUIDELINE
FOR
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)
AND
ENERGY TECHNOLOGY APPLICATIONS PROGRAM (ETAP).

⑫ 136 p.

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CHANGES TO CIVIL ENGINEERING LABORATORY PUBLICATION NO. 78 MR 423

Page 38.

Replace Paragraph 2 with:

"The cost of an EMCS project is determined by the system/functions that individually meet the criteria of the funding program. This minimizes the potential of future project incrementation. A prioritization based on the annual energy savings to investment ratio for each of these system/functions should be performed. This prioritization can be useful in some cases where cost overruns are later experienced and decisions are required on accomplishing the most beneficial scope of the project."

Paragraph 3

Change introductory sentence to:

"The basic steps for the prioritization of an EMCS project are:"

Change items 4 & 5 to:

"4. Calculate the savings to investment ratio and the annual energy savings to investment ratio (E/C) for each alternative."

"5. For those alternatives that meet criteria, rank in descending order the alternatives by the annual energy savings to investment ratio (E/C)."

Delete items 6 & 7

Page 95.

The cutoff line shown is in error. The project cost is determined by the amount of justifiable scope. If Building 200 meets criteria, it would be included in the project.

CONTENTS

APPENDIX

1.0 SUMMARY

This document is prepared in accordance with Contract N68305-8156-0007 from the Civil Engineering Laboratory NCBC, Port Hueneme, California 93043, under the supervision of Mr. Dale H. Johnson, Code L26, AV360-5795/4661, FTS 799-5795/4661, AC(805) 982-5795/4661.

This document establishes methods for performing economic analysis of Energy Monitoring and Control Systems (EMCS) for Energy Conservation Investment Program (ECIP) and Energy Technology Applications Program (ETAP) funding.

Analysis for ETAP funded projects are similar to that of ECIP with the following exceptions:

1. In the economic analysis summary when determining energy savings vs. investment (MBTU/$K) (line 9) and simple payback, (line 10), design costs not yet obligated (1b) must be added to line (1a) for ETAP funded projects.

2. ETAP funding is for energy conservation projects of $5K-$100K range. Projects will be prioritized by energy saved/investment ratio.

3. ECIP funding is for energy conservation projects of greater than $100K range.

Various common EMCS functions along with typical energy consuming systems to which they are applied are described. Procedures for estimating potential energy and cost savings from the application of each EMCS function are included. Data for use in preparing EMCS cost estimates has been obtained through a survey of EMCS manufacturers and is tabulated. Methods for determining the best alternative uses of an EMCS when funding levels are fixed are presented. Forms and requirements specifically related to the completion of an "ECIP Economic Analysis Summary" are included.

General description and derivation of the methods established are included in Sections 2.0 through 8.0 and in the APPENDIX of this report. Section 9.0 provides a step-by-step example of the use of these procedures.

ABSTRACT

2.0 EMCS OVERVIEW

The purpose of this report is to provide guidelines for economic analysis of Energy Monitoring and Control Systems (EMCS) as they apply to basewide Navy installations. A method is presented for completion of an Energy Conservation Investment Program (ECIP) Economic Analysis Summary. This summary may also be used for Energy Technology Applications Program (ETAP) projects. ABSTRACT

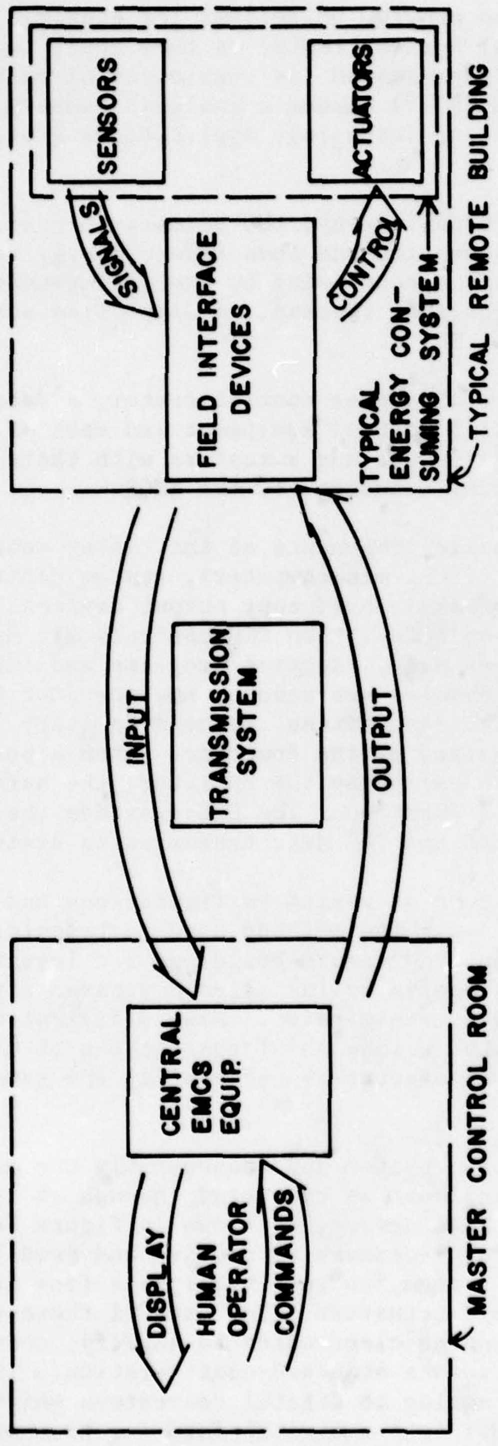
Based on the current Navy design philosophy, the primary purpose of an EMCS is to effect reduced energy consumption and thus reduce energy related operating expenses. This goal is accomplished by exercising control over energy consuming mechanical/electrical systems. A simplified schematic of an EMCS is illustrated in Figure No. 1.

Generally an EMCS will consist of a master control center, a data transmission system between the central control equipment and each of the buildings connected to the EMCS, and sensors and actuators with their related equipment located in each building connected to the EMCS.

As shown in Figure No. 2, the basic components of the master control center includes a Central Control Unit (CCU, minicomputer), system control consoles (CRT's), mass storage devices (disks), hard copy output devices, and a Central Communications Controller (CCC). The CCU controls all master control center devices, processes data, executes programs and interprets commands. The system control consoles are used by the operator to communicate with the EMCS. The mass storage devices are used to store information that is not currently being utilized by the computer. When a permanent copy of an alarm or a report is desired by the operator, the hard copy output devices are used for this function. The CCC provides the interface between the master control center and the data transmission system.

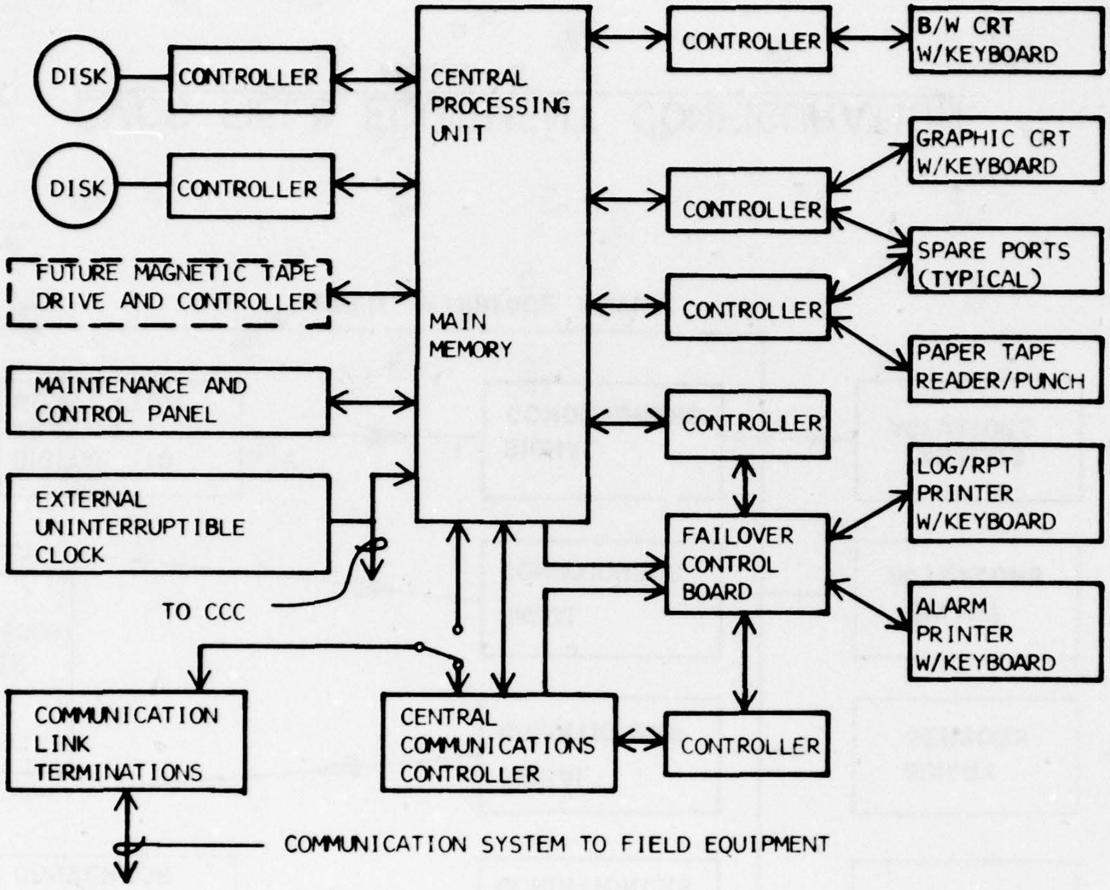
The data transmission system may be of varied configurations and consist of several different components. Among the methods used to transfer data between the master control center and remote buildings are leased or government furnished telephone lines, specially installed dedicated signal lines, radio transmission, and microwave transmission. Many different methods and design philosophies are associated with each of these types of data transfer. At this time, none of the EMCS manufacturers use exactly the same transmission methods and protocols.

To interface with the transmission system and subsequently the master control center, a remote building must be connected through at least one field interface device (FID). This device, as shown in Figure No. 3, includes the electronic equipment necessary to receive and send information over the specific transmission system, to receive signals from field sensors, and to transmit signals to field actuators. For each of these functions, the FID contains signal conditioning electronics to amplify, convert, or otherwise modify field signals into a standard configuration. The field interface device also contains analog to digital convertors which convert analog signals from field sensors into a digital form for transmission to the central control center. Digital to analog converters convert digital signals from the control center to analog signals for control of actuators. Typically, sensors connected to the field interface device measure temper-



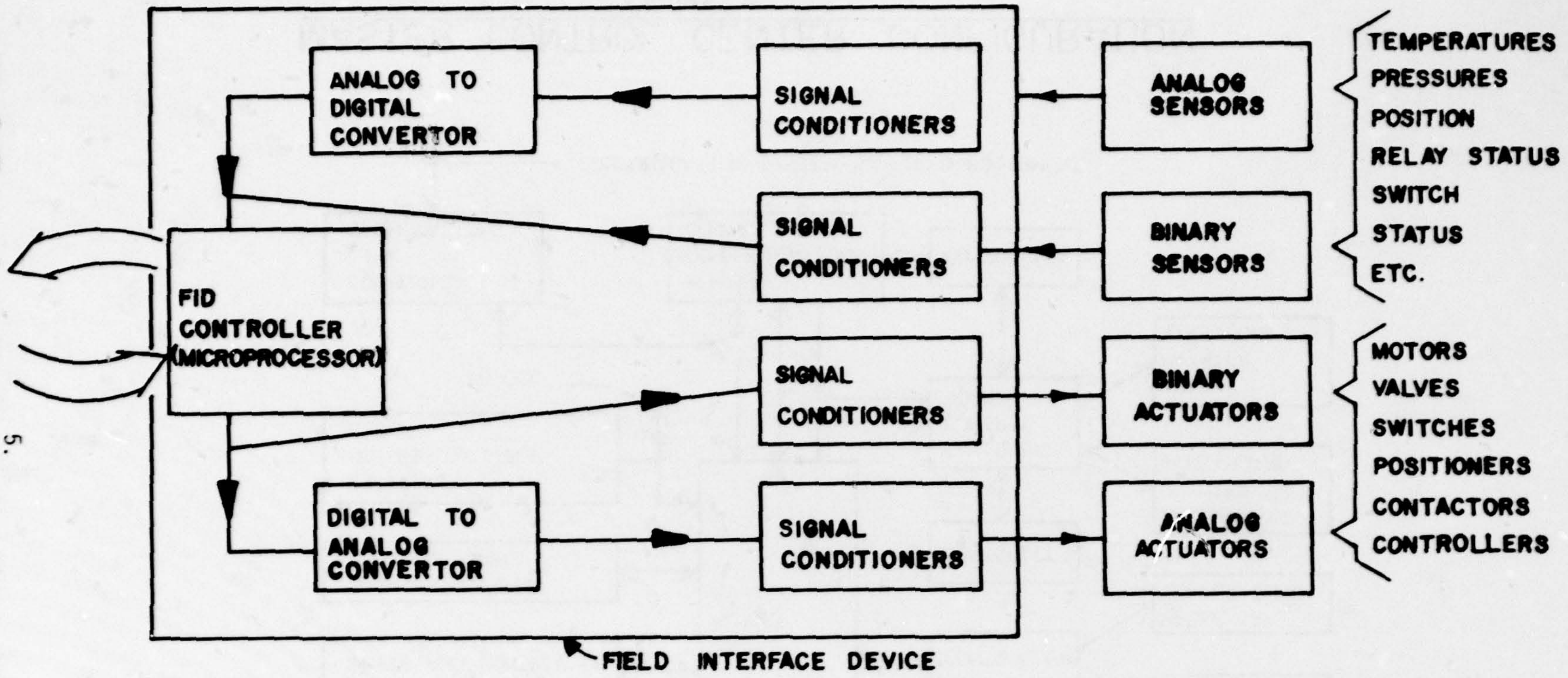
EMCS BLOCK DIAGRAM

FIGURE I



MASTER CONTROL CENTER CONFIGURATION

FIGURE 2



EMCS FIELD EQUIPMENT CONFIGURATION

FIGURE 3

atures, pressures, position of various mechanical devices, relay status, switch status, etc. The actuators discussed consist of a variety of devices including motors, valves, switches, positioners, relays, controllers, etc.

Recent industry trends are toward the use of "smart" field interface devices. In these systems the field interface device contains a microcomputer system capable of handling and storing data from sensors, and transmitting data to the central control center by exception. These FIDs are designed so they can continue operation even when communication with the central control center is interrupted. They are smart enough to do time clock type functions and some system optimization.

This discussion constitutes a simplified and generalized definition of an energy monitoring and control system. There are as many different devices and configurations for each of the components defined as there are EMCS manufacturers.

3.0 ANALYSIS CONCEPTS

The basic steps required in performing an EMCS analysis are:

1. Field Investigation

2. Savings Analysis

3. Cost Analysis

4. Prioritization Analysis

5. Overall Economic Analysis

Field investigation determines what energy consuming systems are present which an EMCS may control, and what EMCS functions may be performed on those systems.

The savings analysis determines the potential energy and cost savings from EMCS installation.

The cost analysis estimates investment required to install the EMCS.

The prioritization analysis determines which alternatives should be included in the project in order to provide the maximum savings for a given investment.

Once the alternatives to be included in the project are determined, an overall economic analysis of the EMCS may be performed.

4.0 FIELD INVESTIGATION

The primary purpose of the field investigation phase of the analysis is to determine what energy consuming systems are present which may be controlled by the proposed EMCS. What EMCS functions may be performed on each of the systems must also be determined. A brief description of common EMCS functions is included in the APPENDIX. Also included in the APPENDIX are schematics of typical energy consuming systems which may be controlled by an EMCS.

In order to perform an EMCS analysis, pertinent information on the site for which the EMCS is proposed must be gathered. The following information is generally required:

1. Base map showing facility numbers and general layout of the Base.
2. Utility maps showing Base electrical distribution, water, sewer, and communications systems.
3. Facility listings indicating:
    a. Facility ID Number
    b. Facility Name/Description
    c. Facility floor area, square feet
4. Utility cost data including rate structures or current prices, and copies of billings over the last year. Estimated local escalation rates should be provided if available.
5. Information from the Base Communications/Telephone Office on the quality, availability, and cost of utilizing Base telephone lines for data transmission.
6. Shop drawings, specifications, or other information on any existing EMCS or similar central control systems.
7. Information on any past, current, or future energy conservation projects such as control upgrades, insulaton projects, etc.
8. Plans for future additions to buildings or new building which might be connected to or affect the EMCS. Also, plans for demolition of existing buildings.
9. Listings of critical facilities which should be connected to the EMCS for monitoring purposes (computer rooms, flight simulators, etc.).
10. "As-built" mechanical, electrical and control drawings of each building being considered for connection to the EMCS.
11. Schedules of occupancy and usage for people, lights, and equipment for each building.

12. Any available small scale plans of buildings under consideration for EMCS connection.

The "as-built" mechanical drawings are a necessity for the efficient use of field survey time. Without them, much time may be wasted in trying to track down every mechanical room in a building, particularly if the building is large and has been extensively remodeled. Because of the large number of systems and drawings on a military base, obtaining the required prints can be a problem. In general, if base personnel are simply asked to provide copies of all mechanical and electrical drawings for the buildings on the list, difficulties occur. Fulfilling such a request will require 500 to 2000 prints. Base Engineering records departments are not usually equipped to handle such a load in the time frame needed. Also, many of the drawings which would be provided by such a request are not needed for the EMCS design analysis. The best solution to this problem is for the EMCS design engineer to review the tracing files for the buildings in question. Only those tracings which are absolutely necessary for use in the EMCS field investigation should be selected for printing. Whatever approach is to be utilized, it must be clearly defined before the project is initiated and dates established by which drawings must be provided.

To perform detailed analysis of a proposed EMCS, schedules of occupancy and usage for people and equipment in the buildings being considered must be obtained. On some bases this information has been gathered for use in other projects and may be available through the Base Engineering Office. If not, it must be obtained. Several approaches may be used, including a telephone survey of custodians of each building, written memos to the users of each building, discussion with base maintenance personnel, or visits to each building to discuss schedules with the occupants.

On some bases, small scale plans of buildings may be available. These have usually been prepared for use in planning, office allocations, fire escape routes, or other purposes. These drawings are generally on 8-1/2" x 11" sheets at whatever scale is necessary to depict floor plans of the building. These drawings are extremely useful in the building by building survey for the identification and location of systems. If these are not available, full scale drawings are not as convenient for the field investigation but they can be used.

Once drawings are obtained, they are used to plan the survey work to be done during each site visit. Much time can be wasted without a definite plan of items to be accomplished during each day of the field investigation and adequate preparations to meet planned requirements.

The purpose of the field investigation is to determine which systems are to be considered for EMCS connection and to gather enough information on each system to allow analysis of that system. Once the design analysis is completed and the systems to be connected to the EMCS are identified, a detailed field inspection of each of those systems must be performed in the final design stage. This detailed survey must closely examine each system for sensor location, existing controls condition, EMCS interface to local controls, damper actions, etc. However, the field investigation required to perform the basic design analysis described in this report does not require this detailed hardware inspection. The field work for the design analysis stage of the project is primarily concerned with identifying the type of system in question, its current operating hours, its required operating hours, the horsepowers of motors in the system, and other data required for the analysis of savings which would result from EMCS control of that system.

The most efficient approach to the field investigation itself has been found to be the gathering of as much data as possible from drawings of each building and using the site survey to verify the data obtained from the drawings. One important aspect of this approach is the development of standard survey data sheets. These sheets provide a basis for the data gathering and should include blanks for all data pertinent to the analysis. Each engineer has a different approach to the survey data recording problem and whether one uses a separate form for each system type, a single standard form, a tabular approach, or some other method is not important as long as the data are recorded and easily referred to. An example of one type of field survey data sheet is included as Figures 4 and 5.

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: ______________ Usage: ______________

Gross Area Sq. Ft.: ______________ No. Floors: __________

Age of Building: __________ Type Construction: __________

Approx. Floor to Floor Height: ______________________

% Glass in Exterior Wall: ______________________

Glass Shading: External __________ Internal __________

"U" Factor: Roof ________ Wall ________ Glass ________

Critical Areas: ______________________________

____

Notes: ______________________________

____

FIGURE 4

PRIMARY SYSTEMS

Sys #____________

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:____________

Capacity:____________BTU/HR.
Pump HP:____________
Pump HP:____________
Comp HP:____________
Fan HP:____________
Other HP:____________

Operation (Annual)
Year Round
Summer Only
Winter Only
Other____________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other____________

Existing Controls:
Time Clock
O.A. Reset
Other:____________
____
____

Notes:
____
____
____
____
____

Sys #____________

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:____________

Capacity:____________BTU/HR.
Pump HP:____________
Pump HP:____________
Comp HP:____________
Fan HP:____________
Other HP:____________

Operation (Annual)
Year Round
Summer Only
Winter Only
Other____________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other____________

Existing Controls:
Time Clock
O.A. Reset
Other:____________
____
____

Notes:
____
____
____
____
____

Sys #____________

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:____________

Capacity:____________BTU/HR.
Pump HP:____________
Pump HP:____________
Comp HP:____________
Fan HP:____________
Other HP:____________

Operation (Annual)
Year Round
Summer Only
Winter Only
Other____________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other____________

Existing Controls:
Time Clock
O.A. Reset
Other:____________
____
____

Notes:
____
____
____
____
____

SECONDARY SYSTEMS

Sys #____________

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other____________

CFM:____________
No. Zones:____________
Fan HP:____________
Capacity:____________BTU/HR
Pump HP____________
%OA:____________
Comp. HP:____________
Cond Fan HP:____________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other____________

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:____________
____
____
____

Notes:____________
____
____
____
____

Sys #____________

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other____________

CFM:____________
No. Zones:____________
Fan HP:____________
Capacity:____________BTU/HR
Pump HP____________
%OA:____________
Comp. HP:____________
Cond Fan HP:____________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other____________

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:____________
____
____
____

Notes:____________
____
____
____
____

Sys #____________

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU
Unit Htr. (HW) (ST
Fan Coil (2) (4)
Convector (HW) (ST
Other____________

CFM:____________
No. Zones:____________
Fan HP:____________
Capacity:____________BTU/HR
Pump HP____________
%OA:____________
Comp. HP:____________
Cond Fan HP:____________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other____________

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:____________
____
____
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Notes:____________
____
____
____
____

FIGURE 5

5.0 SAVINGS ANALYSIS

Savings resulting from installation of an EMCS may be simply stated as:

$$S = RC_1 - RC_2$$

where:

S = net savings

RC_1 = resources (energy, demand, or manpower) consumed prior to EMCS installation

RC_2 = resources (energy, demand, or manpower) consumed after EMCS installation.

Historical data currently does not exist in sufficient detail to allow direct estimation of either RC_1 or RC_2. RC_1 is generally available only on a basewide basis. Sufficient data from existing EMCS installations has not been collected to allow estimation of RC_2 on that basis. Since historical data is not available, engineering estimates based on theoretical equations, accepted engineering practice, and related experience must be used.

The logical basis of EMCS savings calculation is on a function-by-function basis.

Where resource consumption is simply a function of equipment running time or size, straightforward equations may be derived. The equations are suitable for manual calculations. Where resource consumption is a function of more complex variables (such as weather conditions, building occupancy, system type, etc.) more involved analysis is required. This analysis may require extensive manual or computerized calculations to reasonably simulate the conditions. The engineer must use experience and judgement in selecting methods appropriate for each situation.

Because savings resulting from performing several functions on the same energy consuming system are interrelated, false duplication of savings in the analysis must be avoided. This is done by performing calculations in a hierarchical fashion. Generally, functions performed on a system must be analyzed one after the other, with each analysis based on the existance of the previous functions. Examples of such an approach would be found in the estimation of savings resulting from EMCS control of an air handling unit. If, prior to installation of the EMCS, the air handler runs 24 hours per day, even though it is required to operate only 12 hours per day, an obvious EMCS function to perform is TIME SCHEDULED OPERATION. Another potential EMCS function might be ENTHALPY ECONOMIZER. The economizer operation energy savings are dependent on the number of hours per day the air handler operates. Economizer savings calculations must be based on a 12 hour per day operation since that is the schedule on which the system will operate following EMCS installation. In general, those functions which provide the maximum savings should be analyzed first with other function's savings calculated based on the existance of those maximum savings functions.

thods of calculating savings resulting from each typical function have en examined and a summary of the resultant equations are as follows (see PENDIX C for description of the equations and a discussion of simulation quirements where such is indicated):

mbols - The following symbols are used in the savings calculation equations:

= control efficiency factor

) = fraction of an hour which system may be cycled off during critical electrical demand situations.

FLH = equivalent full load hours, annually

H = number of hours of required operation per year

HS = number of hours in summer where system may be shut off because the outside temperature is below a limit.

HW = number of hours in winter where system may be shut off because the outside temperature is above a limit.

I = maximum heat transfer capacity of device in THERMS.

KW/HP = conversion at 0.746 KW/HP

L = load factor

M = number of months during which load operates only applicable when demand is calculated monthly (no ratchet clause) and demand unit cost is in monthly, not annual, units.

O = fraction of an hour which system may be cycled off for consumption reduction.

OD = number of days of required operation per year.

PECD = percent energy consumption decrease, annually (expressed in decimal, i.e. 1% = .01)

PEI = percent efficiency increase per °F increase/decrease in CHW/CDW temperature (expressed in decimal, i.e., 1% = .01)

SKW = Annual kilowatt demand savings

SKWH = Annual kilowatt hour savings

STHERMS = Annual therms heating savings

Methods of calculating savings resulting from each typical function have been examined and a summary of the resultant equations are as follows (see APPENDIX C for description of the equations and a discussion of simulation requirements where such is indicated):

Symbols - The following symbols are used in the savings calculation equations:

C = control efficiency factor

D = fraction of an hour which system may be cycled off during critical electrical demand situations.

EFLH = equivalent full load hours, annually

H = number of hours of required operation per year

HS = number of hours in summer where system may be shut off because the outside temperature is below a limit.

HW = number of hours in winter where system may be shut off because the outside temperature is above a limit.

I = maximum heat transfer capacity of device in THERMS.

KW/HP = conversion at 0.746 KW/HP

L = load factor

M = number of months during which load operates only applicable when demand is calculated monthly (no ratchet clause) and demand unit cost is in monthly, not annual, units.

O = fraction of an hour which system may be cycled off for consumption reduction.

OD = number of days of required operation per year.

PECD = percent energy consumption decrease, annually (expressed in decimal, i.e. 1% = .01)

PEI = percent efficiency increase per °F increase/decrease in CHW/CDW temperature (expressed in decimal, i.e., 1% = .01)

SKW = Annual kilowatt demand savings

SKWH = Annual kilowatt hour savings

STHERMS = Annual therms heating savings

Time Scheduled Operation

° Cooling Savings - Simulation

° Heating Savings - Simulation

° Auxiliary Savings (fans, pumps, constant running apparatus) -

SKWH = HP x L x KW/HP x (8760-H) x C

HP = total nameplate HP of constant loads.

Duty Cycling

° Heating and Cooling Savings - Assume None

° Auxiliary Savings (fans, pumps, constant running motors) -

SKWH = HP x L x O x H x KW/HP

HP = total nameplate HP of constant loads.

Demand Limiting

° SKW = HP x L x KW/HP x D x M

HP = total electrical load of system (fans, pumps, compressors, etc.)

Start/Stop Optimization

° Cooling Savings - Assume None

° Heating Savings - Assume None

° Auxiliary Savings -

SKWH = HP x L x KW/HP x T x OD

Outside Air Limit Shutoff

° Auxiliary Savings (fans, pumps, etc.) -

SKWH = HP x L x KW/HP x (HS + HW)

HP = nameplate HP of constant loads.

Maintenance Run Time

° Savings - estimate manhours based on current maintenance practices (i.e. roving patrols, preventive maintenance schedules, etc.)

Enthalpy Economizer

- Cooling Savings - Simulation
- Heating Savings - None

Hot/Cold Deck Reset

- Cooling Savings - Simulation
- Heating Savings - Simulation

Chilled Water Reset

- Cooling Savings -

SKWH = Tons x EFLH x 1 KWH/ton-hr. x PEI x (°F CHW Increase)

Condenser Water Reset

- Cooling Savings -

SKWH = Tons x EFLH x 1 KWH/ton-hr. x PEI x (°F CW Decrease)

Outside Air Schedule Reset

- Heating Savings -

STHERMS = EFLH x PECD x I

Safety Alarms

- Savings - Estimate Manhours

Intercoms

- Savings - Estimate Manhours

6.0 COST ANALYSIS

The accurate analysis of an EMCS requires accurate and reliable cost estimating data. This is extremely important because potential savings alone do not determine whether a particular function should be connected to the EMCS. The cost of that function is equally important in determining whether or not it should be connected. Cost estimating is of additional importance because cost for a particular EMCS function is relatively constant, irrespective of the size of the system being controlled. It essentially costs the same to start and stop a ten horsepower fan as it does to start and stop a one horsepower fan. However, the difference in potential energy savings is tenfold.

Several items complicate the cost estimating analysis. The first and probably most important complication is the fact that no two manufacturers' EMC systems are identical. Every manufacturer takes a different approach to performing each EMCS function. For example, because of a particular configuration, one manufacturer may be able to provide a status feedback for a piece of equipment being started and stopped by the EMCS for a very small cost, whereas a different manufacturer with a different configuration might actually double the cost of simply providing start-stop capability, if status feedback is required. Another difficulty arises from the reliability of budget estimates received from manufacturers' sales representatives. For obvious reasons, these representatives generally are very guarded about revealing detailed or exact cost information. They generally prefer only to give rough budget estimates based on the total number of points in a system. This type of information is not adequate for the detailed analysis of an EMCS. Each component cost of the EMC system must be broken down separately to perform comparative analysis. Obtaining this type of information has been difficult. However, several manufacturers were willing to provide the information which has been used in this study.

In order to determine an optimum EMCS configuration, each cost component of the system must be analyzed. The five main cost components of an EMCS are 1) general cost, 2) central control center cost, 3) transmission system cost, 4) facility connection cost, 5) sensor/actuator cost.

General cost consists of the following components:

a. Estimation
b. System engineering
c. Shop drawing preparation
d. System testing and debugging
e. Training
f. Maintenance contract

All of these costs involve a considerable amount of overhead time, thus making them only slightly dependent on the number of facilities and sensor/actuators connected to the EMCS.

Operations and Maintenance cost for the EMCS deserves special note. In addition to the maintenance contract cost, government operators must also be employed to properly utilize the system. Traditionally a total annual operations and maintenance cost of 10% of the original system cost is included in economic analysis of EMCS. If more exact figures are available (such as staffing requirements studies) then those should be used in lieu of the 10% figure.

The central control center consists of the following main components:

a. Central processing unit hardware
b. Peripheral hardware and associated software drivers
c. Operating system software
d. EMCS command software
e. EMCS applications software
f. Communications hardware
g. Communications software

The cost of these components is relatively constant, irregardless of the number of facilities or sensor/actuators that are connected to the system.

a. Overhead transmission cable
b. Underground transmission cable
c. Telephone modems (Modulator-demodulator)

This cost is basically a function of the number and location of facilities connected to the EMCS.

Facility connection costs are those fixed costs associated with connecting a facility to the EMCS which are independent of the number of sensors/-actuators that are installed within that facility. Facility connection cost is the fixed cost which would be incurred to connect a facility to the EMCS even though that facility only required a single EMCS sensor. The components of facility connection costs are:

a. A field interface device, along with its power supply and installation

b. The transmission line to the building in question, if a dedicated contractor installed transmission system is being utilized

c. Telephone lines and modems from the building in question back to central console location if a telephone transmission system is used

The facility connection costs listed above are dependent on the number of facilities connected to the EMCS and not on the number of sensor/actuators.

The sensor/actuator cost is the cost to add a sensor/actuator to the EMCS, assuming a field interface device to which this point will be connected is already available in the building. Cost components associated with each sensor/actuator are:

a. A signal conditioning device usually in the form of an integrated circuit card which plugs into an appropriate slot in the field interface device

b. Wiring from the field interface device to the sensor/actuator

c. The sensor/actuator itself

d. The installation and interface of the sensor/actuator with the existing local control system

e. Local controls which must be replaced, repaired, or added

f. Miscellaneous new equipment (dampers, ductwork, thermometer wells, Venturi tubes, insulation, auxiliary starter contacts, etc.)

g. Definition and entry of each sensor/controller into the central control center

The total sensor/actuator cost is a function of the number of points connected to the EMCS and generally not related to the number of different facilities in which those points occur.

Several manufacturers were contacted and presented with a list of questions designed to obtain specific cost estimates for the components listed above. The data supplied as a result of this request is listed in Table 1 thru Table 5. Spaces left blank indicate that information was not supplied for that item by that manufacturer. Some manufacturers requested that their prices not be openly presented for protection from their competition; therefore, none of the manufacturers names have been listed. It should be pointed out that both conventional controls manufacturers and the smaller "systems house" manufacturers are included in those listed. The figures included here were obtained during November, 1978.

TABLE 1
CENTRAL SYSTEM EQUIPMENT
MANUFACTURERS DATA

		A	B	C	D	E	F	G	VALUE USED IN STUDY
1.	CENTRAL CONTROL UNIT (CCU)	* (1) 8,650 * (2) 10,650	(42) 94,000	* (3) 13,200 * (4) 19,400	(5) 21,800	* (6) 8,650 * (7) 10,650	(8) 19,000 (9) 24,500 (10) 36,000	*(13) 16,000	$25,000
2.	CENTRAL COMMUNICATION CONTROLLER (CCC)	*(24) 32,000			(11) 23,000		(12) 17,000	(14) 28,000	$25,000
3.	AUXILIARY POWER SUPPLY			(16) 7,000					
4.	EXTERNAL UNINTERRUPTABLE CLOCK			(53) 1,625					$ 1,625
5.	DISK STORAGE SYSTEM	*(15) 22,500	*(43) 3,940	*(17) 26,700	*(20) 10,200	*(20) 22,500	(18) 22,500	*(21) 10,200	$20,000
6.	PRINTER	*(23) 2,850	(44) 4,700	(26) 1,700	(25) 9,330	(27) 2,850		*(22) 3,000	$ 4,000
7.	CRT COLOR	*(32) 2,685	(45) 15,900	(33) 2,585	(34) 7,500	*(38) 2,685	*(36) 2,360	*(37) 2,780	$ 8,000
8.	CRT B&W	*(28) 2,650	(46) 4,300	(30) 2,000	(38) 3,200	*(29) 2,650	*(31) 1,935	(54) 4,300	$ 3,000
9.	PAPER TAPE READER/ PUNCH	*(39) 2,160	(47) 8,500	*(51) 8,300			*(40) 4,600		$ 5,000
10.	FAILOVER CONTROL BOARD		(49) 1,800						$ 1,800
11.	INTERCOM		(30) MASTER 2,700 REMOTE 160						
12.	MAGNETIC TAPE UNIT		*(48) 13,280	*(52) 9,500			*(41) 13,500		$13,000

* INDICATES PRICES OBTAINED FROM OEM VENDORS. THE PRESENT TREND INDICATES THE EMCS CONTRACTORS USE A 100% MARK UP ON THE OEM ITEMS.

TABLE 1 FOOTNOTES
CENTRAL SYSTEM EQUIPMENT

(1) BASED ON INFORMATION SUPPLIED BY MODULAR COMPUTER SYSTEMS FOR MODCOMP 7810 COMPUTER WITH 64KB MEMORY AND CABINET.

(2) BASED ON INFORMATION SUPPLIED BY MODULAR COMPUTER SYSTEMS FOR MODCOMP 7810 COMPUTER WITH 128KB MEMORY AND CABINET.

(3) BASED ON INFORMATION SUPPLIED BY HEWLETT PACKARD ON 21MX-E PROCESSOR WITH TIME BASE GENERATOR, CHANNEL CONTROLLER, MEMORY PROTECT, POWER FAIL OPTION, 64KB MEMORY AND A CABINET.

(4) SAME AS FOOTNOTE 3 BUT WITH 218KB MEMORY.

(5) BASED ON EMCS VENDOR'S ESTIMATE USING DIGITAL'S PDP 11/34 CPU WITH 64KB MEMORY IN 10-1/2" CABINET.

(6) BASED ON INFORMATION SUPPLIED BY MODULAR COMPUTER SYSTEM FOR MODCOMP 7810 COMPUTER WITH 64KB MEMORY AND CABINET.

(7) BASED ON INFORMATION SUPPLIED BY MODULAR COMPUTER SYSTEM FOR MODCOMP 7810 COMPUTER WITH 128KB MEMORY AND CABINET.

(8) BASED ON INFORMATION SUPPLIED BY THE EMCS VENDOR USING A INTERDATA 816E COMPUTER WITH 64KB CORE MEMORY AND FLOATING POINT PROCESSOR.

(9) BASED ON INFORMATION SUPPLIED BY THE EMCS VENDOR USING A INTERDATA 816E COMPUTER WITH 128KB CORE MEMORY AND FLOATING POINT PROCESSOR.

(10) BASED ON INFORMATION SUPPLIED BY THE EMCS VENDOR USING A INTERDATA 816E COMPUTER WITH 256 CORE MEMORY AND FLOATING POINT PROCESSOR.

(11) BASED ON INFORMATION SUPPLIED BY THE EMCS VENDOR THE CCC WOULD BE IMPLEMENTED USING A PDP 11/34 COMPUTER WITH 64KB MEMORY. THIS APPROACH WOULD SUGGEST THE USE OF THE DMC-11 FOR COMMUNICATION BETWEEN THE CCU AND CCC AND A DZ-11 TO SERVE AS THE CLT.

(12) BASED ON INFORMATION SUPPLIED BY EMCS VENDOR, THE CCC WOULD BE IMPLEMENTED USING THE MULTIPLE MICRO PROCESSORS APPROACH.

(13) BASED ON INFORMATION SUPPLIED BY BIGITAL FOR THE PDP11/34 CPU WITH 64K MEMORY IN A 10-1/2" CABINET.

(14) BASED ON INFORMATION SUPPLIED BY THE EMCS VENDOR THE CCC WILL BE IMPLEMENTED USING A PACKAGED PDP11/34 WITH A DEDICATED DISK AND ONE OR MORE DZ-11'S.

(15) BASED ON INFORMATION SUPPLIED BY MODULAR COMPUTER SYSTEM FOR A 10 MB DISK SYSTEM (L1136) USING TWO 5 MB DISK DRIVES WITH TWO CONTROLLER (4123) AND A SWITCH OVER CONTROL BOX (4906).

(16) BASED ON ESTIMATE SUPPLIED BY EMCS VENDOR FOR U.P.S.

(17) BASED ON INFORMATION SUPPLIED BY HEWLETT PACKARD FOR A 20 MB DISK DRIVES USING TWO 7906, 10 MB DISK UNITS, A 13175A INTERFACE AND A 13178B INTERFACE WITH CABLE.

(18) BASED ON ESTIMATE SUPPLIED BY EMCS VENDOR.

(19) BASED ON INFORMATION SUPPLIED BY MODULAR COMPUTER SYSTEM FOR A 10 MB DISK SYSTEM USING TWO 5 MB DISK UNITS (4136) WITH TWO CONTROLLERS (4136) AND A SWITCH OVER CONTROL BOX (L1906).

(20) BASED ON DIGITAL'S RL01 SERIES OF DISK DRIVE SYSTEM. TWO RL01'S (5.2 MB EACH) CONTROLLED BY TWO RL-11 CONTROLLERS.

(21) BASED ON DIGITAL'S RL01 SERIES OF DISK DRIVE SYSTEM. TWO RL01'S (5.2 MB EACH) CONTROLLED BY TWO RL-11 CONTROLLERS.

(22) BASED ON DIGITAL'S DESK WRITER II ($2,L00) WITH DL-11 TERMINAL INTERFACE ($770) AND CABLE.

(23) BASED ON DIGITAL'S DESK WRITER II AND ONE HALF THE COST OF A MODCOMP ASYNCHRONOUS COMMUNICATION INTERFACE 4811 PLUS CABLE.

(24) TO IMPLEMENT THE CCC, THE EMCS VENDOR WOULD LIKE TO USE A MODCOMP II AS THE COM CONTROLLER. THE COSTING FOR THIS APPROACH IS BASED UPON USING THE MODCOMP II 126/CP2, A PERIPHERAL CONTROLLER INTERFACE (4903), AND A UNIVERSAL COMMUNICATION CONTROLLER (1907). THIS APPROACH WOULD ALLOW COMMUNICATION OVER 138 LINES, AND IS EXPANDABLE TO 192 LINES OR 256 LINES.

(25) BASED ON EMCS VENDOR'S ESTIMATE FOR THEIR CHOICE OF PRINTER. THE PRICING QUOTED REPRESENTS A FASTER PRINTER THAN REQUIRED BY THE GUIDE SPECS.

(26) BASED ON THE EMCS VENDOR'S ESTIMATE USING A TELETYPE 43 ($1000) WITH A ASYNCHRONOUS INTERFACE ($700).

(27) BASED ON DIGITAL'S DECK WRITER II AND ONE HALF THE COST OF MODCOMP ASYNCHRONOUS COMMUNICATION INTERFACE (4811) AND A CONNECTING CABLE.

(28) BASED ON MODCOMP CONVERSATION CRT 4611 AND ONE HALF THE COST OF A ASYNCHRONOUS COMMUNICATION INTERFACE.

(29) BASED ON MODCOMP CONVERSATIONAL CRT 4611 AND ONE HALF THE COST OF A ASYNCHRONOUS COMMUNICATION INTERFACE.

(30) BASED ON EMCS VENDOR'S COST ESTIMATE USING ECCO CRT DS300 ($1500) WITH INTERFACE ($500).

(31) BASED ON INTERDATA'S FUZ 1100 CRT DISPLAY TERMINAL ($1500) WITH CABLE ($60) AND ONE FOURTH OF A CONTROLLER ($375).

(32) BASED ON INTELLIGENT SYSTEMS CORP'S ISC 8001G COLOR CRT TERMINAL ($1950) AND USING ONE HALF OF A MODCOMP ACI (4811) ($840) WITH CABLE ($60).

(33) BASED ON INTELLIGENT SYSTEMS CORP'S ISC 8001G COLOR CRT TERMINAL ($1950) AND HP COMMUNICATION CARD ($575) AND CABLE ($60).

(34) BASED ON EMCS VENDOR'S ESTIMATE. NOTE: SOME OF THE COST FOR SPECIAL CHARACTERS IS INCLUDED IN THE PRICE.

(35) BASED ON INTELLIGENT SYSTEMS CORP'S ISC 8001G COLOR CRT TERMINAL ($1950) AND USING ONE HALF OF A MODCOMP ACI (4811) WITH CABLE ($60).

(36) BASED ON INTELLIGENT SYSTEMS CORP'S ISC 8001G COLOR CRT TERMINAL ($1950) AND ONE FOURTH OF A INTERDATA COMMUNICATION CONTROLLER ($350) AND CABLE ($60

(37) BASED ON INTELLIGENT SYSTEMS CORP'S ISC 8001G COLOR CRT TERMINAL ($1950) AND DIGITAL'S DL-11 TERMINAL INTERFACE ($770) WITH CABLE ($60).

(38) BASED ON EMCS VENDOR'S ESTIMATE.

(39) PAPER TAPE READER ONLY, COST BASED ON MODCOMP MODEL 4513 ($1800), CONTROLLER MODEL 3751 ($850) AND ONE FOURTH PERIPHERAL INTERFACE MODEL 4903 ($500) AND A CABLE.

(40) BASED ON THE INTERDATA PAPER TAPE PUNCH/READER WITH CONTROL BOARD.

(41) BASED ON THE INTERDATA 9 CHANNEL, 800 BPI, 45 IPS UNIT WITH CONTROLLER.

(42) CCU PRICE QUOTED BY EMCS VENDOR HAS DISK SYSTEM INCLUDED AS A PACKAGE ALONE WITH 192KB CORE MEMORY AND I/O DRIVERS NECESSARY TO SUPPORT THE PERIPHERALS.

(43) EMCS VENDOR'S PRICE ESTIMATE FOR CCU PACKAGE IN FOOTNOTE 49 INCLUDED A DUAL DISK DRIVE WITH CONTROLLER. THE PRICE QUOTED HERE IS THE MARGINAL *COST FOR AN ADDITIONAL DRIVE ADDED TO THE CONTROLLER.* IF AN ADDITIONAL CONTROLLER (RL-11) IS USED, THE COST IS $1,150 FOR AN EXTRA CONTROLLER.

(44) EMCS VENDOR'S QUOTED PRICE FOR A 30 CPS PRINTER WITH KEYBOARD.

(45) EMCS VENDOR'S QUOTED PRICE FOR COLOR CRT TERMINAL WITH 30 GRAPHICS CHARACTERS. NOTE: THIS PRICE INCLUDES SPECIAL GRAPHICS AS REQUIRED BY THE GUIDE SPEC., IN ADDITION TO THE COST OF THE COLOR CRT.

(46) EMCS VENDOR'S QUOTED PRICE FOR A B&W CRT TERMINAL.

(47) EMCS VENDOR'S QUOTED PRICE FOR PAPER TAPE READER AND PUNCH.

(48) EMCS VENDOR'S QUOTED PRICE FOR TAPE UNIT 800 BPI, 9 TRACK 45-IPS WITH CONTROLLER.

(49) EMCS VENDOR'S QUOTED PRICE FOR FAIL OVER CONTROL BOARD.

(50) EMCS VENDOR'S QUOTED PRICE FOR INTERCOM; MASTER STATION IS $2700 AND THE REMOTE STATION IS $160 PER UNIT.

(51) BASED ON HP PAPER TAPE READER MODEL 12925 ($3300) AND PUNCH MODEL 12926A ($5000) PRICE INCLUDES CABLE AND CONTROLLER.

(52) BASED ON HP TAPE UNIT 79700 WITH ON7IOW 236, PRICE INCLUDES CABLE AND CONTROLLER.

(53) BASED ON THE EMCS VENDOR'S ESTIMATE USING HP'S ASCII CLOCK 59309A ($1025) WITH INTERFACE CARD ($600) CABLE INCLUDED.

(54) BASED ON THE EMCS VENDOR'S ESTIMATE FOR HIS CHOICE OF CRT.

TABLE 2
SOFTWARE
MANUFACTURERS DATA

	A	B	C	D	E	F	G	VALUE USED IN STUDY
1. SYSTEM SOFTWARE								
A REAL TIME OPERATING SYSTEM	(25) 300	(1) 65,000	(21) 5,000	(33)	(26) 300	(22) 1,700	(32) 300,000	
B FORTRAN		(2) 2,000				(23) 550		
C BASIC		(3) 7,000 (4) 2,000 (5) 7,000				(24) 450		
D MATHMATICS PACKAGE								
2. COMMAND SOFTWARE		(9) 28,000	(28) 30,000					
A GRAPHICS		(7) 18,000						
B DATA BASE CONFIGURATION		(8) 4,000						
3. APPLICATION PROGRAMS			(29) 44,000					
A TIME PROGRAM FUNCTIONS								
B EXTENDED SERVICE CONTROL								
C SOFTWARE INTERLOCKING SEQUENCES								
D ELECTRICAL DEMAND LIMITING		(27) 8,000						
E DUTY CYCLE PROGRAMS		(10) 2,000						
F POWER DEMAND STATISTICS		(11) 4,000						
G ENTHALPY/PSYCHROMETIC		(12) 2,000						
H DAMPER/ENTHALPH CONTROL		(13)						
I HEATING/COOLING RESET OPTIMIZING		(14) 6,000						
J CHILLER PLANT OPTIMIZATION		(15) 4,000						
K BOILER MANAGEMENT		(16) 4,000						
L CALCULATED POINT								
M ANALOG TOTALIZATION								
N ANALOG MONITORING								
O RUN TIME TOTALIZATION		(19) 2,000						
P ENERGY TOTALIZATION		(20)						
Q OPTIMAL START		(17) 6,000						
R POWER FAIL RESTART OF MOTORS		(18) 4,000						

TABLE 2
SOFTWARE
MANUFACTURERS DATA

	A	B	C	D	E	F	G	VALUE USED IN STUDY
4. CENTRAL COMMUNICATIONS CONTROLLER SOFTWARE		(6) 15,000	(30) 7,500					
5. FIELD INTERFACE DEVICE SOFTWARE			(31) 75					

TABLE 2 FOOTNOTES
SOFTWARE

(1) BASED ON EMCS VENDOR'S ESTIMATES FOR RSXIIM OPERATION SYSTEM.

(2) BASED ON EMCS VENDOR'S ESTIMATES FOR STANDARD FORTRAN.

(3) BASED ON EMCS VENDOR'S ESTIMATES FOR EXTENDED FORTRAN.

(4) BASED ON EMCS VENDOR'S ESTIMATES FOR STANDARD BASIC.

(5) BASED ON EMCS VENDOR'S ESTIMATES FOR EXTENDED BASIC.

(6) BASED ON EMCS VENDOR'S ESTIMATES FOR COMMUNICATION SOFTWARE.

(7) BASED ON EMCS VENDOR'S ESTIMATES FOR GRAPHICS PACKAGE.

(8) BASED ON EMCS VENDOR'S ESTIMATES FOR SYSTEM 200 POINTS. FOR EACH ADDITIONAL ANALOG PT ADD $40 AND FOR EACH ADDITIONAL BINARY POINT ADD $20.

(9) BASED ON EMCS VENDOR'S ESTIMATES FOR SYSTEM SOFTWARE.

(10) BASED ON EMCS VENDOR'S ESTIMATES FOR DUTY CYCLE PROGRAM.

(11) BASED ON EMCS VENDOR'S ESTIMATES FOR POWER DEMAND STATISTIC PROGRAM.

(12) BASED ON EMCS VENDOR'S ESTIMATES FOR ENTHALPY MGT. SYSTEM.

(13) PRICE INCLUDED IN ENTHALPY MGT. STATION FOR FOOTNOTE 12.

(14) BASED ON EMCS VENDOR'S ESTIMATES FOR HEATING AND COOLING RESET OPTIMIZATION PROGRAM.

(15) BASED ON EMCS VENDOR'S ESTIMATES FOR CHILLER PLANT OPTIMIZATION PROGRAM.

(16) BASED ON EMCS VENDOR'S ESTIMATES FOR BOILER MANAGEMENT AND OPTIMIZATION PROGRAM.

(17) BASED ON EMCS VENDOR'S ESTIMATES FOR OPTIMAL START/STOP PROGRAM.

(18) BASED ON EMCS VENDOR'S ESTIMATES FOR POWER FAIL RESTART OF MOTORS.

(19) BASED ON EMCS VENDOR'S ESTIMATES FOR RUN TIME TOTALIZATION.

(20) ENERGY TOTALIZATION INCLUDED WITH RUN TIME TOTALIZATION PROGRAM.

(21) BASED ON HEWLETT PACKAGE 92067A RTE-4 DISK BASED OPERATING SYSTEM FOR 21MX COMPUTER ON A 5MB DISK (OPTION 31). OPERATING SYSTEM SOFTWARE SUPPORT AND UPDATES ARE $17,580/MO.

(22) BASED ON INTERDATA OPERATING SYSTEM OS-10MT2 SUPPLIED ON DISK.

(23) BASED ON INTERDATA FORTRAN IV.

(24) BASED ON INTERDATA BASIC.

(25) BASED ON MODCOMP OPERATING SYSTEM MAX3. PRICE COVERS COST OF DOCUMENTATION.

(26) BASED ON MODCOMP OPERATING SYSTEM MAX3. PRICE COVERS COST OF DOCUMENTATION.

(27) BASED ON EMCS VENDOR'S ESTIMATE FOR ELECTRICAL DEMAND LIMITING PROGRAM.

(28) BASED ON THE VENDOR'S ESTIMATE FOR THE NUMBER OF MAN MONTHS FOR EACH TASK. (SEE TABLE BELOW). IT IS ASSUMED THE COST OF THE TASK CAN BE SPREAD OVER AT LEAST 10 JOBS. THE RATE USED IN THIS CALCULATION IS AN ESTIMATED RATE OF 3150$/MAN MONTHS.

COMMAND SOFTWARE	
GENERAL	12
COMMAND LINE MNEMONIC INTERPRETER	12
DEFINITION PROCESS	12
REPORT GENERATOR	4
INDEX	18
GRAPHICS SOFTWARE	24
CONTROL SEQUENCE SOFTWARE	6
ALARMS	12
PERIPHERAL DEVICE SHARING	2
OPERATOR'S CONTROL SOFTWARE	0
PREDICTOR/CORRECTOR PROGRAM	3
SYSTEM ACCESS CONTROL	2
FID SOFTWARE EDITING	12
TOTAL TIME FOR DEVELOPING COMMAND SOFTWARE	95 MAN MONTHS

(29) BASED ON THE VENDOR'S ESTIMATE FOR THE NUMBERS OF MAN MONTHS FOR EACH TASK. (SEE TABLE BELOW). IT IS ASSUMED THE COST OF THE TASK CAN BE SPREAD OVER AT LEAST 10 JOBS. MUCH OF THE COMMAND SOFTWARE HAS EXISTED IN MODIFIED FROM FOR SOME TIME, AND HAS BEEN USED ON PREVIOUS JOBS BEFORE THE GUIDE SPEC REQUIREMENTS. THE RATE USED FOR THIS CALCULATION IS $3150/MAN MO. IT SHOULD BE NOTED THAT ANY NEW PROGRAM REQUIREMENT NOT LISTED IN THE GUIDE SPEC COULD GREATLY AFFECT THE SOFTWARE COST.

APPLICATIONS PROGRAMS	
GENERAL	
TIME PROGRAM FUNCTIONS	8
EXTENDED SERVICE CONTROL	4
SOFTWARE INTERLOCKING SEQUENCES	6
ELECTRICAL DEMAND LIMITING	12
DUTY CYCLE PROGRAM (DCP)	10
POWER DEMAND STATISTICS	2
ENTHALPY/PSYCHROMETRIC PROGRAM	4
DAMPER/ENTHALPY CONTROL PROGRAM	4
HEATING/COOLING RESET OPTIMIZING PORGRAM (H/C ROP)	8
CHILLER PLANT OPTIMIZATION	24
BOILER MANAGEMENT	6
CALCULATED POINT	2
ANALONG TOTALIZATION	1
ANALOG MONITORING	24
RUN TIME TOTALIZATION	2
ENERGY TOTALIZATION	6
OPTIMAL START	10
POWER FAIL RESTART OF MOTORS	6
TOTAL TIME FOR DEVELOPING APPLICATION PROGRAM	101 MAN MONTHS

(30) BASED ON VENDOR'S ESTIMATE OF 24 MAN MONTHS ASSUMING A $3150/MAN MONTH RATE AND THE COST SPREAD OVER 10 SYSTEMS.

(31) BASED ON VENDOR'S ESTIMATE OF 12 MAN MONTHS NECESSARY TO MODIFY THE PROGRAMS THAT COME WITH THE FID'S, AND ASSUMING A PROGRAMING RATE OF 3150/MAN MONTH, WITH THE COST AMORTIZED OVER 500 FID'S.

(32) VENDOR'S ESTIMATE ON TOTAL SOFTWARE COST.

(33) THE STANDARD SOFTWARE COMES WITH THE SYSTEM AT NO ADDITIONAL SOFTWARE COST.

TABLE 3
COMMUNICATION
MANUFACTURER'S DATA

	A	B	C	D	E	F	G	VALUE USED IN STUDY
1. COMMUNICATION CABLE								
A OUTSIDE ON EXISTING POLES			(1) 985 $/1000 FT.					
B INSIDE								(2) 673 $/1000 FT.
C BURIED			(7) 3,140 $/1000 FT.					
D CABLE COST			(10) 275 $/1000 FT.					
2. COAX (4)								
A OUTSIDE ON EXISTING POLES				(11) 1.50 TO 2$/FT.				
B INSIDE (5)								
C DIRECT BURIAL OF COAX				(6) 3$/FT.				
D CABLE COST				(3) 250 $/1000 FT.				
3. FIBER OPTICS (8)								
4. RADIO								
5. POWER LINE MODEM		(9) 910						

TABLE 3 FOOTNOTES
COMMUNICATION
MANUFACTURER'S DATA

(1) COST BASED ON INFORMATION SUPPLIED BY EMCS VENDOR TO RUN 1,000 FT. OF EXISTING POLES WITH FIGURE EIGHT CABLE WITHOUT ANY OBSTACLE. THREE MEN CAN PUT UP 1,000 FT OF CABLE IN ONE DAY WITH A BUCKET TRUCK USING FIGURE EIGHT CABLE.

3 MAN DAYS @ $15/MAN HR.	3MD :: 8 MHR/MD :: $15/MHR	=	$360.
CABLE COST $275/1,000 FT.		=	275.
MOUNTING HARDWARE $20/MOUNT POINT	$20/MP :: 10MP/100A	=	200.
BUCKET TRUCK $150/DAY			150.
TOTAL $985/1,000 FT.			$985.

IF A POLE IS REQUIRED IT TAKES ABOUT A DAY TO PUT UP A POLE WITH A THREE MAN TEAM AND A AUGER TRUCK.

ONE AUGER TRUCK WITH DRIVER $250/DAY			$250.
2 MEN AT $16/MAN HR	2MD :: 8 MRH/MD :: $16/MHR	=	256.
POLE $75.			75.
COST FOR ONE POLE			$581.

(2) BASED ON 1978 BUILDING COST FILE - SOUTHERN EDITION FOR 5 PAIRS OF CABLE. (MATERIAL COST $429/1,000 FT; LABOR $240/1,000 FT.)

NOTE: THAT PRICING WILL VARY WITH TIME, LOCATION, AND WITH THE EXACT NATURE OF THE JOB. CABLE RUNS IN EXISTING BUILDING WILL COST MORE THAN IN NEW BUILDING WHILE UNDER CONSTRUCTION. OUR EXPERIENCE HAS SHOWN THIS COST TO BE ABOUT 50% MORE IN EXISTING BUILDINGS THAN IN NEW CONSTRUCTION.

(3) INFORMATION SUPPLIED BY EMCS VENDOR FOR 1/2" SOLID SHIELD COAX.

(4) LONG COAX CABLE RUNS MAY REQUIRE REPEATERS (LINE AMPS) EVERY 1/2 MILE, COST $300 PER LINE AMP.

(5) NOTE: THE COST TO RUN COAX CABLE INSIDE A BUILDING IS COMPARABLE TO THE COST OF RUNNING INSIDE SIGNAL WIRE ONCE YOU ADJUST FOR THE DIFFERENCE IN CABLE COST.

(6) EXTIMATE SUPPLIED BY EMCS VENDOR FOR RUNING COAX IN EXISTING BANKS.

(7) BASED ON ESTIMATES SUPPLIED BY EMCS VENDOR FOR CABLE BURIED IN EXISTING BANKS. THE COST TO BURY CABLE IN EXISTING BANK RUNS ABOUT 400% THAT OF AERIAL CABLE.

(8) NONE OF THE VENDOR'S CONTACTED EXPRESSED INTEREST IN USING FIBER OPTICS AT THIS TIME.

(9) BASED ON INFORMATION SUPPLIED BY EMCS VENDOR. NOTE: REPEATERS MAY BE NEEDED IF SIGNAL MUST BE TAKEN MORE THAN TWO MILES. COST OF REPEATERS IS ABOUT $2,000. NOTE ALSO A POWER TRANSFORMER IN SIGNAL PATH MUST BE BYPASSED WITH A HIGH FREQUENCY COUPLING DEVICE.

(10) COST DATE SUPPLIED FROM EMCS VENDOR BASED ON FIGURE EIGHT CABLE FOR USE OUTDOORS ON POLES.

(11) COST ESTIMATE SUPPLIED BY EMCS VENDOR BASED ON HIS PAST EXPERIENCE USING COAX THAT WAS HUNG ON EXISTING POLES.

TABLE 4
FID'S
MANUFACTURER'S DATA

	A	B	C	D	E	F	G	VALUE USED IN STUDY
A FIELD INTERFACE (1) DEVICE (FID)	(2) $3,000/ 22 SLOTS	(3) $2,510/ 12 SLOT $2,270/ 8 SLOT	(4)	(5) $5,000 INCLUDES MODEM/ 28 SLOT	(6) $4,284/ 5 SLOTS $6,540/ 13 SLOTS $8,290/ 21 SLOT	(7) LARGE $2,300 SMALL $1,200	(8) $1,200/ 14 SLOTS	$2,400
B FID SUPPORT EQUIPMENT								
(A) PROM PROGRAMMER		$1,150		(11) $2,000	(15)			
(B) TEST SET (C) DIGITAL MULTI-METER (D) TESTER & ANALYZER		(B),(C),(D) PACKAGE $9,300						
C MULTIPLEXER PANELS (MUX) (9)	(12) $500	(10) $920/ 3 CARDS OR $720/1 CARD						
D MODEM		(13) $425					(14) $350	
E FUNCTION CARDS FOR FID OR MUX								
(A) ANALOG OUTPUT		$970/4 PTS			$610/4 PTS		$625/4 PTS	(19) $368/PT
(B) ANALOG INPUT		$970/16 PTS		$375/4 PT	(16)$260/4 PTS		$600/8 PTS	(19) $110/PT
(C) BINARY INPUT		SEE COMBO BELOW		$100/8 PTS	$325/8 PTS		$260/12 PTS	(19) $ 33/PT
(D) BINARY OUTPUT		SEE COMBO BELOW		$150/8 PTS	(17)$290/4 PTS W/ STATUS, FEED-BACK		$300/8 PTS	(19) $ 43/PT
(E) COMBO OF A, B, C, D		(18) $1,040						(19) $ 61/PT

TABLE 4 FOOTNOTES
FID'S

(1) FID'S - PRICES REFLECT "EMPTY" FID'S, I.E. NO FUNCTION CARDS BUT WITH POWER SUPPLY, CPU CARD, MEMORY AND OTHER SUPPORTING ELECTRONICS. AN EXCEPTION IS MANUFACTURER F. SEE NOTE (7) BELOW.

(2) FID HAS A "COMMON CAGE" WITH SIX SLOTS REMAINING AFTER SUPPORTING ELECTRONICS HAVE BEEN INSTALLED. THEN, ADDITIONAL CAGES ARE ADDED AS NEEDED WITH EACH CAGE CONTAINING 16 CARD SLOTS.

(3) THE 12 CARD SLOT FID CAN BE EXPANDED (DOUBLE IN CAPACITY) BY ADDING A REMOTE CHASSIS UP TO ABOUT 1000 FEET FROM THE MAIN FID. THE CHASSIS COMMUNICATES WITH THE FID VIA A RS422 PATCH, CONTAINS 12 SLOTS AND COST $1,470.

(4) USE FID'S MANUFACTURED BY ANOTHER EMCS OEM.

(5) EMCS VENDOR'S ESTIMATE FOR A BARE FID.

(6) ONE FID CARD SLOT IS UTILIZED BY AN A/D CONVERTER CARD IF THE FID HAS AT LEAST 1 ANALOG POINT. (PRACTICALLY ALL EMCS FID'S HAVE ANALOG POINTS).

(7) PRICE BASED ON A FULL FID CAPABLE OF HANDLING ABOUT: 48 DIGITAL OUT, 32 DIGITAL IN, 32 ANALOG IN. ANALOG OUT POINTS CAN BE DONE USING ONE DIGITAL OUT AND ONE DIGITAL IN POINT. THE SMALL FID COMES PREPACKAGED WITH A SINGLE, COMBINATION FUNCTION CARD WHICH CAN HANDLE: 16 DIGITAL IN, 16 DIGITAL OUT, 8 (SOON TO BE 16) ANALOG IN. ANALOG OUT POINTS FORMED AS DESCRIBED ABOVE.

(8) DOES NOT NEED MODEM UNLESS TRANSMITTING FURTHER THAN ABOUT 2000 FEET.

(9) MUX'S - MOST MANUFACTURERS DO NOT HAVE A SMALL, INEXPENSIVE MUX FOR LOW POINT DENSITY BUILDINGS. THEY WOULD HAVE TO BID BASED ON A FID IN EACH BUILDING.

(10) EMCS VENDOR OFFERS MUX'S USING FUNCTION CARDS WHICH ARE THEMSELVES MICROPROCESSOR-BASED. THEY CAN PERFORM CERTAIN STAND ALONE FUNCTIONS, SUCH AS TIME OF DAY START/STOP AND DUTY CYCLING, WHICH ARE NORMALLY THOUGHT OF AS FID CAPABILITIES. THIS TENDS TO EXTEND THE CONCEPT OF DISTRIBUTED PROCESSIN EVEN TO MUX-CONTROLLED BUILDINGS.

(11) EMCS VENDOR'S TEST BOX FOR A FID THAT CAN SIMULATE THE COMPUTER INTERFACE.

(12) BASED ON EMCS VENDOR'S ESTIMATE FOR A LOW POINT DENSITY MULTIPLEXER.

(13) BASED ON EMCS VENDOR'S ESTIMATE FOR 300 BAUD MODEM.

(14) BASED ON EMCS VENDOR'S ESTIMATE FOR A GENERAL PURPOSE LOW SPEED MODEM.

(15) UNDER DEVELOPMENT AT THIS TIME. NO PRICE AVAILABLE.

(16) ANALOG INPUT CARD REQUIRES ONE SNAP-ON ANALOG TRANSMITTER (AT) PER POINT AT ABOUT $45 PER AT.

(17) START/STOP CARD HAS STATUS FEEDBACK POINTS INCORPORATED ON SAME CARD.

(18) THIS COMBINATION CARD HAS THE FOLLOWING POINT CAPACITIES: 16 BINARY IN, 4 BINARY OUT, 4 ANALOG OUT. THE 16 BINARY IN CAN BE CONFIGURED AS 16 ANALOG IN.

(19) POINT PRICES ARE ADJUSTED UPWARD SOMEWHAT TO ACCOUNT FOR THE FACT THAT OFTEN THE MAXIMUM POINT CAPACITY OF A FID FUNCTION CARD IS NOT USED. FOR EXAMPLE, IF A FID HAS ONLY TWO BINARY INPUT POINTS, A "WHOLE" CARD OF 4, 8, OR 12 POINTS, ETC., WOULD BE USED. ALTHOUGH THIS IS FINE FOR FUTURE EXPANSION, IT MEANS INITIALLY, THE PER POINT PRICE ESTIMATE OF FUNCTION CARDS SHOULD BE HIGHER THAN THE FIGURE ARRIVED AT BY DIVIDING THE CARD COST BY THE MAXIMUM POINTS THAT CARD WILL HANDLE. THE PRICES SHOWN ASSUMED THE FOLLOWING AVERAGE USAGE:

	MAX. CARD POINT CAPACITY	POINTS ACTUALLY USED
ANALOG OUT	4	2
BINARY OUT	4	2
	8	4
BINARY IN OR, ANALOG IN	4	3
	8	6
	12	9
	16	12

IT SHOULD BE NOTED THAT THESE PER POINT PRICES ARE ESTIMATES. ACTUAL COST IN A PARTICULAR FID IS GREATLY INFLUENCED BY SEVERAL FACTORS INCLUDING:

- *FID POINT TOTAL* - LARGE POINT TOTALS MEAN THAT SEVERAL "WHOLE" CARDS COULD BE USED WITH ONLY THE LAST ONE LIKELY TO BE PARTIALLY USED.
- MANUFACTURER - TOTAL POINTS HANDLED ON AN INDIVIDUAL CARD VARIES FROM ONE MANUFACTURER TO THE NEXT. ALSO, SOME MANUFACTURERS HAVE DEVELOPED COMBINATION CARDS WHICH MIGHT FIT A PARTICULAR CONFIGURATION WELL ENOUGH TO AVOID THE USE OF ONE OR MORE TYPE OF SINGLE FUNCTION CARDS ALTOGETHER.

TABLE 5
SENSORS AND CONTROLS

THESE POINT COSTS DO NOT INCLUDE THE COST OF A SHARE OF AN FID FUNCTION CARD (SEE TABLE 4, ITEM 3, ABOVE).

		MATERIAL	•LABOR
A. START/STOP, OPEN/CLOSE, ON/OFF			
1. MOTOR STARTER, SINGLE SPEED			
(A) RELAY INTERFACE TO MOTOR STARTER		$ 36	$ 16
(B) 50 FT OF WIRING AND CONDUIT		12	54
	TOTAL A.1	$ 48	$ 70
2. MOTOR CONTROL, TWO SPEED			
(A) RELAY INTERFACE (2) TO MOTOR (REQUIRES TWO FID CARD SHARES)		$ 72	$ 32
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL A.2	$ 84	$ 86
3. VALVE OPEN/CLOSE			
(A) RELAY INTERFACE TO VALVE		$ 36	$ 14
(B) 50 FT. OF WIRING AND CONDUIT, OR PNEUMATIC TUBING		12	54
(C) ELECTRIC-TO-PNEUMATIC SWITCH		24	10
	TOTAL A.3	$ 72	$ 78
B. TEMPERATURE MEASUREMENT POINTS			
1. DUCT, AIR, AVERAGING			
(A) AVERAGING SENSOR		$ 54	$ 25
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL B.1	$ 66	$ 79
2. DUCT, AIR, BULB SENSOR			
(A) RTD		$ 36	$ 20
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL B.2	$ 48	$ 74
3. SPACE, AIR			
(A) SENSOR, W/COVER		$ 30	$ 30
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL B.3	$ 42	$ 84

4. LIQUID, SENSOR IN EXISTING WELL			
(A) RTD		$ 30	$ 10
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL B.4	$ 42	$ 64

NOTE: COST OF INSTALLING NEW WELLS VARY FROM $100
TO OVER $1,000 EACH DEPENDING ON HOW MANY
WELLS, IF SYSTEM TO BE DRAINED, ACCESSIBILITY, ETC.

C. PRESSURE, DIFFERENTIAL

L. ANALOG			
(A) DP CELL W/TRANSMITTER, PLATES, FLANGES		$ 734	$ 300
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL C.1	$ 744	$ 354
2. SWITCH			
(A) TRANSDUCER		$ 50	$ 40
(B) 50 FT. OF WIRING AND CONDUIT		$ 12	$ 54
	TOTAL C.2	$ 62	$ 94

D. CONTACT (ALARM, STATUS, ETC)

L. 50 FT. OF WIRING AND CONDUIT		$ 12	$ 54
	TOTAL D.1	$ 12	$ 54

NOTE: SHOULD ADD ABOUT $50 LABOR IF SEVERAL SAFETY ALARMS MUST
BE WIRED IN SERIES.

E. RELATIVE HUMIDITY

1. DUCT OR SPACE			
(A) SENSOR		$ 150	$ 20
(B) 50 FT. OF WIRING AND CONDUIT		12	54
	TOTAL E.1	$ 162	$ 74

F. MISCELLANEOUS WIRING COST
USING SOUTHERN EDITION OF BUILDING COST FILE FOR LABOR AND CONDUIT, AND MANHATTEN CABLE CO. MATERIAL PRICES FOR WIRE.

1. CONDUIT, 1 INCH, $/FT.	$0.370	$1.300
2. CONDUIT, 1/2 INCH, $/FT.	0.160	0.980
3. CABLE, 12 PAIR, $/FT.	1.299	0.280
4. CABLE, 5 PAIR, $/FT.	0.670	0.244
5. CABLE, 1 PAIR, $/FT.	0.074	0.098

NOTE: COST OF CABLE FLUCTUATES CONSIDERABLY WITH CURRENT COPPER PRICES.

7.0 PRIORITIZATION ANALYSIS

On a Naval installation there are many possible uses of an Energy Monitoring and Control System (EMCS). Some of those uses are worthwhile from a cost and energy savings standpoint, and some are not. Each EMCS installed using Energy Conservation Investment Program (ECIP) funds must be justified according to certain economic and energy conservation criteria. Each EMCS function to be applied to each existing energy consuming system (call this a system/function) should be analyzed to assure that that system/function meets the criteria. System/functions which are not justified should be deleted from the project.

Once system/functions are eliminated which are not justifiable, the remaining system/functions must be analyzed. In general, no EMCS project includes enough funds to perform all justifiable uses of an EMCS on a particular base. An analysis must be performed which determines which of the many alternatives should be performed with the funds avilable. Such an analysis is called a "prioritization analysis". The prioritization analysis determines which of a set of alternatives should be included in the project to provide the most savings for the least investment.

The basic steps in performing a prioritization analysis for an EMCS (or any other project involving a large number of alternatives and a limited budget) are:

1. Determine alternatives to be considered.
2. Calculate savings for each alternative (Note that savings may be in dollars or energy units, depending on the criteria.)
3. Calculate investment for each alternative
4. Calculate the savings/investment ratio for each alternative
5. Prepare a list of alternatives ranked based on savings/investment ratio (best alternative at top of list, worst at bottom)
6. Cumulate the investment costs for the alternatives until the total reaches the budget amount. This establishes the cutoff line.
7. All alternatives above the cutoff line on the list should form the basic project. Alternatives listed below the cutoff line should be deleted from the project (or be included as additive bid items).

The prioritization process described above is applicable to EMCS projects. The first step is to determine the alternatives to be considered. There are two approaches to this. One is to consider each individual system/-function as an alternative. This results in anywhere from 600 to 5,000 individual alternatives. Such an approach is very difficult to perform using manual calculation techniques. Computer programs have been written which can accomplish this type of analysis, however, those programs are highly specialized, expensive to run, and require intimate familiarity on the part of the user to be used effectively. A second approach is to consider all work within each building as an alternative. This is a more practical method, and is more consistant with the general level of accuracy of the analysis.

Once the alternatives are determined, savings (in energy BTU's and dollars) and investment may be estimated as discussed in Section 5 and 6 of this report. Tabulation, ranking, and cutoff of the alternatives is illustrated in the example problem, Section 9.0 of this report.

It is very important to note that current ECIP projects are funded based on their E/C (energy saved (in million BTU) divided by thousand dollars invested) ratio as long as the project has an S/I (life cycle dollar savings divided by dollars invested) ratio greater than one. All projects which have an S/I ratio greater than one are prioritized for funding strictly on their E/C ratios. Projects which have higher E/C ratios will be funded prior to projects with lower E/C ratios, regardless of what the S/I ratios actually are for those projects (as long as the S/I ratio is greater than one).

8.0 OVERALL ECONOMIC ANALYSIS

An overall economic analysis must be performed for each Energy Monitoring and Control System funded under the Energy Conservation Investment Program (ECIP). Criteria for the required analysis is as follows (according to instructions issued from the Office of the Chief of Naval Operations dated 27 July 1978):

1. EMCS ECIP projects must be cost-effective based on a savings-to-investment (S/I) ratio greater than one utilizing a life cycle cost analysis.

2. Each project must have an energy savings-to-investment ratio of at least the following values for annual million BTU's (MBTU's) saved per $1000 of total investment (E/C ratio): FY-80, 22; FY-81, 20; FY-82, 19; FY-83, 18; and FY-84, 17.

3. Projects shall be supported with engineering calculations in sufficient detail to allow validation of energy savings.

4. Actual fuel heating value rates should be used when known. If not known, the following conversion factors will be used to permit standardized project evaluation comparisons:

Distillate Fuel Oil	138,700	BTU/gal
Residual Fuel Oil	150,000	BTU/gal
Natural Gas	1,031,000	BTU/1000 cu.ft.
LPG, Propane, Butane	95,500	BTU/gal
Bituminous Coal	24,580,000	BTU/Short Ton
Purchased Steam	1,390	BTU/lb
Electrical Source Fuel	11,600	BTU/KWH

5. Boiler efficiencies should be included in the calculation of savings from reduced steam consumption. The resulting reduction in fuel input and boiler feedwater represent a real cost avoidance when steam consumption is reduced. The "as-consumed" cost of fuel and electricity shall be used in determining energy dollar savings. The energy costs, as reported by each activity in the monthly Defense Energy Information System (DEIS-II) report, are "as-consumed" costs. An "Activity Rate or Host Rate", which includes overhead and maintenance costs, should not be used for calculating savings. Such costs do not normally change with small percentage reductions in overall steam consumption.

6. Energy, material, and labor prices should be escalated from current rates to those projected for 30 September of the fiscal year for which the project is submitted for funding. Unless more definitive future prices can be determined or predicted for an individual activity, the following rates are to be used for escalation:

	FY-79	FY-80	FY-81	FY-82	FY-83
Design & Construction	7.0%	6.5%	6.0%	6.0%	6.0%
Operations & Maintenance	6.4%	6.2%	5.6%	5.6%	5.6%
Coal	10.0%	10.0%	10.0%	10.0%	10.0%
Fuel Oil	16.0%	16.0%	14.0%	14.0%	14.0%
Natural Gas & LPG	15.0%	15.0%	14.0%	14.0%	14.0%
Electricity (KWH & KW)	16.0%	16.0%	13.0%	13.0%	13.0%

7. The life cycle cost analysis used to determine the project's savings-to-investment ratio shall utilize a base fiscal year commencing on 1 October following the project's programmed year. The long-term differential escalation rates below are to be used for computing the present worth of recurring annual costs and benefits if more definitive data is not available at individual activities.

Operations & Maintenance 0%

Coal. 5%

Fuel Oil. 8%

Natural Gas & LPG 8%

Electricity (KWH & KW). 7%

8. The present worth factors for multiplication of recurring annual savings can be selected from the appropirate differential escalation rate column in the DISCOUNT FACTORS table below.

ECIP DIFFERENTIAL ESCALATION RATES

ECONOMIC LIFE IN YEARS	O&M COSTS 0%	COAL 5%	ELECTRICITY 7%	OIL & GAS 8%
15	7.980	10.798	12.278	13.112

9. Economic life is the period of time over which the life cycle benefits to be gained from a project may reasonably be expected to accrue. As

such, the economic life may differ from its physical and technological life. The economic lives below may be used as guides, and ordinarily will not be exceeded.

CATEGORY	ECONOMIC LIFE
ENERGY MONITORING AND CONTROL SYSTEMS	15 years

An ECIP economic analysis summary format is included on Figure No. 6 to illustrate the minimum life cycle costing analysis necessary to determine a savings-to-investment ratio.

The project cost for line 1a of the economic analysis format is the cost of construction plus the cost of supervision, inspection and overhead. The project cost should include contingencies. The design costs in line 1b are not to include any design or survey costs which have already been obligated.

ECIP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION ______________________________ P-______

TITLE OF PROJECT ________________________________ FY-______

INVESTMENT

1. PROJECT COSTS (Economic life of ____ years)
   a. Project cost escalated to end of program year.... $________
   b. Design costs not yet obligated .... $________
   c. Total Project Cost (a + b) .... $________

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH:____________________
   a. Equivalent energy: KWH x 0.0116 ....(MBTU's: $________)
   b. Cost per KWH at end of program year .... $________
   c. First year annual dollar savings (KWH x b) ...... $________
   d. Differential escalation present worth factor .... ________
   e. Discounted savings (c x d) .... $________

3. ANNUAL ENERGY SAVINGS (TYPE:________________MBTU's: ________)
   a. Cost per MBTU at end of program year .... $________
   b. First year annual dollar savings .... $________
   c. Differential escalation present worth factor ..... ________
   d. Discounted savings (b x c) .... $________

4. ANNUAL ENERGY SAVINGS (TYPE:________________MBTU's: ________)
   a. Cost per MBTU at end of program year .... $________
   b. First year annual dollar savings .... $________
   c. Differential escalation present worth factor .... ________
   d. Discounted savings (b x c) .... $________

5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
   a. Labor .... $________
   b. Material & Other .... $________
   c. Total (a + b) .... $________
   d. 10% Discount Factor .... ________
   e. Discounted Other-than-energy savings (or costs) . $________

6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c + 3b + 4b + 5c) .. $________

7. TOTAL DISCOUNTED SAVINGS (2e + 3d + 4d + 5e) .... $________

COST ESCALATION

Current rates as of ________

Elec $______ x______ x______ x______ x______ = $______

Oil $______ x______ x______ x______ x______ = $______

Gas $______ x______ x______ x______ x______ = $______

____ $______ x______ x______ x______ x______ = $______

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) .... ________
9. TOTAL MBTU SAVINGS ________ ÷ (Line 1a ÷ 1000) ..... ________
10. SIMPLE PAYBACK PERIOD (1a ÷ Line 6) .... ______YRS

NOTE: For ETAP projects use line 1c in lines 9 and 10 in lieu of 1a.

9.0 SAMPLE NAVAL BASE

In order to demonstrate the analysis discussed in this report, a hypothetical Naval Base has been created on which the analysis has been performed. This procedure has been prepared for use by professional engineering personnel. It is not possible to describe completely all activites involved in an engineering design process. For this reason, this section is meant only to be used as a framework for EMCS analysis. Every military base is different, and parts of the process described herein must be adapted, added to, or ignored as the situation requires. The judgement required to make these decisions requires a mechanical and electrical engineering design team fully familiar with the mechanical and electrical systems an EMCS is to control and how that control is to be accomplished.

9.1 EXAMPLE PROBLEM DESCRIPTION

The example problem chosen is a hypothetical five building Naval Base. The five buildings and the systems serving those buildings have been chosen as typical of the type found on many Naval Bases. This approach for a step by step explanation was chosen so that the principles of each step can be clearly explained and illustrated without being confused by the complexity and sheer volume of an analysis of an actual Base (from 10 to 100 times the complexity of this simple five building example).

The buildings which comprise the hypothetical Naval Base and the systems within each building are listed below:

BUILDING NUMBER: 100
USAGE: PUBLIC WORKS
SYSTEMS: Hot Water Boiler
Air Cooled Chiller
Multizone Air Handler

BUILDING NUMBER: 200
USAGE: BASE PERSONNEL
SYSTEMS: Steam Boiler
Single Zone Split System

BUILDING NUMBER: 300
USAGE BASE HEADQUARTERS
SYSTEMS 2 Hot Water Boilers
Air Cooled Chiller
Single Zone Air Handler
2 Multizone Air Handlers

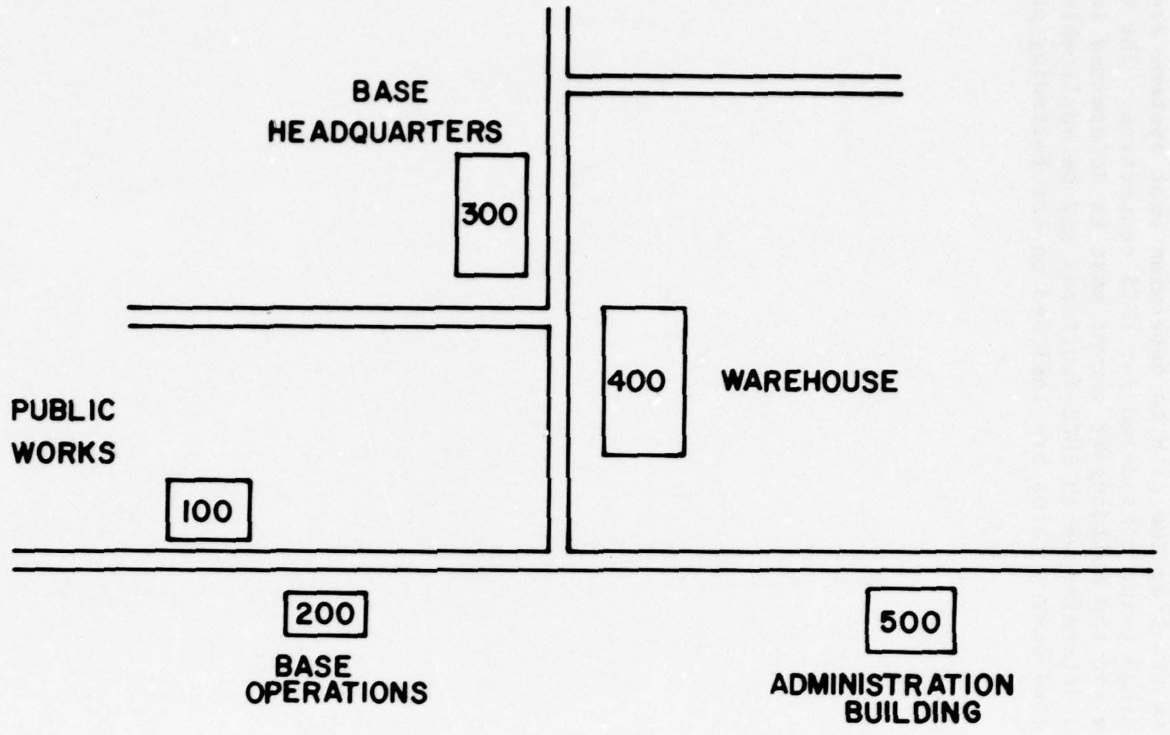
BUILDING NUMBER: 400
USAGE: WAREHOUSE
SYSTEMS: Steam Unit Heater System
Steam Boiler

BUILDING NUMBER: 500
USAGE: ADMINISTRATION BUILDING
SYSTEMS: Hot Water Boiler
Single Zone Split System

A map of the Sample Naval Base is included on Figure 7.

Criteria for this example analysis will be assumed to require the use of government furnished telephone lines.

Another criterion used will be the assumption that the purpose of the EMCS is to provide energy savings through control of energy consuming equipment. This is consistent with current policy. Performing the analysis to optimize monetary savings is very simple if that were given as the desired end.



SAMPLE NAVAL BASE
FIGURE 7

9.2 FIELD INVESTIGATION

Field investigaton is visiting the site to determine what systems are present in the buildings being considered for EMCS connection. The operation of each system and the building it serves must be determined in sufficient detail to determine which EMCS functions may be applicable to each system. Completed survey forms are included on the following pages.

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: 100 **Usage:** Public Works

Gross Area Sq. Ft.: 14,000 **No. Floors:** 1

Approx. Floor to Floor Height: 12'

Approx. Glass Dimensions: Height 4' **Width** 3'

Type of Glass: single glazed clear

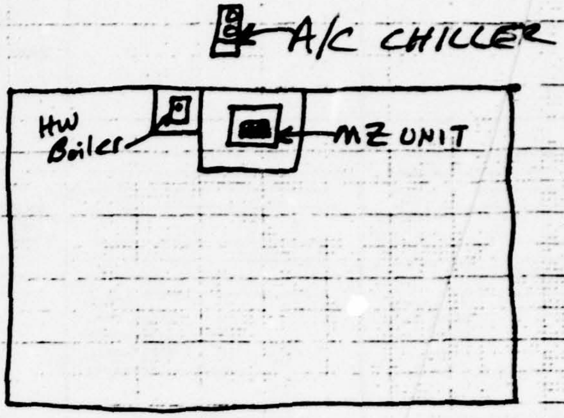
Glass Shading: External — **Internal** blinds

"U" Factor: Roof .15 **Wall** .2 **Glass** 1.0

Glass SC: .56

Critical Areas: NONE

Notes: occupied 730-1630 M-F



~ 20% Glass
Block const

Sys # 1

Type:
Boiler [✓ (HW)] (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: 750000 BTU/HR.
Pump HP: 3/4
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
[✓ Winter Only]
Other

Operation (Daily)
1 Shift
2 Shift
[✓ 3 Shift]
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys # 2

Type:
Boiler (HW) (STM)
Chiller [✓ (A/C)] (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: 40 TONS ~~BTU/HR.~~
Pump HP: 3
Pump HP:
Comp HP: 48
Fan HP: 3
Other HP:

Operation (Annual)
Year Round
[✓ Summer Only]
Winter Only
Other

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes: runs 24 hrs/day

Sys #

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys # 3

Type:
AHU (SZ) (TR)
[✓ (MZ)] (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM: 16,000
No. Zones: 5
Fan HP: 15
Capacity: BTU/HR
Pump HP
ZOA: 10
Comp. HP:
Cond Fan HP:

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes: runs 24 hrs/day

since boiler & chiller don't operate at same time, unit acts like SZ AHU

Sys #

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: BTU/HR
Pump HP
ZOA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

Sys #

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: BTU/HR
Pump HP
ZOA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: Z00 Usage: Base Personell

Gross Area Sq. Ft.: 7000 No. Floors: 1

Approx. Floor to Floor Height: 11'

Approx. Glass Dimensions: Height ______ Width ______

Type of Glass: single, clear

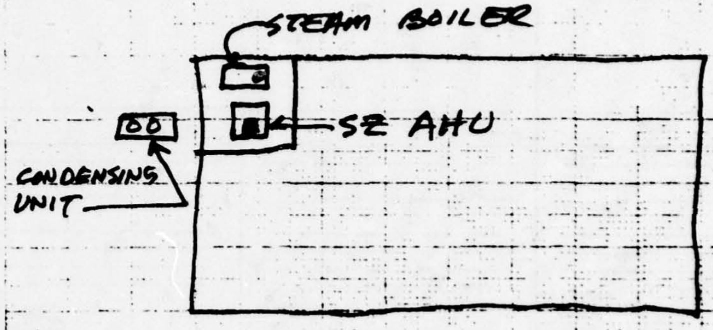
Glass Shading: External — Internal drapes

"U" Factor: Roof .20 Wall .25 Glass 1.0

Glass SC: .56

Critical Areas: ______

Notes: occupied 730-1630 M-F



~10% glass
wood frame const.

Sys # 1

Type:
Boiler (HW) [✓ (STM)]
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other: ____

Capacity: 500,000 BTU/HR.
Pump HP: ____
Pump HP: ____
Comp HP: ____
Fan HP: ____
Other HP: ____

Operation (Annual)
Year Round
Summer Only
[✓ Winter Only]
Other ____

Operation (Daily)
1 Shift
2 Shift
[✓ 3 Shift]
Other ____

Existing Controls:
Time Clock
O.A. Reset
Other: ____

Notes:

Sys # ____

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other: ____

Capacity: ____ BTU/HR.
Pump HP: ____
Pump HP: ____
Comp HP: ____
Fan HP: ____
Other HP: ____

Operation (Annual)
Year Round
Summer Only
Winter Only
Other ____

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other ____

Existing Controls:
Time Clock
O.A. Reset
Other: ____

Notes:

Sys # ____

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other: ____

Capacity: ____ BTU/HR.
Pump HP: ____
Pump HP: ____
Comp HP: ____
Fan HP: ____
Other HP: ____

Operation (Annual)
Year Round
Summer Only
Winter Only
Other ____

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other ____

Existing Controls:
Time Clock
O.A. Reset
Other: ____

Notes:

Sys # 2

Type:
AHU (SZ) (TR)
(MZ) (HV)
[✓ (SP)] (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other ____

CFM: 8000
No. Zones: ____
Fan HP: 5
Capacity: ____ BTU/HR
Pump HP ____
ZOA: ~15
Comp. HP: 20
Cond Fan HP: 2

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other ____

Existing Controls:
[✓ Time Clock]
[✓ Economizer]
Deck Reset
Other: ____

Notes: ____

Sys # ____

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other ____

CFM: ____
No. Zones: ____
Fan HP: ____
Capacity: ____ BTU/HR
Pump HP ____
ZOA: ____
Comp. HP: ____
Cond Fan HP: ____

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other ____

Existing Controls:
Time Clock
Economizer
Deck Reset
Other: ____

Notes: ____

Sys # ____

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other ____

CFM: ____
No. Zones: ____
Fan HP: ____
Capacity: ____ BTU/HR
Pump HP ____
ZOA: ____
Comp. HP: ____
Cond Fan HP: ____

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other ____

Existing Controls:
Time Clock
Economizer
Deck Reset
Other: ____

Notes: ____

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: 300 Usage: Base Headquarters

Gross Area Sq. Ft.: 51,000 No. Floors: 2

Approx. Floor to Floor Height: 12'

Approx. Glass Dimensions: Height 4' Width 3'

Type of Glass: single, gray tint

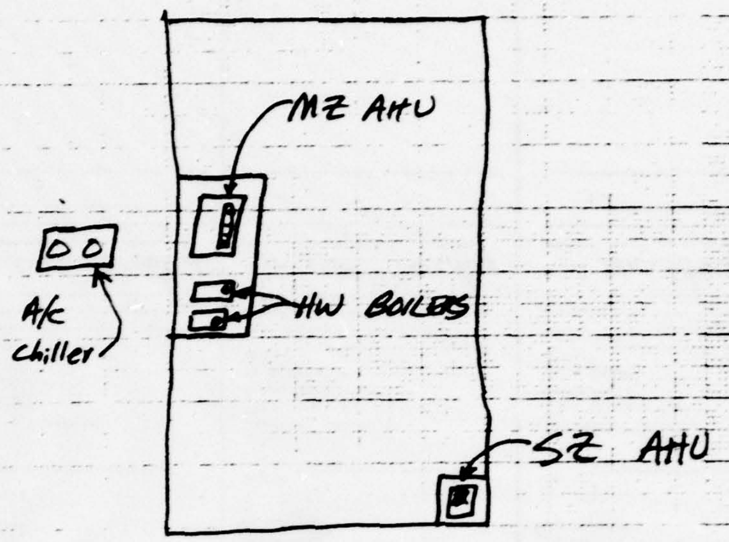
Glass Shading: External — Internal —

"U" Factor: Roof .10 Wall .12 Glass 1.0

Glass SC: .45

Critical Areas:

Notes:



FIRST FLOOR

Sys # 1&2

Type:
Boiler [✓ (HW)] (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: 1,500,000 each BTU/HR.
Pump HP: 5 each
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
[✓ Year Round]
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
[✓ 3 Shift]
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys # 3

Type:
Boiler (HW) (STM)
Chiller [✓ (A/C)] (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: 160 TONS BTU/HR.
Pump HP: 15
Pump HP:
Comp HP: 200
Fan HP: 10
Other HP:

Operation (Annual)
[✓ Year Round]
Summer Only
Winter Only
Other

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:
runs 24hrs/day

Sys #

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys # 4

Type:
AHU [✓ (SZ)] (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM: 30,000
No. Zones:
Fan HP: 30
Capacity: BTU/HR
Pump HP
ZOA: ~15
Comp. HP:
Cond Fan HP:

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
[✓ Economizer]
Deck Reset
Other:

Notes: runs 24 hrs/day

Sys # 5

Type:
AHU (SZ) (TR)
[✓ (MZ)] (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM: 18,000
No. Zones: 3
Fan HP: 20
Capacity: BTU/HR
Pump HP
ZOA: ~10
Comp. HP:
Cond Fan HP:

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes: runs 24hrs/day

Sys # 6

Type:
AHU (SZ) (TR)
[✓ (MZ)] (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM: 20,000
No. Zones: 4
Fan HP: 30
Capacity: BTU/HR
Pump HP
ZOA: ~10
Comp. HP:
Cond Fan HP:

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes: runs 24hrs/day

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: 400 Usage: Warehouse

Gross Area Sq. Ft.: 70,000 No. Floors: 1

Approx. Floor to Floor Height: 18

Approx. Glass Dimensions: Height – Width –

Type of Glass: NONE

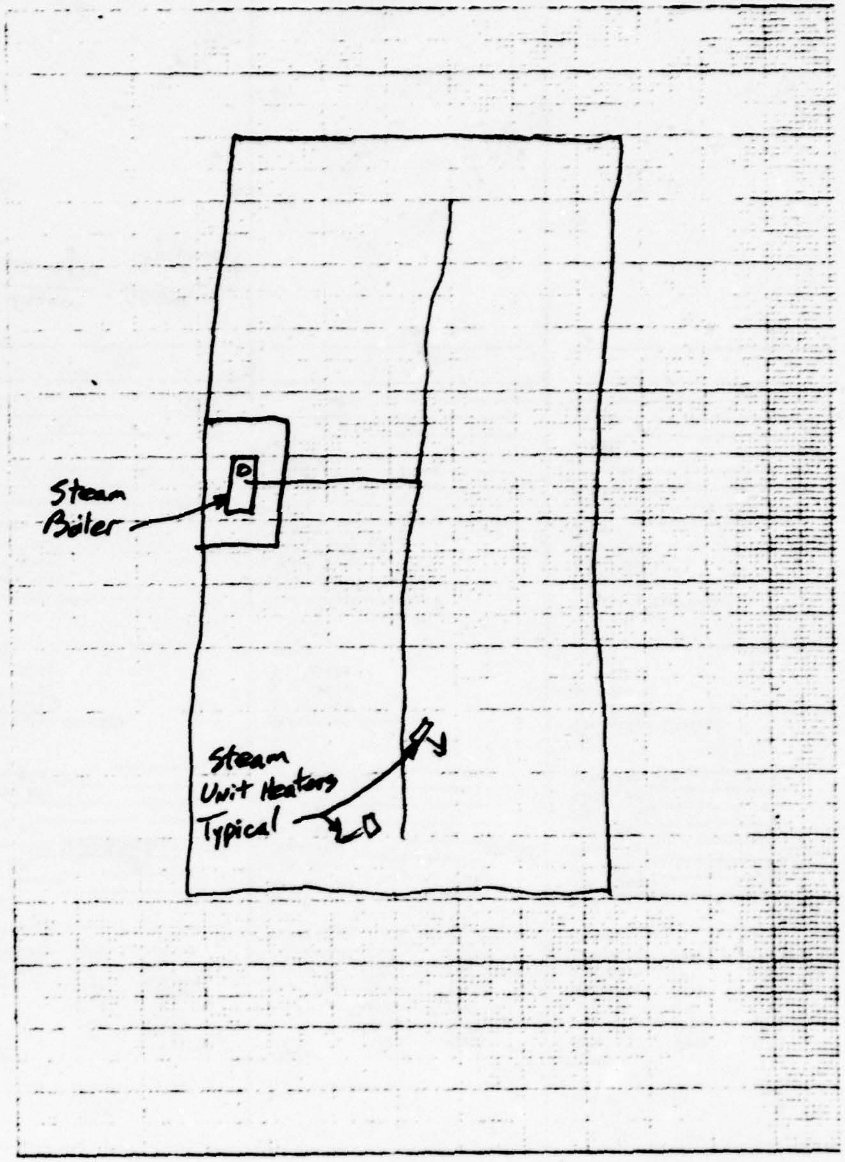
Glass Shading: External ____ Internal ____

"U" Factor: Roof .20 Wall .25 Glass ____

Glass SC: ____

Critical Areas: ____

Notes: occupied 730-1630 M-F



Sys # 1

Type:
Boiler (HW) [✓ (STM)]
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: 3,000,000 BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
[✓ Winter Only]
Other

Operation (Daily)
1 Shift
2 Shift
[✓ 3 Shift]
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys #

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys #

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys # 2

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) [✓ (STM)]
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: 2800,[illegible] BTU/HR
Pump HP
%OA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

$\frac{2,800,000}{1.08 \times 40°\Delta T} = 64815$ cfm equivalent

Sys #

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: BTU/HR
Pump HP
%OA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

Sys #

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: BTU/HR
Pump HP
%OA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: 500 **Usage:** Administration Building

Gross Area Sq. Ft.: 13,000 **No. Floors:** 1

Approx. Floor to Floor Height: 12'

Approx. Glass Dimensions: Height 5' **Width** 2.5'

Type of Glass: single, clear

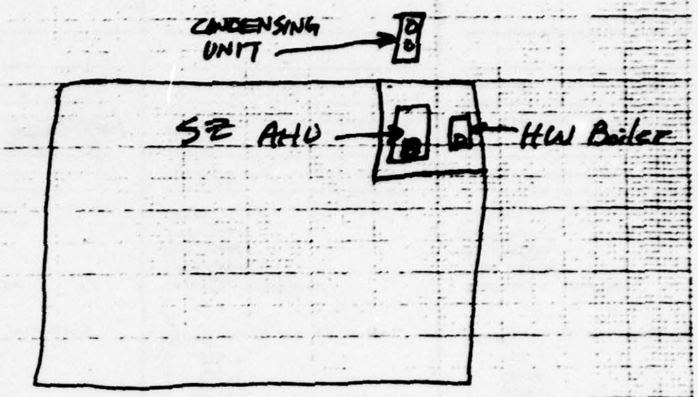
Glass Shading: External — **Internal** blinds

"U" Factor: Roof .15 **Wall** .20 **Glass** 1.0

Glass SC: .56

Critical Areas: —

Notes: occupied 730-1630 M-F



Sys # 2

Type:
Boiler [✓ (HW)] (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: 600000 BTU/HR.
Pump HP: 1
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
[✓ Winter Only]
Other

Operation (Daily)
1 Shift
2 Shift
[✓ 3 Shift]
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys #

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys #

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:

Capacity: BTU/HR.
Pump HP:
Pump HP:
Comp HP:
Fan HP:
Other HP:

Operation (Annual)
Year Round
Summer Only
Winter Only
Other

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
O.A. Reset
Other:

Notes:

Sys # 1

Type:
AHU (SZ) (TR)
(MZ) (HV)
[✓ (SP)] (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM: 15000
No. Zones:
Fan HP: 20
Capacity: BTU/HR
Pump HP
ZOA:
Comp. HP: 40
Cond Fan HP: 3

Operation (Daily)
[✓ 1 Shift]
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes: runs 24hrs/day

Sys #

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: BTU/HR
Pump HP
ZOA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

Sys #

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other

CFM:
No. Zones:
Fan HP:
Capacity: BTU/HR
Pump HP
ZOA:
Comp. HP:
Cond Fan HP:

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:

Notes:

9.3 SAVINGS ANALYSIS

The savings resulting from EMCS installation on the SAMPLE NAVAL BASE are calculated in this section. A summary of the equations used in estimating the savings is included on the following pages. Following that is a summary of computerized simulation results for the analysis of functions which are not easily calculated manually. Also included are example computer program output summaries. The actual savings - cost calculation worksheets for the Sample Naval Base are included at the end of Section 9.4 Cost Analysis.

Note: Special attention should be paid to the fact that false duplication of calculated savings must be avoided. EMCS functions are interrelated and that fact must be accounted for as discussed in Section 5.0. If both time scheduled operation and duty cycling are to be performed on a system then the duty cycling savings would have to be calculated based on only the time period the system is turned on by the time scheduled operation function.

9.3.1 SAVINGS EQUATION SUMMARY

Symbols - The following symbols are used in the savings calculation equations:

C = control efficiency factor, use 1.0 if no time clock existing and 0.3 if time clock is existing.

D = fraction of an hour which system may be cycled off during critical electrical demand situations, use 15 minutes per hour.

EFLH = equivalent full load hours, annually. Assume 1000 EFLH for both heating and cooling.

H = number of hours of required operation per year

HS = number of hours in summer where system may be shut off because the outside temperature is below a limit.

HW = number of hours in winter where system may be shut off because the outside temperature is above a limit.

I = maximum heat transfer capacity of device in THERMS.

KW/HP = conversion at 0.746 KW/HP

L = load factor, use 0.8 to account for combination of diversity, motor efficiency, power factor, and motor oversizing

M = number of months during which load operates, for refrigeration equipment use 6 months/year, air handlers 12 months/year.

O = fraction of an hour which system may be cycled off for consumption reduction, use 10 minutes per your

OD = number of days of required operation per year.

PECD = percent energy consumption decrease, annually (expressed in decimal, i.e. 1% = .01), use 1% savings.

PEI = percent efficiency increase per °F increase/decrease in CHW/CDW temperature (expressed in decimal, i.e., 1% = .01), use 1.5% efficiency increase per degree F.

SKW = Kilowatt demand savings

SKWH = annual Kilowatt hour savings

STHERMS = annual therms heating savings

Time Scheduled Operation

- ° Cooling Savings - Simulation (do not include auxiliaries)
- ° Heating Savings - Simulation (do not include auxiliaries)
- ° Auxiliary Savings (fans, pumps, constant running apparatus) -

SKWH = HP x L x KW/HP x (8760-H) x C= HP x .8 x .746 x (8760-H) x C
= HP x (8760-H) x C x .597

HP = total nameplate HP of constant loads.

Duty Cycling

- ° Heating and Cooling Savings - Assume None
- ° Auxiliary Savings (fans, pumps, constant running motors) -

SKWH = HP x L x O x H x KW/HP = HP x 0.8 x 10/60 x H x .746
= HP x H x .099

HP = total nameplate HP of constant loads.

Demand Limiting

- ° SKW = HP x L x KW/HP x D x M = HP x 0.8 x .746 x 15/60 x M
= HP x M x 0.149

HP = total electrical load of system (fans, pumps, compressors, etc.)

Start/Stop Optimization

- ° Cooling Savings - Assume None
- ° Heating Savings - Assume None
- ° Auxiliary Savings -

SKWH = HP x L x KW/HP x T x OD = HP x .8 x .746 x .5 x OD
= HP x OD x 0.298

Outside Air Limit Shutoff

- ° Auxiliary Savings (fans, pumps, etc.) -

SKWH = HP x L x KW/HP x (HS + HW) = HP x .8 x .746 x (HS + HW)
= HP x (HS + HW) x .597

HP = nameplate HP of constant loads.

Maintenance Run Time

° Savings - estimate manhours at 2 manhours per system

Enthalpy Economizer

° Cooling Savings - Simulation

° Heating Savings - None

Hot/Cold Deck Reset

° Cooling Savings - Simulation

° Heating Savings - Simulation

Chilled Water Reset

° Cooling Savings -

SKWH = Tons x EFLH x 1 KWH/ton-hr. x PEI x (°F CHW Increase)
= Tons x 1000 x 1 x .015 x 2
= Tons x 30

Condenser Water Reset

° Cooling Savings -

SKWH = Tons x EFLH x 1 KWH/ton-hr. x PEI x (°F CW Decrease)
= Tons x 1000 x 1 x .015 x 3
= Tons x 45

Outside Air Schedule Reset

° Savings -

STHERMS = EFLH x PECD x I = 1000 x 0.01 x I = I x 10

Safety Alarms

° Savings - Estimate Manhours at 2 manhours per system

The following page is a system savings - cost calculation sheet with equations and constants as indicated above. This form will be used for estimating savings for each system.

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. ________ System No. ________ System Type ________

FUNCTION	SAVINGS CALCULATIONS (See _____ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: ______ (cfm/MBH) x ______ (Table ___) Heating: ______ (cfm/MBH) x ______ (Table ___) Auxiliaries: ______ HP x (8760 - ______) x $\frac{[illegible]}{0.3}$ x 0.597	0 0 0	 0 	0 0	0 0 0	Basic Functions $ ______
Duty Cycling	______ HP x ______ Hrs x 0.099	0		0	0	
Demand Limiting	______ HP x ______ Mo. x 0.149		0	0	0	
Outside Air Temp. Limit	______ HP x (______ Summer + ______ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	______ HP x ______ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system					
H/C Deck Reset	Cooling: ______ (cfm) x ______ (Table ___) Heating: ______ (cfm) x ______ (Table ___)	0 0	 0	0	0 0	$ ______
Enthalpy Economizer	______ (cfm) x ______ (Table ___)	0		0	0	$ ______
Chilled Water Reset	______ Tons x 1000 FLH x 0.030	0		0	0	$ ______
Condenser Water Reset	______ Tons x 1000 FLH x 0.045	0		0	0	$ ______
Outside Air Temp. Reset	~~FLH x~~ ______ THERMS ~~(MBH)~~ x 10	0	0		0	$ ______
Safety Alarms	2 man-hours/system	0	0		0	$ ______
	TOTALS FOR SYSTEM					$ ______

9.3.2 COMPUTER SIMULATION RESULTS

The computerized energy analysis results used in calculating cooling and heating savings are included on the following page. The analysis was performed using the APEC ESP-1 computer program. Example printouts from the analysis are included after the summary. Two types of buildings were analyzed, a two story, 30,000 square foot administration type building, and a one story, 80,000 square foot shop/warehouse type structure. Several occupancy and usage schedules were analyzed which represents those most prevalent at the Sample Naval Base.

COMPUTERIZED ENERGY ANALYSIS RESULTS

BUILDING OCCUPANCY	BASE RUN #	BASE SYSTEM OPERATION	REVISED RUN #	REVISED SYSTEM OPERATION	FUEL SAVINGS GALLONS	ELECT SAVINGS KWH	HEATING UNIT SAVINGS THERM/CFM	COOLING UNIT SAVINGS (KWH/CFM)
Admin-SZAHU 1 shift/5 day	1	24 Hr	2	1 shift/5 day	8,359	40,773	0.390	1.3591
Admin-SZAHU 1 shift/5 day	2	1 shift/5 day	3	1 shift/5 day w/economizer	0	8,155	0	0.2718
Admin-MZAHU 1 shift/5 day	4	24 Hr	5	1 shift/5 day	25,077	122,319	1.17	4.0773
Admin-MZAHU 1 shift/5 day	5	1 shift/5 day	6	1 shift/5 day w/deck reset	5,015	24,464	0.234	0.8155
Shop 1 shift/5 day	9	24 Hr	10	1 shift/5 day	13,479	60,292	0.236	0.7537

Note:

SZAHU = Single zone air handling unit.
MZAHU = Multi-zone air handling unit.

EXAMPLE COMPUTERIZED ENERGY ANALYSIS SUMMARY PRINTOUTS

```
                MASTER METER ENERGY REPORT

        ELECTRICITY          GAS               STEAM             DIESEL
        KWH      KWH     CFH       CF       LBH       LBS     GPH       GAL
JAN     141.   22565.   1077.  331390.       0.        0.      0.        0.
FEB     147.   20452.   1212.  326261.       0.        0.      0.        0.
MAR     146.   23608.    866.  258331.       0.        0.      0.        0.
APR     161.   25579.    556.  108953.       0.        0.      0.        0.
MAY     165.   34934.    408.   45584.       0.        0.      0.        0.
JUN     187.   45206.    194.    5847.       0.        0.      0.        0.
JUL     198.   53960.     94.     583.       0.        0.      0.        0.
AUG     196.   56563.    115.     869.       0.        0.      0.        0.
SEP     171.   38144.    372.   13752.       0.        0.      0.        0.
OCT     160.   30496.    396.   50804.       0.        0.      0.        0.
NOV     148.   23337.    959.  260570.       0.        0.      0.        0.
DEC     145.   21632.   1259.  313936.       0.        0.      0.        0.
              --------         --------           --------          --------
TOTAL          396518.         1716881.                 0.                0.

        OIL TYPE 1        OIL TYPE 2           COAL              TOTAL
        GPH      GAL     GPH      GAL       LBH       LBS     MBTU
JAN       0.       0.      0.       0.       0.        0.     408402.
FEB       0.       0.      0.       0.       0.        0.     396061.
MAR       0.       0.      0.       0.       0.        0.     338903.
APR       0.       0.      0.       0.       0.        0.     196253.
MAY       0.       0.      0.       0.       0.        0.     164810.
JUN       0.       0.      0.       0.       0.        0.     160134.
JUL       0.       0.      0.       0.       0.        0.     184819.
AUG       0.       0.      0.       0.       0.        0.     193986.
SEP       0.       0.      0.       0.       0.        0.     143936.
OCT       0.       0.      0.       0.       0.        0.     154891.
NOV       0.       0.      0.       0.       0.        0.     340218.
DEC       0.       0.      0.       0.       0.        0.     387765.
              --------         --------           --------  ---------
TOTAL               0.               0.                 0.   3070175.

ENERGY SOURCE    TYPE             HEAT CONTENT          DEMAND

        1     ELECTRICITY      3413.   BTU/KW          HOURLY
        2     GAS              1000.   BTU/CU FT       HOURLY
        3     STEAM            1060.   BTU/LB          HOURLY
        4     DIESEL         134700.   BTU/GAL         HOURLY
        5     OIL TYPE 1     138500.   BTU/GAL         HOURLY
        6     OIL TYPE 2     152000.   BTU/GAL         HOURLY
        7     COAL            10900.   BTU/LB          HOURLY
```

$$\frac{1{,}716{,}881 \text{ ft}^3 \times 1000 \text{ BTU/ft}^3}{138{,}700 \text{ BTU/gal}} = 12{,}378 \text{ gal}$$

①

```
AUTOMATED PROCEDURES FOR ENGINEERING CONSULTANTS, INC.               7/ 6/78
------------------------------------------------------------------------------
ESP-1 SYSTEMS   VER 00 LEV 00      NEWCOMB AND BOYD CONSULTING ENGINEERS
******************************************************************************
PROJECT - 7cN53          NORFOLK NAVAL SHIPYARD-ADMIN BLDG            PAGE  24

                         MASTER METER ENERGY REPORT

          ELECTRICITY            GAS                STEAM              DIESEL
         KW-        KWH     CFH       CF        LBH          LBS     GPH        GAL
JAN      141.    22492.   1409.  128074.         0.           0.      0.         0.
FEB      147.    19817.   1409.  105852.         0.           0.      0.         0.
MAR      146.    23536.   1409.   86435.         0.           0.      0.         0.
APR      152.    25408.    627.   22174.         0.           0.      0.         0.
MAY      166.    33185.    358.    4540.         0.           0.      0.         0.
JUN      193.    37770.    157.     332.         0.           0.      0.         0.
JUL      202.    41877.      0.       0.         0.           0.      0.         0.
AUG      198.    45216.      0.       0.         0.           0.      0.         0.
SEP      173.    32567.    171.     494.         0.           0.      0.         0.
OCT      160.    29174.    386.    8882.         0.           0.      0.         0.
NOV      149.    23355.   1409.   88993.         0.           0.      0.         0.
DEC      144.    21346.   1409.  111626.         0.           0.      0.         0.
                --------         --------                --------           --------
TOTAL            355745.          557402.                      0.                 0.

          OIL TYPE 1       OIL TYPE 2              COAL               TOTAL
         GPH        GAL     GPH       GAL       LBH          LBS      MBTU
JAN       0.         0.      0.        0.        0.           0.    204840.
FEB       0.         0.      0.        0.        0.           0.    173487.
MAR       0.         0.      0.        0.        0.           0.    166762.
APR       0.         0.      0.        0.        0.           0.    108890.
MAY       0.         0.      0.        0.        0.           0.    117799.
JUN       0.         0.      0.        0.        0.           0.    129243.
JUL       0.         0.      0.        0.        0.           0.    142925.
AUG       0.         0.      0.        0.        0.           0.    154329.
SEP       0.         0.      0.        0.        0.           0.    111647.
OCT       0.         0.      0.        0.        0.           0.    108452.
NOV       0.         0.      0.        0.        0.           0.    168702.
DEC       0.         0.      0.        0.        0.           0.    184480.
                --------         --------                --------   ---------
TOTAL                0.                0.                      0.   1771556.

ENERGY SOURCE      TYPE            HEAT CONTENT            DEMAND

         1    ELECTRICITY        3413.    BTU/KW           HOURLY
         2    GAS                1000.    BTU/CU FT        HOURLY
         3    STEAM              1060.    BTU/LB           HOURLY
         4    DIESEL           134700.    BTU/GAL          HOURLY
         5    OIL TYPE 1       138500.    BTU/GAL          HOURLY
         6    OIL TYPE 2       152000.    BTU/GAL          HOURLY
         7    COAL              10900.    BTU/LB           HOURLY
```

$$\frac{557402\ ft^3 \times 1000\ ^{BTU}/_{ft^3}}{138,700\ ^{BTU}/_{gal}} = 4019\ g$$

②

9.4 COST ANALYSIS

The EMCS installation cost consists of central hardware and software cost, transmission system cost, building connection cost, and individual point cost.

The central hardware and software cost (along with other miscellaneous costs) are estimated as follows (using data from Section 6.0 of this report):

Item	Cost
Central Hardware:	
Central Control Unit (CCU)	$ 25,000.
Central Communications Controller (CCC)	$ 25,000.
Printers (2 @ $4,000.)	$ 8,000.
Paper Tape Reader/Punch	$ 5,000.
Disk Storage System	$ 20,000.
B&W CRT	$ 3,000.
Graphic CRT	$ 8,000.
Uninterruptable Clock	$ 1,625.
Central Software:	
Command Software Package	$ 30,000.
Applications Software Package	$ 40,000.
Graphics Pages (50 @ 100)	$ 5,000.
CCC Software Package	$ 10,000.
Training	$ 7,000.
Documentation	$ 14,000.
Testing	$ 27,000.
Shop Drawings, Supervision, etc.	$ 30,000.
Subtotal	$258,625.
Overhead and Profit (use 35%)	$ 90,519.
Current Construction Cost	$349,144.
Escalation (from Nov 1978 to bid date of Nov 1979 @ 7% per year)	$ 24,440.
Total Estimated Bid Price (central)	$373,584.

The building connection cost consists of the FID cost, that cost is:

FID (each)	$ 3,000.
Overhead and Profit (use 35%)	$ 1,050.
Current Construction Cost	$ 4,050.
Escalation (7%)	$ 284.
Total Estimated Bid Price (per FID)	$ 4,334.

Point costs are those itemized in the Section 6.0 tables plus overhead and profit and escalation. Those values have been multiplied by 1.4445 (1.35 x 1.07) to account for these items. Point costs to perform applicable functions on different system types are tabulated on the following pages. Points required to perform each function are illustrated on the system schematics in APPENDIX B.

SYSTEM/FUNCTION POINT COSTS

System Type	Function	Points Required	Point Cost
H.W. Boiler	Run Time Record	H.W. Flow Status	$ 199.
		Subtotal	$ 199.
		x 1.445 =	$ 288.
	O.A. Temp Reset	H.W.S. Temp.	$ 216.
		H.W.R. Temp	$ 216.
		H.W.S. Controller Reset	$ 533.
		Subtotal	$ 965.
		x 1.445 =	$1,394.
	Safety Alarms	Alarm Contact Status	$ 159.
		Subtotal	$ 159.
		x 1.445 =	$ 230.
Single Zone Air Handler	Basic (Note 1)	Fan Start/Stop Control	$ 179.
		Fan Flow Status	$ 199.
		Space Temp.	$ 236.
		Subtotal	$ 614.
		x 1.445 =	$ 887.
	Enthalpy Economizer	R.A. Temp.	$ 232.
		R.A. Humid.	$ 346.
		Economizer Cont Interface	$ 479.
		Subtotal	$1,057.
		x 1.445 =	$1,527.
Air Cooled Chiller	Basic (Note 1)	Chiller Start/Stop Control	$ 179.
		C.W. Pump Flow Status	$ 199.
		Subtotal	$ 378.
		x 1.445	$ 546.
	Chilled Wtr. Reset	C.W.S. Temp.	$ 216.
		C.W.R. Temp.	$ 216.
		C.W. Controller Reset	$ 533.
		Subtotal	$ 965.
		x 1.445	$1,394.
	Safety Alarms	Alarm Contact Status	$ 159.
		Subtotal	$ 159.
		x 1.445	$ 230.
Multizone Air Handler	Basic (Note 1)	Fan Start/Stop Control	$ 179.
		Fan Flow Status	$ 199.
		Space Temp.	$ 236.
		Subtotal	$ 614.
		x 1.445	$ 887.

	H/C Deck Reset	H. Deck Temp	$ 255.
		C. Deck Temp.	$ 255.
		H.D. Cont. Reset	$ 533.
		C.O. Cont. Reset	$ 533.
		Demand Selectors (2)	$1,046.
		Subtotal	$2,622.
		x 1.445	$3,789.
Stm. Boiler	Safety Alarms	Alarm Contact Status	$ 159.
		Subtotal	$ 159.
		x 1.445	$ 230.
Stem. Unit	Basic (Note 1)	Valve Open/Close Interface	$ 211.
		Space Temp.	$ 236.
		Steam Valve	$1,698.
		Aquastat Status	$ 199.
		Subtotal	$2,344.
		x 1.445	$3,387.

SYSTEM/SAVINGS COST CALCULATION WORK SHEETS

Note: Sensors and controls used to perform certain functions may also be used to perform other functions. Duplication of cost of these devices in the analysis of each function must be avoided. On the following calculation forms, this has been accomplished by grouping functions which require the same field devices (such as time scheduled operation, duty cycling, demand limiting, etc.).

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 100 System No. 1 System Type HW Boiler

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: ____ (cfm/MBH) x ____ (Table ___) Heating: ____ (cfm/MBH) x ____ (Table ___) Auxiliaries: ____ HP x (8760 - ____) x [illegible] x0597	0 0 0	0	0 0	0 0 0	Basic Funct: $ 288
Duty Cycling	____ HP x ____ Hrs x 0.099	0		0	0	
Demand Limiting	____ HP x ____ Mo. x 0.149		0	0	0	
Outside Air Temp. Limit	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	____ HP x ____ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
H/C Deck Reset	Cooling: ____ (cfm) x ____ (Table ___) Heating: ____ (cfm) x ____ (Table ___)	0 0	0	0	0 0	$ ____
Enthalpy Economizer	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
Chilled Water Reset	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
Condenser Water Reset	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
Outside Air Temp. Reset	~~____ FLH x~~ 7.5 THERMS ~~(MBH)~~ x 10	0	0	75	0	$ 1394
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	0	0	75	4	$ 1912.

SYSTEM SAVINGS - COST CALCULATIONS

Project: Sample Naval Base

Building No. 100 System No. 2 System Type A/C CHILLER

FUNCTION	SAVINGS CALCULATIONS (See _____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	~~Cooling~~: _____ (cfm/MBH) x _____ (Table ___) ~~Heating~~: _____ (cfm/MBH) x _____ (Table ___) Auxiliaries: 3 HP x (8760 - 2500) x ~~[illegible]~~ x0.597	0 0 0	0 0 11212	0 0 0	0 0 0	Basic Functi $ 546
~~Duty Cycling~~	_____ HP x _____ Hrs x 0.099	0		0	0	
Demand Limiting	48 HP x 6 Mo. x 0.149	43	0	0	0	
~~Outside Air Temp. Limit~~	_____ HP x (_____ Summer + _____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	3 HP x 250 days x 0.298	0	224	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
~~H/C Deck Reset~~	Cooling: _____ (cfm) x _____ (Table ___) Heating: _____ (cfm) x _____ (Table ___)	0 0	 0	0	0 0	$ _____
~~Enthalpy Economizer~~	_____ (cfm) x _____ (Table ___)	0		0	0	$ _____
~~Chilled Water Reset~~	TOO SMALL Tons x 1000 FLH x 0.030	0		0	0	$ _____
~~Condenser Water Reset~~	_____ Tons x 1000 FLH x 0.045	0		0	0	$ _____
~~Outside Air Temp. Reset~~	~~_____ FLH x~~ _____ THERMS ~~(MBH)~~ x 10	0	0		0	$ _____
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	43	11436	0	4	$ 776

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 100 System No. 3 System Type Multizone AHU

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: 16000 (cfm/~~MBH~~) x 1.3591 (Table ___) Heating: 16000 (cfm/~~MBH~~) x 0.390 (Table ___) Auxiliaries: 15 HP x (8760 - 2500) x 12 ~~12~~ x0.597	0 0 0	21746 0 56058	0 6240 0	0 0 0	Basic Funct: $ 887
Duty Cycling	15 HP x 2500 Hrs x 0.099	0	3713	0	0	
Demand Limiting	15 HP x 12 Mo. x 0.149	27	0	0	0	
~~Outside Air Temp. Limit~~	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	15 HP x 250 days x 0.298	0	1118	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
~~H/C Deck Reset~~	Cooling: ____ (cfm) x ____ (Table ___) Heating: ____ (cfm) x ____ (Table ___)	0 0	 0	0	0 0	$ ____
~~Enthalpy Economizer~~	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
~~Chilled Water Reset~~	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
~~Condenser Water Reset~~	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
~~Outside Air Temp. Reset~~	~~____ FLH x~~ ____ THERMS ~~(MBH)~~ x 10	0	0		0	$ ____
~~Safety Alarms~~	2 man-hours/system	0	0		0	$ ____
	TOTALS FOR SYSTEM	27	82635	6240	2	$ 887

SYSTEM SAVINGS - COST CALCULATIONS

Project: Sample Naval Base

Building No. 200 System No. 1 System Type Steam Boiler

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
~~Time Scheduled Operation~~	Cooling: ____ (cfm/MBH) x ____ (Table ___) Heating: ____ (cfm/MBH) x ____ (Table ___) Auxiliaries: ____ HP x (8760 - ____) x [illegible] x 0.597	0 0 0	0	0 0	0 0 0	Basic Functi $ ____
~~Duty Cycling~~	____ HP x ____ Hrs x 0.099	0		0	0	
~~Demand Limiting~~	____ HP x ____ Mo. x 0.149		0	0	0	
~~Outside Air Temp. Limit~~	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
~~Start/Stop Optimization~~	____ HP x ____ days x 0.298	0		0	0	
~~Run Time Recording~~	2 man-hours/system					
~~H/C Deck Reset~~	Cooling: ____ (cfm) x ____ (Table ___) Heating: ____ (cfm) x ____ (Table ___)	0 0	0	0	0 0	$ ____
~~Enthalpy Economizer~~	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
~~Chilled Water Reset~~	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
~~Condenser Water Reset~~	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
~~Outside Air Temp. Reset~~	~~____ FLH x~~ ____ THERMS ~~(MBH)~~ x 10	0	0		0	$ ____
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	0	0	0	2	$ 230

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 200 System No. 2 System Type split system

FUNCTION	SAVINGS CALCULATIONS (See ___ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: 8000 (cfm/~~MBH~~) x 1.3591 x .3 (Table ___) Heating: 8000 (cfm/~~MBH~~) x 0.390 x .3 (Table ___) Auxiliaries: 5 HP x (8760 - 2500) x ~~.25~~ x 0.597	0 0 0	3262 0 5606	0 936 0	0 0 0	Basic Functi $ 887
Duty Cycling	5 HP x 2500 Hrs x 0.099	0	1238	0	0	
Demand Limiting	27 HP x 6 Mo. x 0.149	24	0	0	0	
~~Outside Air Temp. Limit~~	___ HP x (___ Summer + ___ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	5 HP x 250 days x 0.298	0	373	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
~~H/C Deck Reset~~	Cooling: ___ (cfm) x ___ (Table ___) Heating: ___ (cfm) x ___ (Table ___)	0 0	 0	0	0 0	$ ___
Enthalpy Economizer	8000 (cfm) x .2718 (Table ___)	0	2174	0	0	$ 1527
~~Chilled Water Reset~~	___ Tons x 1000 FLH x 0.030	0		0	0	$ ___
~~Condenser Water Reset~~	___ Tons x 1000 FLH x 0.045	0		0	0	$ ___
~~Outside Air Temp. Reset~~	~~FLH x~~ ___ THERMS (~~MBH~~) x 10	0	0		0	$ ___
~~Safety Alarm~~	2 man-hours/system	0	0		0	$ ___
	TOTALS FOR SYSTEM	24	12653	936	2	$ 2414

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 300 System No. 1 System Type H.W. Boiler

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: ____ (cfm/MBH) x ____ (Table ___) Heating: ____ (cfm/MBH) x ____ (Table ___) Auxiliaries: ____ HP x (8760 - ____) x $\frac{1.0}{0.1}$ x 0.597	0 0 0	0	0 0	0 0 0	Basic Functi $ 288
Duty Cycling	____ HP x ____ Hrs x 0.099	0		0	0	
Demand Limiting	____ HP x ____ Mo. x 0.149		0	0	0	
Outside Air Temp. Limit	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	____ HP x ____ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
H/C Deck Reset	Cooling: ____ (cfm) x ____ (Table ___) Heating: ____ (cfm) x ____ (Table ___)	0 0	0	0	0 0	$ ____
Enthalpy Economizer	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
Chilled Water Reset	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
Condenser Water Reset	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
Outside Air Temp. Reset	~~FLH x~~ 15 THERMS ~~(MBH)~~ x 10	0	0	150	0	$ 1394
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	0	0	150	4	$ 1912

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 300 System No. 2 System Type H.W. Boiler

FUNCTION	SAVINGS CALCULATIONS (See _____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
~~Time Scheduled Operation~~	Cooling: _______ (cfm/MBH) x _______ (Table ___) Heating: _______ (cfm/MBH) x _______ (Table ___) Auxiliaries: _______ HP x (8760 - _______) x [illegible] x 0.597	0 0 0	0	0 0	0 0 0	Basic Functi $ 288
~~Duty Cycling~~	_______ HP x _______ Hrs x 0.099	0		0	0	
~~Demand Limiting~~	_______ HP x _______ Mo. x 0.149		0	0	0	
~~Outside Air Temp. Limit~~	_______ HP x (_______ + _______) Hrs x 0.597 Summer Winter	0		0	0	
~~Start/Stop Optimization~~	_______ HP x _______ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
~~H/C Deck Reset~~	Cooling: _______ (cfm) x _______ (Table ___) Heating: _______ (cfm) x _______ (Table ___)	0 0	0	0	0 0	$ _______
~~Enthalpy Economizer~~	_______ (cfm) x _______ (Table ___)	0		0	0	$ _______
~~Chilled Water Reset~~	_______ Tons x 1000 FLH x 0.080	0		0	0	$ _______
~~Condenser Water Reset~~	_______ Tons x 1000 FLH x 0.045	0		0	0	$ _______
Outside Air Temp. Reset	~~_______ FLH x~~ 15 THERMS (~~MBH~~) x 10	0	0	150	0	$ 1394
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	0	0	150	4	$ 1912

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 300 System No. 3 System Type A/C CHILLER

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	~~Cooling~~: ____ (cfm/MBH) x ____ (Table ___) ~~Heating~~: ____ (cfm/MBH) x ____ (Table ___) Auxiliaries: 15 HP x (8760 - 2500) x [illegible] x 0.597	0 0 0	 0 56058	0 0	0 0 0	Basic Functi $ 546
Duty Cycling	____ HP x ____ Hrs x 0.099	0		0	0	
Demand Limiting	225 HP x 6 (at load) Mo. x 0.149	201	0	0	0	
~~Outside Air Temp. Limit~~	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	15 HP x 250 days x 0.298	0	1118	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
~~H/C Deck Reset~~	Cooling: ____ (cfm) x ____ (Table ___) Heating: ____ (cfm) x ____ (Table ___)	0 0	 0	0	0 0	$ ____
~~Enthalpy Economizer~~	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
Chilled Water Reset	160 Tons x 1000 FLH x 0.030	0	4800	0	0	$ 1394
~~Condenser Water Reset~~	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
~~Outside Air Temp. Reset~~	~~____ FLH x~~ ____ THERMS ~~(MBH)~~ x 10	0	0		0	$ ____
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	201	61,976	0	4	$ 2170

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 300 System No. 4 System Type Single Zone AHU

FUNCTION	SAVINGS CALCULATIONS (See _____ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: 30000 (cfm/~~MBH~~) x 1.3591 (Table ___) Heating: 30000 (cfm/MBH) x 0.390 (Table ___) Auxiliaries: 30 HP x (8760 - 2500) x [illegible] x0.597	0 0 0	40773 0 112117	0 11700 0	0 0 0	Basic Functi $ 887
~~Duty Cycling~~	NO-ABOVE 25HP- DO NOT CYCLE	0		0	0	
Demand Limiting	30 HP x 12 Mo. x 0.149	54	0	0	0	
~~Outside Air Temp Limit~~	_____ HP x (_____ + _____) Hrs x 0.597 Summer Winter	0		0	0	
Start/Stop Optimization	30 HP x 250 days x 0.298	0	4478	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
~~H/C Deck Reset~~	Cooling: _____ (cfm) x _____ (Table ___) Heating: _____ (cfm) x _____ (Table ___)	0 0	0	0	0 0	$ _____
Enthalpy Economizer	30000 (cfm) x 0.2718 (Table ___)	0	8154	0	0	$ 1527
~~Chilled Water Reset~~	_____ Tons x 1000 FLH x 0.030	0		0	0	$ _____
~~Condenser Water Reset~~	_____ Tons x 1000 FLH x 0.045	0		0	0	$ _____
~~Outside Air Temp. Reset~~	~~_____ FLH x~~ _____ THERMS ~~(MBH)~~ x 10	0	0		0	$ _____
~~Safety Alarms~~	2 man-hours/system	0	0		0	$ _____
	TOTALS FOR SYSTEM	54	165522	11700	2	$ 2414

SYSTEM SAVINGS - COST CALCULATIONS   Project: Sample Naval Base

Building No. 300   System No. 5   System Type Multizone AHU

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS KW	 KWH	 THERMS	 MH	COST (Table ___)
Time Scheduled Operation	Cooling: 18000 (cfm/~~MBH~~) x 4.0773 (Table ___) Heating: 18000 (cfm/~~MBH~~) x 1.17 (Table ___) Auxiliaries: 20 HP x (8760 - 2500) x 1.0 x0.597	0 0 0	73391 0 74744	0 21060 0	0 0 0	Basic Functi $ 887
Duty Cycling	20 HP x 2500 Hrs x 0.099	0	4950	0	0	
Demand Limiting	20 HP x 12 Mo. x 0.149	36	0	0	0	
Outside Air Temp. Limit	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	20 HP x 250 days x 0.298	0	1490	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
H/C Deck Reset	Cooling: 18000 (cfm) x 0.8155 (Table ___) Heating: 18000 (cfm) x 0.234 (Table ___)	0 0	14679 0	0 4212	0 0	$ 3789
Enthalpy Economizer	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
Chilled Water Reset	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
Condenser Water Reset	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
Outside Air Temp. Reset	~~FLH x~~ ____ THERMS ~~(MBH)~~ x 10	0	0		0	$ ____
Safety Alarms	2 man-hours/system	0	0		0	$ ____
	TOTALS FOR SYSTEM	36	169254	25272	2	$ 4676

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 300 System No. 6 System Type Multi-zone AHU

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: 20000 (cfm/MBH) x 4.0733 (Table ___) Heating: 20000 (cfm/MBH) x 1.17 (Table ___) Auxiliaries: 30 HP x (8760 - 2500) x [illegible] x 0.597	0 0 0	8146 0 112117	0 23400 0	0 0 0	Basic Funct: $ 887
~~Duty Cycling~~	____ HP x ____ Hrs x 0.099	0		0	0	
Demand Limiting	30 HP x 12 Mo. x 0.149	54	0	0	0	
~~Outside Air Temp. Limit~~	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	30 HP x 250 days x 0.298	0	2235	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
H/C Deck Reset	Cooling: 20000 (cfm) x 0.8155 (Table ___) Heating: 20000 (cfm) x 0.234 (Table ___)	0 0	16310 0	0 4680	0 0	$ 3789
~~Enthalpy Economizer~~	____ (cfm) x ____ (Table ___)	0		0	0	$ ____
~~Chilled Water Reset~~	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
~~Condenser Water Reset~~	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
~~Outside Air Temp. Reset~~	~~____ FLH x~~ ____ THERMS ~~(MBH)~~ x 10	0	0		0	$ ____
~~Safety Alarms~~	2 man-hours/system	0	0		0	$ ____
	TOTALS FOR SYSTEM	54	212128	28080	2	$ 4676

SYSTEM SAVINGS - COST CALCULATIONS

Project: Sample Naval Base

Building No. 400 System No. 1 System Type Stm Boiler

FUNCTION	SAVINGS CALCULATIONS (See _____ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: _______ (cfm/MBH) x _______ (Table ___) Heating: _______ (cfm/MBH) x _______ (Table ___) Auxiliaries: _______ HP x (8760 - _______) x [illegible] x 0.597	0 0 0	0	0 0	0 0 0	Basic Functi $ _______
Duty Cycling	_______ HP x _______ Hrs x 0.099	0		0	0	
Demand Limiting	_______ HP x _______ Mo. x 0.149		0	0	0	
Outside Air Temp. Limit	_______ HP x (_______ Summer + _______ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	_______ HP x _______ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system					
H/C Deck Reset	Cooling: _______ (cfm) x _______ (Table ___) Heating: _______ (cfm) x _______ (Table ___)	0 0	0	0	0 0	$ _______
Enthalpy Economizer	_______ (cfm) x _______ (Table ___)	0		0	0	$ _______
Chilled Water Reset	_______ Tons x 1000 FLH x 0.030	0		0	0	$ _______
Condenser Water Reset	_______ Tons x 1000 FLH x 0.045	0		0	0	$ _______
Outside Air Temp. Reset	~~_______ FLH x~~ _______ THERMS ~~(MBH)~~ x 10	0	0		0	$ _______
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	0	0	0	2	$ 230

SYSTEM SAVINGS - COST CALCULATIONS

Project: Sample Naval Base

Building No. 400 System No. 2 System Type Steam Unit Heaters

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Coo~~ling~~: ______ (cfm/MBH) x ______ (Table ___) Heating: 64815 (cfm/MBH) x 0.236 (Table ___) Auxiliaries: ______ HP x (8760 - ______) x [illegible] x0.597	0 0 0	 0 	0 15296 0	0 0 0	Basic Functi $ 3387
Duty Cycling	______ HP x ______ Hrs x 0.099	0		0	0	
Demand Limiting	______ HP x ______ Mo. x 0.149		0	0	0	
Outside Air Temp. Limit	______ HP x (______ Summer + ______ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	______ HP x ______ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system					
H/C Deck Reset	Cooling: ______ (cfm) x ______ (Table ___) Heating: ______ (cfm) x ______ (Table ___)	0 0	 0	0 	0 0	$ ______
Enthalpy Economizer	______ (cfm) x ______ (Table ___)	0		0	0	$ ______
Chilled Water Reset	______ Tons x 1000 FLH x 0.030	0		0	0	$ ______
Condenser Water Reset	______ Tons x 1000 FLH x 0.045	0		0	0	$ ______
Outside Air Temp. Reset	~~______ FLH x~~ ______ THERMS ~~(MBH)~~ x 10	0	0		0	$ ______
Safety Alarms	2 man-hours/system	0	0		0	$ ______
	TOTALS FOR SYSTEM	0	0	15296	0	$ 3387

SYSTEM SAVINGS - COST CALCULATIONS

Project: Sample Naval Base

Building No. 500 System No. 1 System Type Split System

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: 15000 (cfm/MBH) x 1.3591 (Table __) Heating: 15000 (cfm/MBH) x 0.390 (Table __) Auxiliaries: 20 HP x (8760 - 2500) x ~~[illegible]~~ 1.0 x0.597	0 0 0	20387 0 74744	0 5850 0	0 0 0	Basic Functi $ 887
Duty Cycling	20 HP x 2500 Hrs x 0.099	0	4950	0	0	
Demand Limiting	63 HP x 6 Mo. x 0.149	56	0	0	0	
Outside Air Temp. Limit	____ HP x (____ Summer + ____ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	20 HP x 250 days x 0.298	0	1490	0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
H/C Deck Reset	Cooling: ____ (cfm) x ____ (Table __) Heating: ____ (cfm) x ____ (Table __)	0 0	0	0	0 0	$ ____
Enthalpy Economizer	____ (cfm) x ____ (Table __)	0		0	0	$ ____
Chilled Water Reset	____ Tons x 1000 FLH x 0.030	0		0	0	$ ____
Condenser Water Reset	____ Tons x 1000 FLH x 0.045	0		0	0	$ ____
Outside Air Temp. Reset	~~FLH x~~ ____ THERMS ~~(MBH)~~ x 10	0	0		0	$ ____
Safety Alarms	2 man-hours/system	0	0		0	$ ____
	TOTALS FOR SYSTEM	56	101571	5850	2	$ 887

SYSTEM SAVINGS - COST CALCULATIONS Project: Sample Naval Base

Building No. 500 System No. 2 System Type HW Boiler

FUNCTION	SAVINGS CALCULATIONS (See ____ for Derivation of Constants)	SAVINGS				COST (Table ___)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: ______ (cfm/MBH) x ______ (Table ___) Heating: ______ (cfm/MBH) x ______ (Table ___) Auxiliaries: ______ HP x (8760 - ______) x [illegible] x0.597	0 0 0	 0 	0 0	0 0 0	Basic Functi $ 288
Duty Cycling	______ HP x ______ Hrs x 0.099	0		0	0	
Demand Limiting	______ HP x ______ Mo. x 0.149		0	0	0	
Outside Air Temp. Limit	______ HP x (______ Summer + ______ Winter) Hrs x 0.597	0		0	0	
Start/Stop Optimization	______ HP x ______ days x 0.298	0		0	0	
Run Time Recording	2 man-hours/system	0	0	0	2	
H/C Deck Reset	Cooling: ______ (cfm) x ______ (Table ___) Heating: ______ (cfm) x ______ (Table ___)	0 0	 0	0 	0 0	$ ______
Enthalpy Economizer	______ (cfm) x ______ (Table ___)	0		0	0	$ ______
Chilled Water Reset	______ Tons x 1000 FLH x 0.030	0		0	0	$ ______
Condenser Water Reset	______ Tons x 1000 FLH x 0.045	0		0	0	$ ______
Outside Air Temp. Reset	~~______ FLH x~~ 6 THERMS (~~MBH~~) x 10	0	0	60	0	$ 1394
Safety Alarms	2 man-hours/system	0	0	0	2	$ 230
	TOTALS FOR SYSTEM	0	0	60	4	$ 1912

BUILDING SAVINGS - COST SUMMARY

Building # 100

SYSTEM NO.	SYSTEM TYPE	SAVINGS				COST
		KW	KWH	THERMS	MH	
1	H.W. Boiler	0	0	75	4	1912
2	A/C Chiller	43	11436	0	4	776
3	MZ AHU	27	82635	6240	2	887
	TOTALS	70	94071	6315	10	3575
		BUILDING CONNECT COST				4334
		TOTAL COST				7909

ENERGY SAVINGS = (94071 KWH X 11,600) + (6315 THERMS x 100,000) / 1,000,000 BTU/MBTU = 1723 MBTU

$ SAVINGS = (70 KW x $ 4.00 /KW) + (94071 KWH x $ .03 /KWH) + (6315 THERMS x $ .40 /THERM) + (10 MH x $ 10 /MH) = $ 5728

E/C RATIO = 218

BUILDING SAVINGS - COST SUMMARY

Building # 200

SYSTEM NO.	SYSTEM TYPE	SAVINGS				
		KW	KWH	THERMS	MH	COST
1	Stm. Boiler	0	0	0	2	230
2	Split Sys.	24	12653	936	2	2414
	TOTALS	24	12653	936	4	2644
		BUILDING CONNECT COST				4334
		TOTAL COST				6978

ENERGY SAVINGS = (12653 KWH X 11,600) + (936 THERMS x 100,000) / 1,000,000 BTU/MBTU = 240 MBTU

$ SAVINGS = (24 KW x $4.00 /KW) + (12653 KWH x $.03 /KWH)
+ (936 THERMS x $.40 /THERM) + (4 MH x $ 10 /MH) = $ 890

E/C RATIO = 34

9.5 BUILDING SAVINGS-COST SUMMARY SHEETS

BUILDING SAVINGS - COST SUMMARY

Building # 300

SYSTEM NO.	SYSTEM TYPE	SAVINGS				COST
		KW	KWH	THERMS	MH	
1	H.W. Boiler	0	0	150	4	1912
2	H.W. Boiler	0	0	150	4	1912
3	A/C Chiller	201	61,976	0	4	2170
4	SZ AHU	54	165522	11700	2	2414
5	MZ AHU	36	169254	25272	2	4676
6	MZ AHU	54	212128	28080	2	4676
	TOTALS	345	608880	65352	18	17760
		BUILDING CONNECT COST				4334
		TOTAL COST				22094

ENERGY SAVINGS = (608880 KWH X 11,600) + (65352 THERMS x 100,000) / 1,000,000 BTU/MBTU = 7241 MBTU

$ SAVINGS = (345 KW x $ 4.00 /KW) + (608880 KWH x $ .03 /KWH)
+ (65352 THERMS x $ .40 /THERM) + (18 MH x $ 10 /MH) = $ 45967

E/C RATIO = 328

BUILDING SAVINGS - COST SUMMARY

Building # 400

SYSTEM NO.	SYSTEM TYPE	SAVINGS				COST
		KW	KWH	THERMS	MH	
1	Stm Boiler	0	0	0	2	230
2	Stm. U. Htrs.	0	0	15296	0	3387
	TOTALS	0	0	15296	2	3617
		BUILDING CONNECT COST				4334
		TOTAL COST				7951

ENERGY SAVINGS = (0 KWH X 11,600) + (15296 THERMS x 100,000) / 1,000,000 BTU/MBTU = 1530 MBTU

$ SAVINGS = (0 KW x $ ____/KW) + (0 KWH x $ ____/KWH)
+ (15296 THERMS x $.4 /THERM) + (____ MH x $ ____/MH) = $ 6118

E/C RATIO = 192

AD-A073 419 CIVIL ENGINEERING LAB (NAVY) PORT HUENEME CA F/G 5/1
ENERGY MONITORING AND CONTROL SYSTEM (EMCS). ECONOMIC ANALYSIS --ETC(U)
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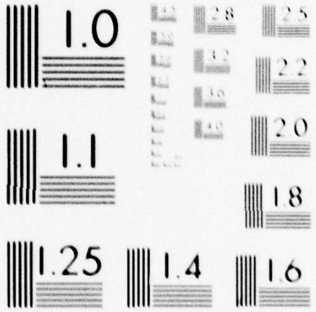


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

BUILDING SAVINGS - COST SUMMARY

Building # 500

SYSTEM NO.	SYSTEM TYPE	SAVINGS				COST
		KW	KWH	THERMS	MH	
1	Split Sys.	56	101571	5850	2	887
2	H.W. Boiler	0	0	60	4	1912
	TOTALS	56	101571	5910	6	2799
		BUILDING CONNECT COST				4334
		TOTAL COST				7133

ENERGY SAVINGS = $\frac{(\ 101571 \text{ KWH X } 11{,}600) + (\ 5910 \text{ THERMS x } 100{,}000)}{1{,}000{,}000 \text{ BTU/MBTU}}$ = 1769 MBTU

$ SAVINGS = (56 KW x $ 4.00/KW) + (101571 KWH x $ .03/KWH)
+ (5910 THERMS x $ .40 /THERM) + (6 MH x $ 10 /MH) = $ 5695

E/C RATIO = 248

9.6 PRIORITIZED BUILDING LIST

PRIORITIZED BUILDING LIST

BUILDING NUMBER	SAVINGS					E/C	COST	CUMULATIVE COST	
	KW	KWH	THERMS	MH	$				
——	——	——	——	——	——	——	——	373,584	FIXED COST
300	345	608880	65352	18	45967	328	22094	395,678	
500	56	101571	5910	6	5695	248	7133	402,811	
100	70	94071	6315	10	5728	218	7909	410,720	
400	0	0	15296	2	6118	192	7951	418,671	
200	24	12653	936	4	890	34	6978	425,649	
Totals above cutoff	471	710451	92873	36					

Cutoff line for budget = 420,000

9.7 ECIP ECONOMIC ANALYSIS SUMMARY

ECIP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION Norfolk, Va. P-001

TITLE OF PROJECT Sample Naval Base FY-80

INVESTMENT

1. PROJECT COSTS (Economic life of 15 years)
   - a. Project cost escalated to end of program year.... $420,000
   - b. Design costs not yet obligated $25,200
   - c. Total Project Cost (a + b) $445,200

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH: 710,451
   - a. Equivalent energy: KWH x 0.0116 ....(MBTU's: $ 8241)
   - b. Cost per KWH at end of program year .... $ 0.04
   - c. First year annual dollar savings (KWH x b) ...... $ 28418
   - d. Differential escalation present worth factor 12.278
   - e. Discounted savings (c x d) .... $ 348916

3. ANNUAL ENERGY SAVINGS (TYPE: Oil MBTU's: 9287)
   - a. Cost per MBTU at end of program year .... $ 5.38
   - b. First year annual dollar savings .... $ 49964
   - c. Differential escalation present worth factor 13.112
   - d. Discounted savings (b x c) .... $ 655128

4. ANNUAL ENERGY SAVINGS (TYPE: Elec Demand MBTU's: 471 kw)
   - a. Cost per ~~MBTU~~ KW at end of program year .... $ 5.38
   - b. First year annual dollar savings .... $ 2534
   - c. Differential escalation present worth factor 12.278
   - d. Discounted savings (b x c) .... $ 31112

5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
   - a. Labor ....(36mh. x 11.30)........................ $ 407
   - b. Material & Other (Op. & Maint.: 10% of const.)..... $(42000)
   - c. Total (a + b) .... $(41593)
   - d. 10% Discount Factor 7.980
   - e. Discounted Other-than-energy savings (or costs) . $(331,912)

6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c + 3b + 4b + 5c) .. $ 39,323

7. TOTAL DISCOUNTED SAVINGS (2e + 3d + 4d + 5e) .... $ 703,244

COST ESCALATION

			79	80			
Current	Elec	$ .03	x 1.16	x 1.16	x	x	= $ 0.04
rates	Oil	$ .40	x 1.16	x 1.16	x	x	= $ 0.538/therm = $5.38/MBTU
as of	Labor ~~Gas~~	$ 10.00	x 1.064	x 1.062	x	x	= $ 11.30
10/78	Demand	$ 4.00	x 1.16	x 1.16	x	x	= $ 5.38

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) 1.58
9. TOTAL MBTU SAVINGS 17528 ÷ (Line 1a ÷ 1000) 41.7
10. SIMPLE PAYBACK PERIOD (1a ÷ Line 6) .... 10.7 YRS

NOTE: For ETAP projects use line 1c in lines 9 and 10 in lieu of 1a.

APPENDIX

APPENDIX A - FUNCTION IDENTIFICATION

As stated previously, an EMCS function is defined as a specific independent operational capability. An EMCS can perform many different functions. It can be programmed to monitor, regulate, and control almost an infinite number of tasks. The same tasks may also be accomplished in an infinite number of ways. The identification used for a particular function varies with the individual EMCS manufacturers and their methods and approach to a particular function may also vary. This variation generally depends on the particular software or hardware a manufacturer uses to accomplish each function, rather than the function itself. Therefore, it is possible to identify individual functions the EMCS can perform. The following paragraphs identify the EMCS functions considered in this study. These represent the most common functions available from EMCS manufacturers today. Additional functions exist and may provide some additional energy and manpower savings, however, those listed will most certainly provide the bulk of these savings.

The following paragraphs describe each function considered in this study.

TIME SCHEDULED OPERATION

Time scheduled operation consists of the starting and stopping of a system based on the time and type of day. Type of day refers to weekdays, Saturdays, Sundays, holidays, or any other day which has a different schedule of operation. This is the simplest of all EMCS functions to install, maintain, and operate. It also provides the greatest potential for energy conservation if systems are currently being operated unnecessarily during unoccupied hours. HVAC systems connected to the EMCS generally include a temperature sensor in a space which prompts the EMCS to override the shutoff if the temperature drops below a certain level.

DUTY CYCLING

Duty cycling consists of the shutdown of a system for predetermined short periods of time during normal operating hours. This function is normally only applicable to heating, ventilating, and air conditioning systems. Its operation is based on the theory that HVAC systems seldom operate at peak output, thus if the system is shut off for a short period of time, it has enough capacity to overcome the slight temperature drift which occurs during this shutdown. Although the interruption does not reduce the net space heating or cooling energy, it does reduce energy input to constant auxiliary loads such as fans and pumps. This function also reduces outside air heating and cooling loads since the outside air intake damper is closed while an air handling unit is off. Systems are generally cycled off for some fixed period of time, say 15 minutes, out of each hour of operation. The off period time length and its frequency should be adjustable. The off period time length is normally adjusted for a longer duration during moderate seasons and shorter duration during peak seasons. Duty cycling does produce additional wear on belts and motor starting circuits. Further, it may affect building air balance between building zones. Awareness of these problems may preclude use of this function in certain cases.

DEMAND LIMITING START/STOP

This function consists of the stopping of electrical loads to prevent setting a high electrical demand peak and thus increasing electrical costs where demand oriented rate schedules apply. There are many complex schemes for accomplishing this function. They all generally monitor the base electrical demand continuously. Based on the monitored data, demand predictions are made by the EMCS. When these predictions exceed preset limits, certain scheduled electrical loads are shut off by the EMCS to reduce the rate of consumption and the predicted peak demand. Additional loads are turned off on a priority basis if the initial load shed action does not reduce the predicted demand enough to satisfy the function requirements. Generally, the loads to be shed are HVAC items. The reasoning used in the Duty Cycling discussion holds here also: allow a slight temperature drift in the space by shutting off the HVAC equipment. Utility rate schedules, which include "time of day" pricing, offer additional savings opportunities. Running of certain equipment, such as water well pumps, during off peak hours has significant impact under that type of schedule and should be thoroughly investigated.

OUTSIDE AIR TEMPERATURE LIMIT SHUTOFF

An Outside Air Temperature Limit Shutdown function provides the capability to automatically shut off or disable designated control points based on seasonally dependent designated outside air temperature limits. The EMCS disables or shuts off control points automatically if the outside air temperature rises above a preset value (WINTER mode of operation) or drops below a preset value (SUMMER mode of operation). The control point is restarted or reenabled whenever the outside air temperature drops below the preset value (WINTER) minus an adjustable differential or rises above the preset value (SUMMER) plus an adjustable differential. The current mode (SUMMER or WINTER) is defined and altered manually by the operator.

ENTHALPY ECONOMIZER

The utilization of an all outside air economizer cycle can be a cost effective energy conservation measure, depending on the climatic conditions and the type of mechanical system. Where applicable, the cycle uses outside air to satisfy all or a portion of the building's cooling requirements when the enthalpy or total heat content of the outside air is less than that of the return air from the space. Outside air is introduced through the mechanical system and relieved during this cycle in lieu of the normal recirculation system.

HOT/COLD DECK TEMPERATURE RESET

Mechanical systems such as dual duct systems and some multizone systems use a parallel arrangement of heating and cooling surfaces commonly referred to as hot and cold deck surfaces for the purposes of providing heating and cooling mediums simultaneously. Generally speaking, both heated and cooled air streams are mixed to satisfy the individual space thermal requirements.

In the absence of optimization controls, these systems can waste energy because the final space control merely mixes the two air streams to produce the desired result. While the space conditions may be acceptable, the greater the difference between the temperatures of the two streams, the more inefficiently the system will operate. This function can select the individual areas with the greatest heating and cooling requirements, establish the necessary hot deck and cold deck temperatures based on these extremes, and minimize the inefficiency of the system.

A variation of the hot and cold deck multizone system is the system equipped with a cold deck and a bypass section at the mechanical system and individual heating coils in the reheat position downstream from the unit. the system operates with a constant cold deck temperature which is, in turn, mixed with the bypass air in an effort to satisfy individual zone requirements. Air supplied at temperatures below the individual space temperature requirements is elevated in temperature by the reheat coil in response to signals from an individual space thermostat. Selection of the space with the greatest cooling requirements and resetting the cold deck discharge temperature in response to these requirements minimizes the energy used for reheat.

CHILLED WATER TEMPERATURE RESET

The energy required to generate chilled water in a reciprocating or centrifugal electric driven refrigeration machine is a function of a number of parameters including the temperature of the chilled water leaving the machine. Because the refrigerant suction temperature is a direct function of the leaving water temperature, the higher the two temperatures, the lower the energy input per ton of refrigeration. As a result, because chilled water temperatures are selected for peak design times, in the absence of strict humidity control requirements, most chilled water temperatures can be elevated during most operating hours. Depending on the operating hours, size of the equipment, and configuration of the system, energy savings can be effected by resetting the chilled water. The chilled water temperature can be elevated to satisfy the greatest cooling requirements. Generally, this determination is made by the position of the chilled water valves on the various cooling systems. The positions of the control devices supplying the various cooling coils are monitored and the chilled water temperature is elevated until at least one control device is in the maximum position. Other control schemes may be necessary to satisfy different system configurations.

CONDENSER WATER TEMPERATURE RESET

Another parameter affecting the energy input to a refrigeration system is the temperature of the condenser water entering the machine. Conventionally, heat rejection equipment is designed to produce a specified condenser water temperature such as 85° at peak wet bulb temperatures. In many instances, automatic controls are provided to maintain a specified temperature at conditions other than peak design. To optimize the performance of the condenser water system, however, this system can be reset when outdoor wet bulb temperatures will produce lower condenser water temperature.

Where applicable, this function will reduce the energy input to the refrigeration machine.

OUTSIDE AIR TEMPERATURE RESET SCHEDULE

Hot water heating systems, whether the hot water is supplied by a boiler or a converter, are designed to supply the heating requirements for the system at outdoor design temperatures. Frequently, depending on the specific system design, the hot water supply temperature can be reduced as the heating requirements for the facility are reduced. For most facilities, this reduction in heating requirements is directly related to an increase in outdoor ambient temperature. Where applicable, the capability to reduce the temperature of the supply water as a function of outdoor temperature will effect operating savings. To accomplish this function, the temperature controller for the hot water supply is reset on a predetermined schedule as a function of outdoor temperature.

START/STOP OPTIMIZATION

An additional feature of the time scheduled operation of mechanical systems described above is the optimized start/stop feature available from the system. Mechanical systems serving areas that are not occupied 24 hours a day should be shut down during the unoccupied hours. Traditionally, the systems are restarted before occupancy in order to cool down or heat up the space. Normally this function is performed on a fixed schedule independent of weather, space conditions, etc. The optimized start/stop feature of the system automatically starts and stops the system to minimize the energy required to provide the desired environmental conditions during occupied hours. The function automatically evaluates the thermal inertia of the structure, the capacity of the system to either increase or reduce temperatures in the facility, start-up and shut-down times, and weather conditions to accurately determine the minimum hours of operation of the HVAC system to satisfy the thermal requirements of the building.

BOILER PROFILE AND SELECT

In certain application of multi-boiler central heating plants, there is the opportunity to optimize the boiler plant by selecting the most efficient equipment to satisfy the instantaneous heating requirement. By monitoring fuel input as a function of the output, profiles can be developed for each of the units in a central plant. Based on the operating history developed, and the loads, plant operation can be optimized to minimize energy input.

CHILLER PROFILE AND SELECT

This function is very similar to the boiler profile described above. Operating data is obtained and compared with the predicted operating characteristics of each individual machine prepared by the manufacturer. Based on the operating data for each machine with the energy input requirements for each operating condition and the instantaneous load, the function would select the chiller or chillers required to meet the load with the minimum energy input.

MAINTENANCE RUN TIME REPORTS:

A number of maintenance functions associated with mechanical equipment are related to or can be related to the number of operating hours of the specific item of equipment. Some of these functions include lubrication, cleaning, bearing checks, etc.

SAFETY ALARMS:

Many items of mechanical equipment are provided with various types of alarms for both personnel and equipment protection. Alarms such as high and low water for boilers, gas pressure alarms, and various temperature and pressure alarms on refrigeration machines, are typical of the types of functions that can be monitored. Monitoring of such alarms provides the console operator with information regarding the failure of equipment or the development of potential problems with the system operation.

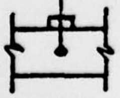
INTERCOM:

A function of the system that can be beneficial from a maintenance standpoint is the capability of communicating between the operators console, the field interface devices or other remote intercom station locations. The system can be used for intercommunication between maintenance personnel and console operator for a check out of the overall system, and for monitoring of start up of equipment.

APPENDIX B - SYSTEM SCHEMATICS

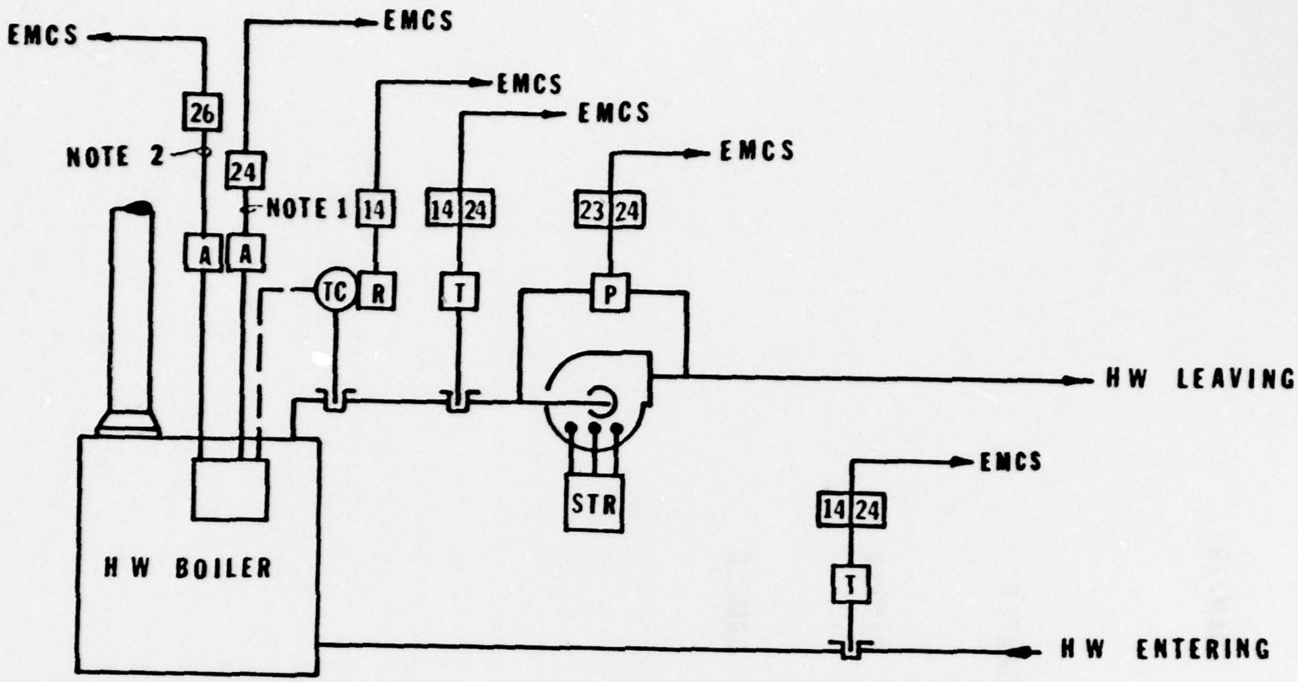
On the following pages find simplified schematics of common mechanical systems to which an EMCS may be applicable. EMCS functions commonly performed along with the sensors and controls required for each function are indicated for each schematic.

SYMBOLS

→ EMCS	SIGNAL TRANSMITTED TO EMCS
← EMCS	SIGNAL RECEIVED FROM EMCS
$\boxed{A}$	ALARM CONTACT SIGNAL
$\boxed{C}$	GREATEST COOLING DEMAND SIGNAL
$\boxed{E}$	ENTHALPY ECONOMIZER CONTROL INTERFACE
$\boxed{H}$	GREATEST HEATING DEMAND SIGNAL
$\boxed{I}$	LOCAL CONTROL INTERRUPTION INTERFACE
$\boxed{L}$	PRESSURE INDICATION SIGNAL
$\boxed{O}$	ON/OFF STATUS SIGNAL
$\boxed{P}$	DIFFERENTIAL PRESSURE SWITCH STATUS SIGNAL
$\boxed{R}$	CONTROLLER RESET INTERFACE
$\boxed{S}$	START/STOP INTERFACE
$\boxed{T}$	TEMPERATURE INDICATION
$\boxed{W}$	HUMIDITY INDICATION SIGNAL
$\boxed{14}$	FUNCTION NUMBER WHICH REQUIRES SIGNAL
(TC)	TEMPERATURE CONTROLLER
(PC)	PRESSURE CONTROLLER
$\boxed{DS}$	HIGH/LOW DEMAND SIGNAL SELECTOR
$\boxed{STR}$	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER

SYMBOLS CONTINUED

EA	EXHAUST AIR
EAD	EXHAUST AIR DAMPER
HW	HOT WATER
MA	MIXED AIR
MZD	MULTIZONE DAMPER
OA	OUTSIDE AIR
OAD	OUTSIDE AIR DAMPER
RA	RETURN AIR
RAD	RETURN AIR DAMPER
SA	SUPPLY AIR



NOTES:

1. PROVIDE INDIVIDUAL STATUS INDICATION SIGNALS TO THE EMCS FOR EACH OF FOLLOWING SAFETY DEVICES

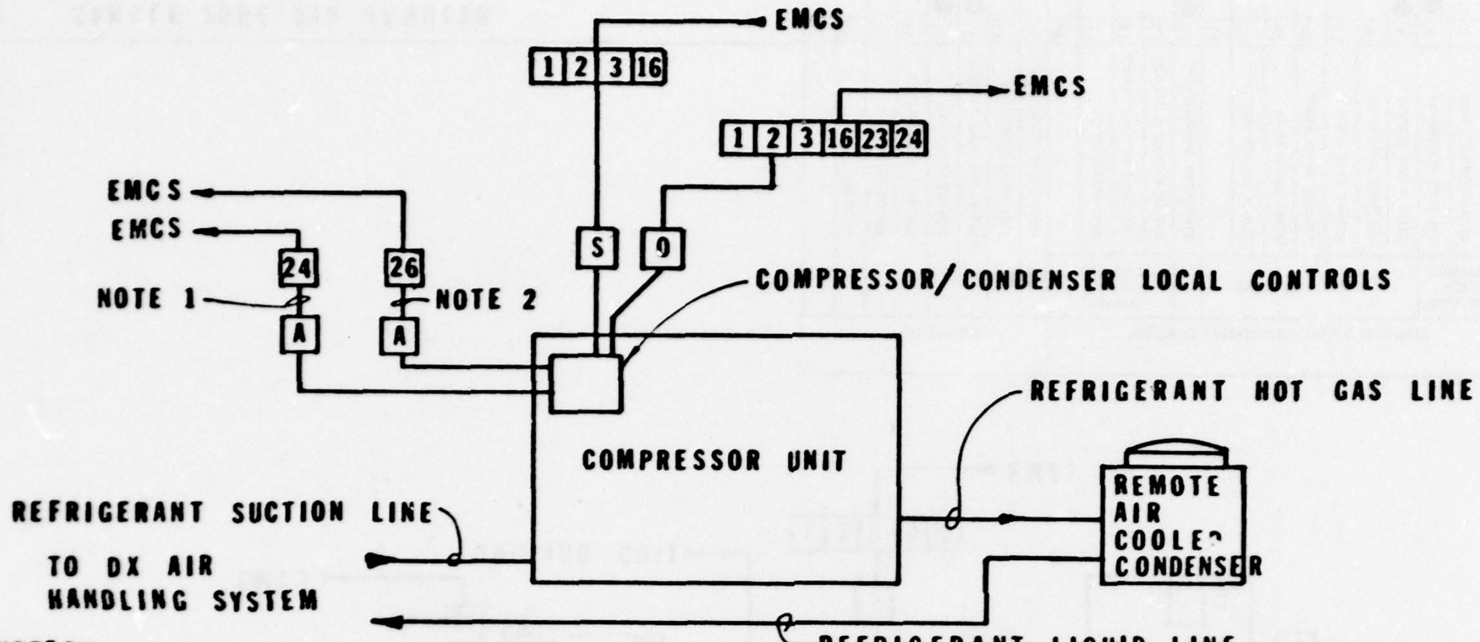
   LOW WATER CUTOFF
   FLAME SAFETY CUTOFF
   HI TEMPERATURE CUTOFF

2. PROVIDE SINGLE SIGNAL TO EMCS IN EVENT ANY OF THE ABOVE LISTED SAFETY DEVICES TRIP.

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	●
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	●
		INTERCOM	27	
			28	

HOT WATER BOILER

SCHEMATIC S—1



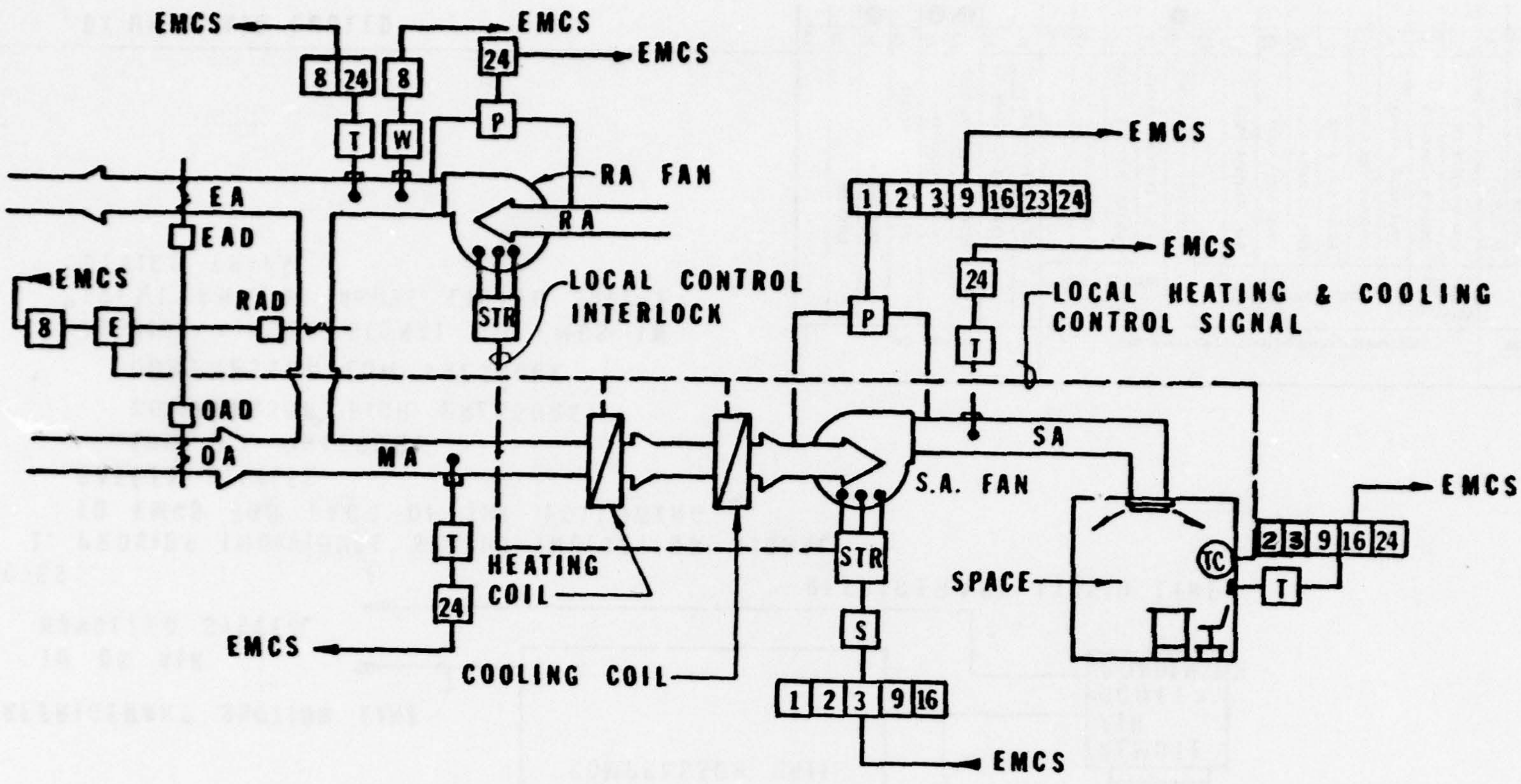
NOTES:

1. PROVIDE INDIVIDUAL STATUS INDICATION SIGNAL TO EMCS FOR EACH OF THE FOLLOWING SAFETY DEVICES:
   - LOW OIL PRESSURE
   - COMPRESSOR HIGH PRESSURE
   - COMPRESSOR LOW PRESSURE
2. PROVIDE SINGLE SIGNAL TO EMCS IN EVENT ANY OF ABOVE LISTED SAFETY DEVICE TRIPS.

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	●
		INTERCOM	27	
			28	

DX UNIT, AIR COOLED

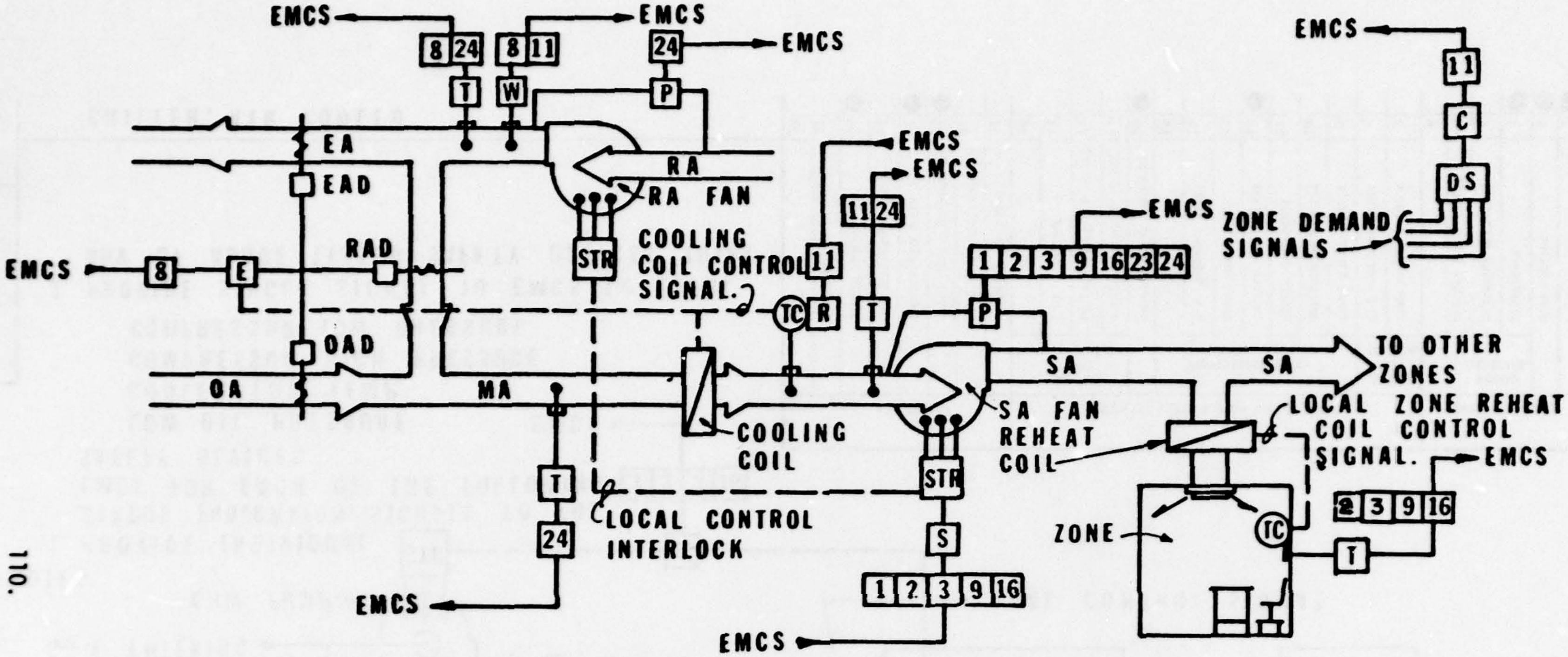
SCHEMATIC S-2



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	●
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

SINGLE ZONE AIR HANDLER

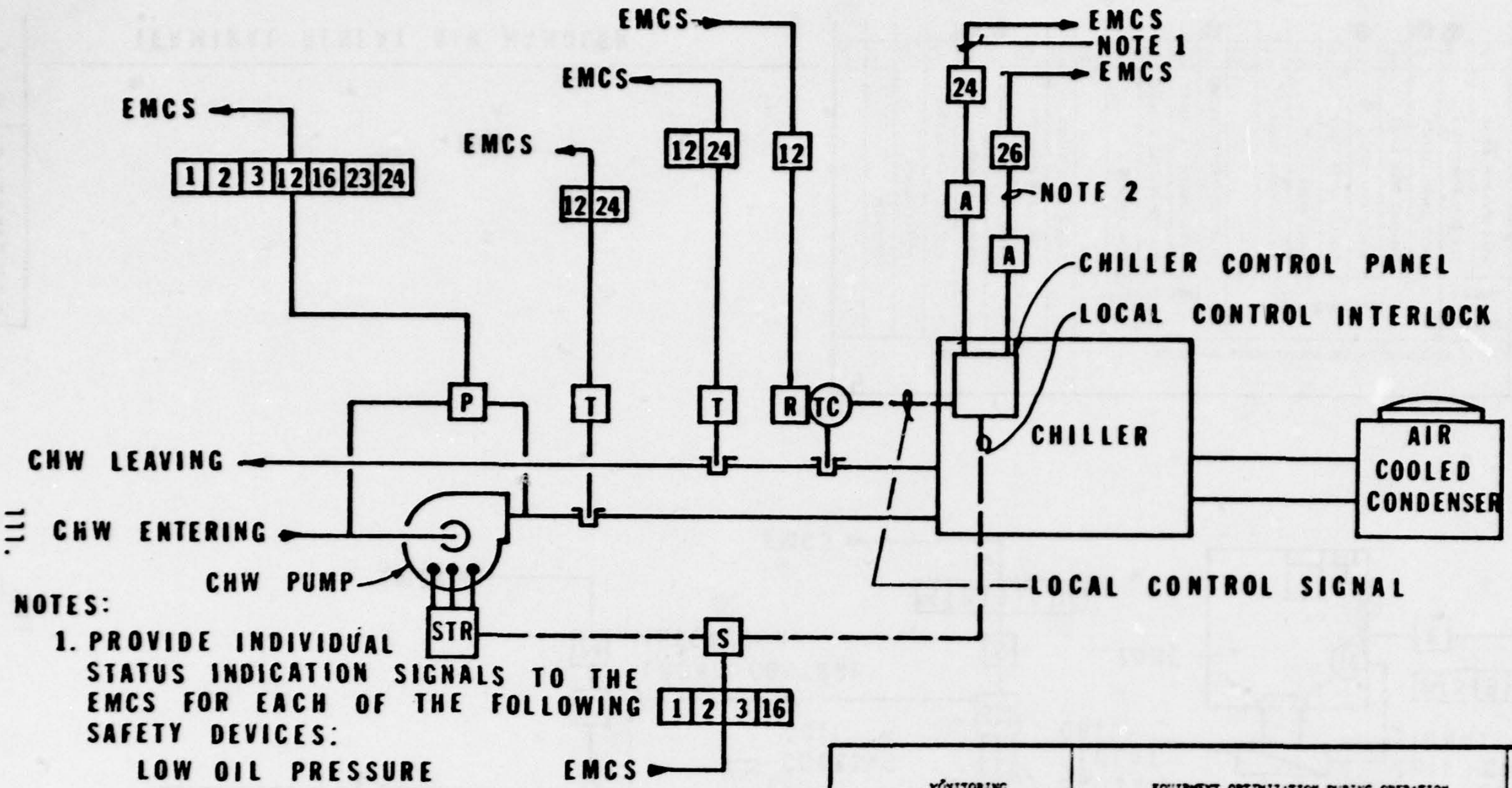
SCHEMATIC | S—3



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	●
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	●
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

TERMINAL REHEAT AIR HANDLER

SCHEMATIC | S—4



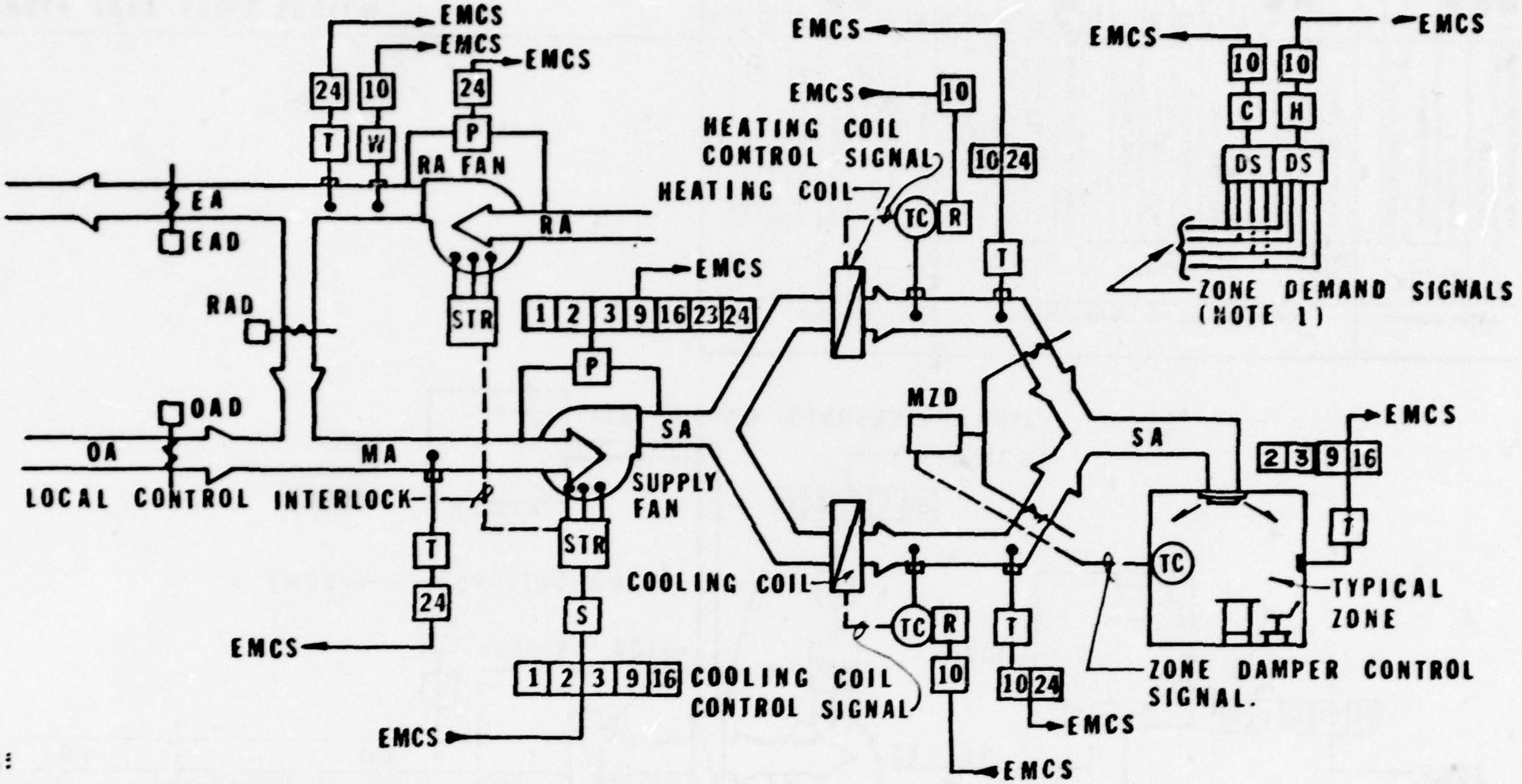
NOTES:

1. PROVIDE INDIVIDUAL STATUS INDICATION SIGNALS TO THE EMCS FOR EACH OF THE FOLLOWING SAFETY DEVICES:
   - LOW OIL PRESSURE
   - COOLER LOW TEMP.
   - COMPRESSOR HIGH PRESSURE
   - COMPRESSOR LOW PRESSURE
2. PROVIDE SINGLE SIGNAL TO EMCS IN EVENT ANY OF ABOVE LISTED SAFETY DEVICES TRIPS

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	●
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	●
		INTERCOM	27	
			28	

CHILLER, AIR COOLED

SCHEMATIC | S-5



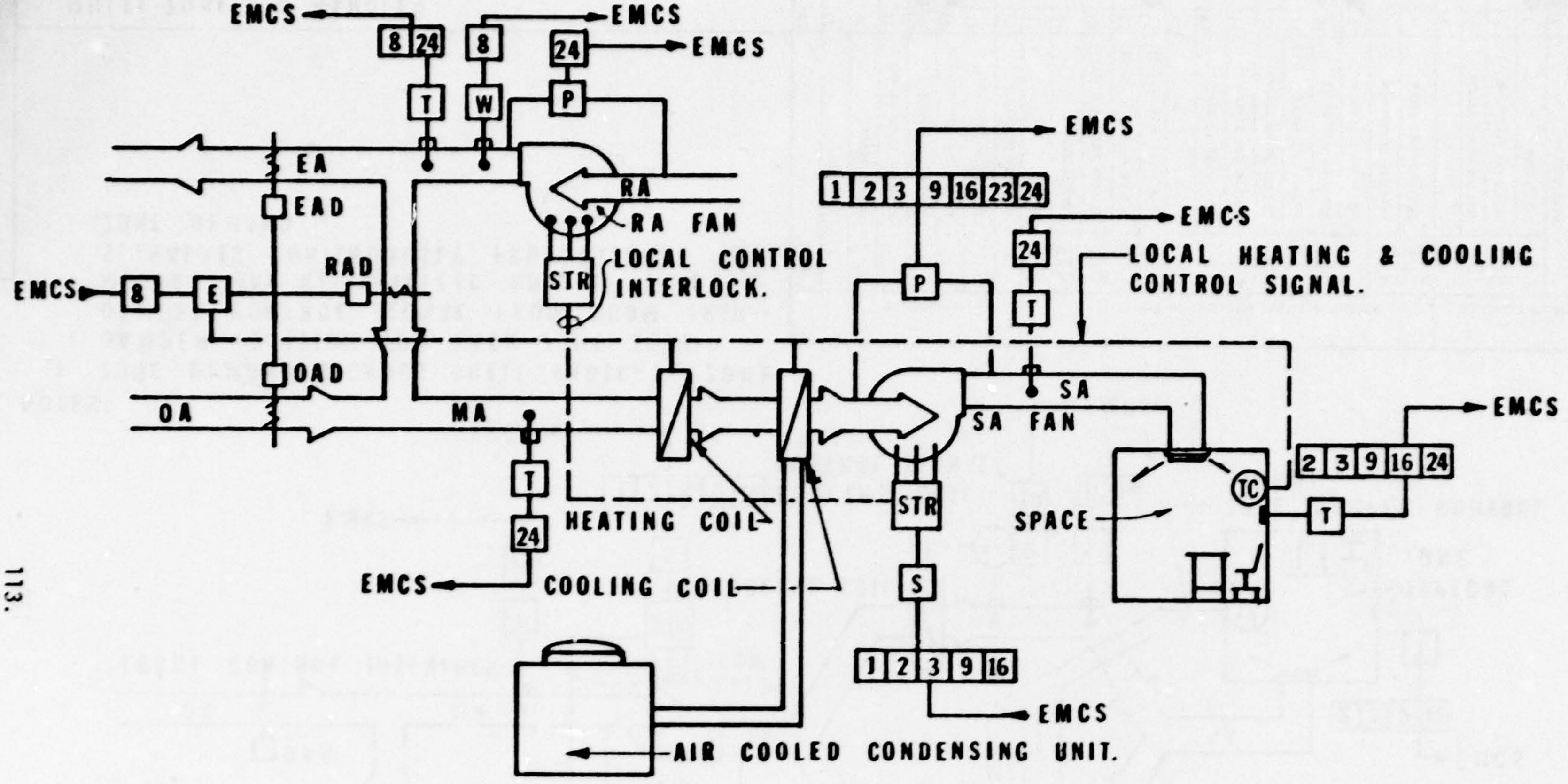
NOTES:

1. ZONE DEMAND SIGNALS SHALL INDICATE ZONE DAMPER POSITION FOR EACH ZONE. ZONE DAMPER CONTROL SIGNAL FROM ROOM THERMOSTAT MAY BE UTILIZED ONLY IF THAT SIGNAL IS CONTINUOUSLY PROPORTIONAL TO ZONE DEMAND.

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	●
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

MULTI ZONE AIR HANDLER

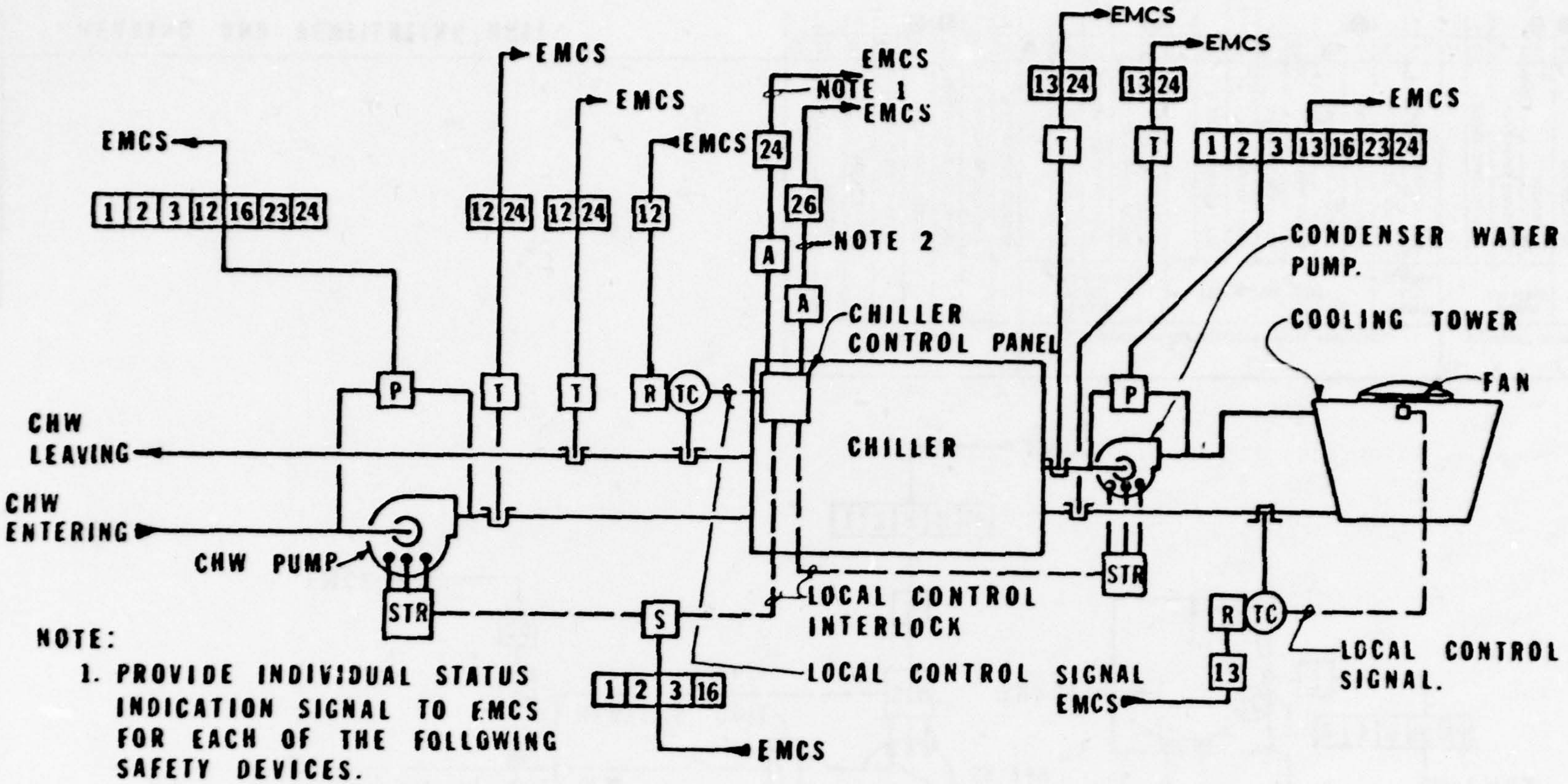
SCHEMATIC | S-6



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	●
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSTICS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

SINGLE ZONE SPLIT SYSTEM

SCHEMATIC | S-7



NOTE:

1. PROVIDE INDIVIDUAL STATUS INDICATION SIGNAL TO EMCS FOR EACH OF THE FOLLOWING SAFETY DEVICES.

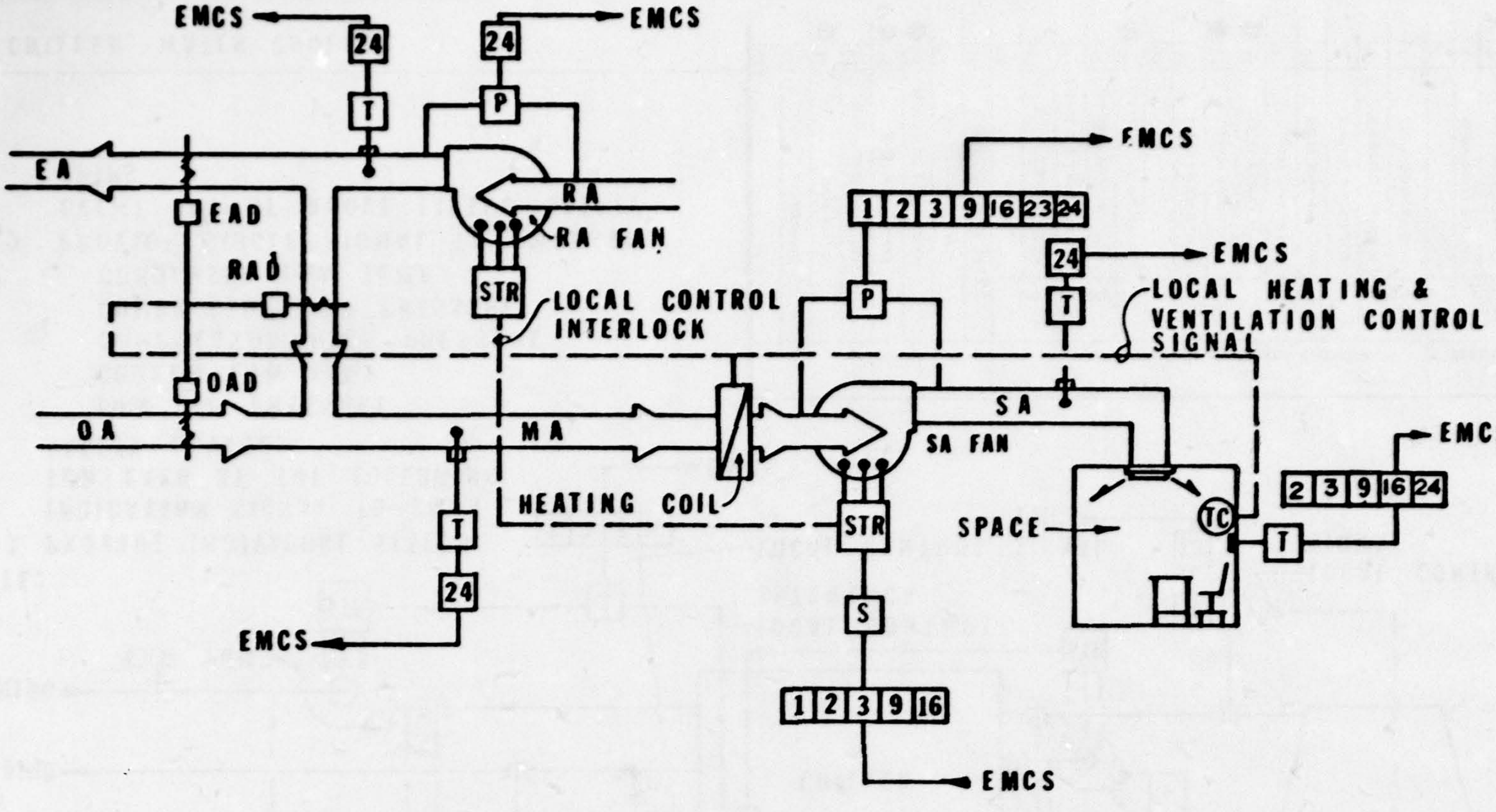
   LOW OIL PRESSURE
   COOLER LOW TEMP
   COMPRESSOR HIGH PRESSURE
   COMPRESSOR LOW PRESSURE
   CONDENSER LOW TEMP

2 PROVIDE SINGLE SIGNAL TO EMCS IN EVENT ANY OF ABOVE LISTED SAFETY TRIPS

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	●
		COND. WATER RESET	13	●
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	●
		INTERCOM	27	
			28	

CHILLER, WATER COOLED

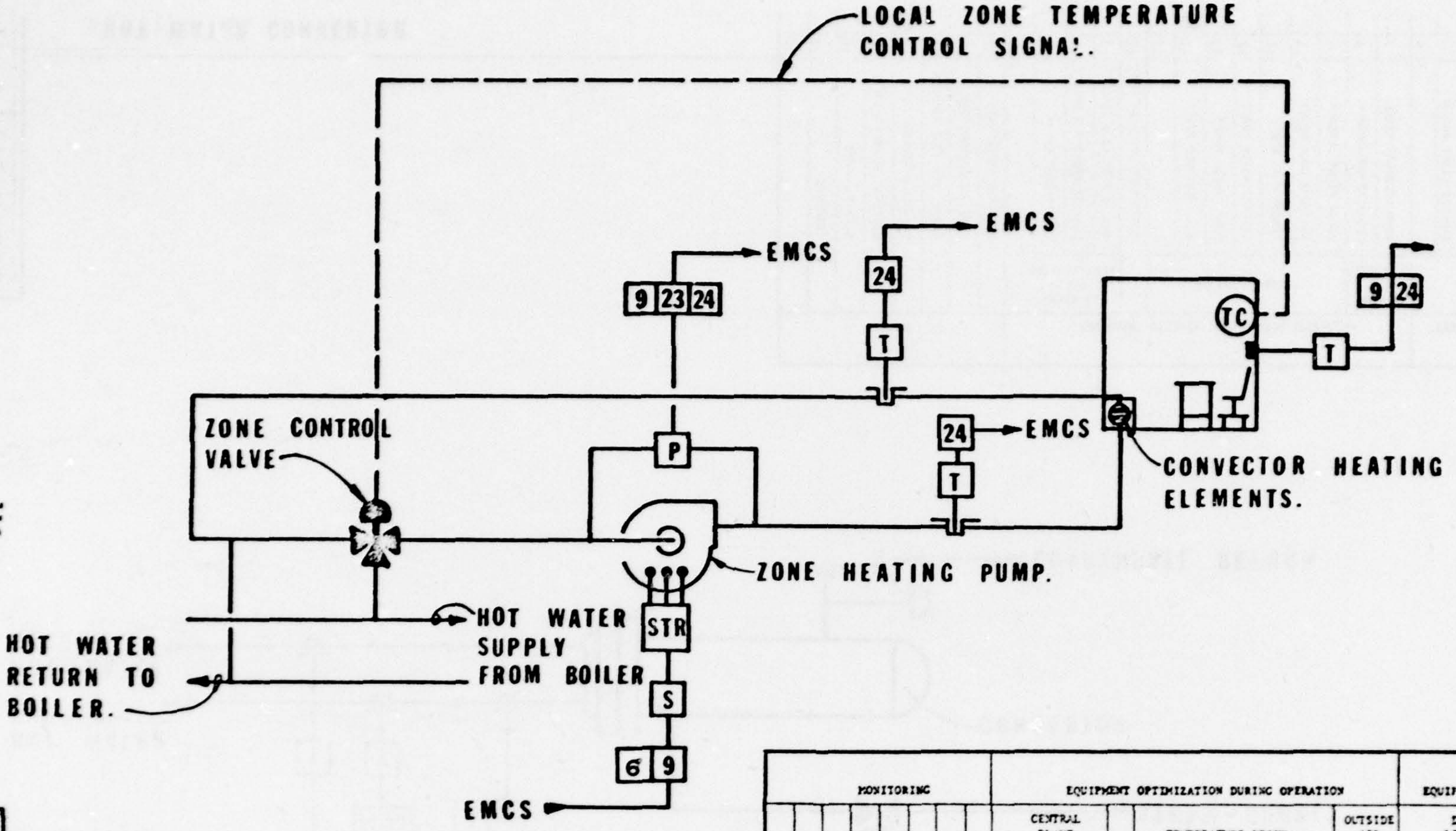
SCHEMATIC | S-8



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

HEATING AND VENTILATING UNIT

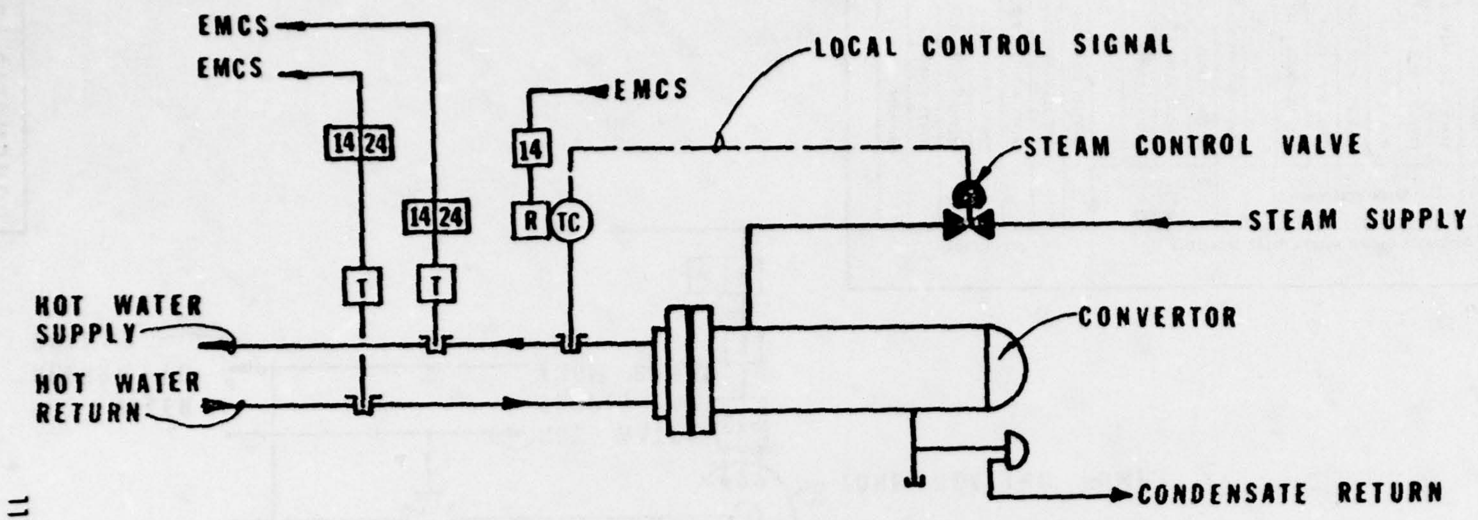
SCHEMATIC | S—9



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
		O. A. LIMIT SHUTOFF	6	●
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

CONVECTOR HEATING SYSTEM

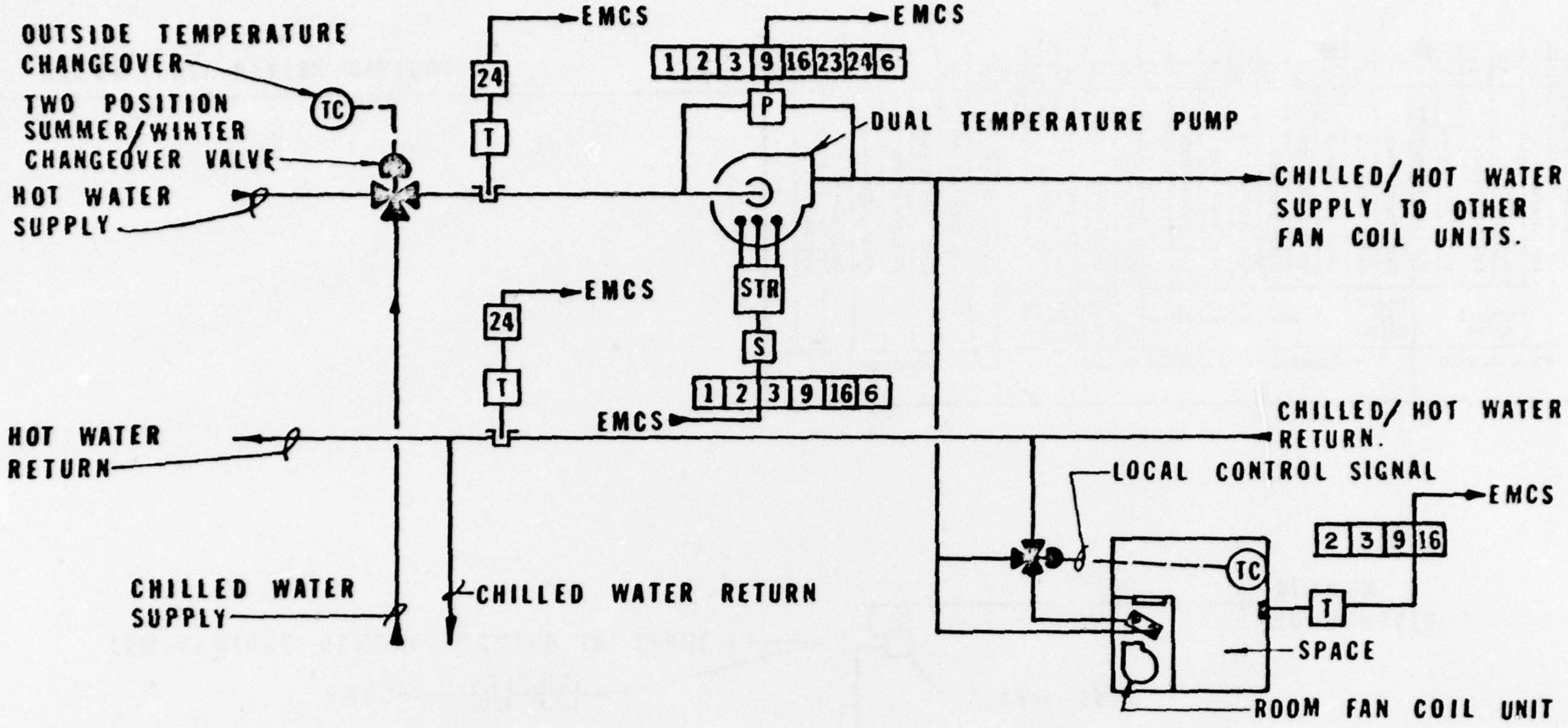
SCHEMATIC S-10



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	●
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

HOT WATER CONVERTOR

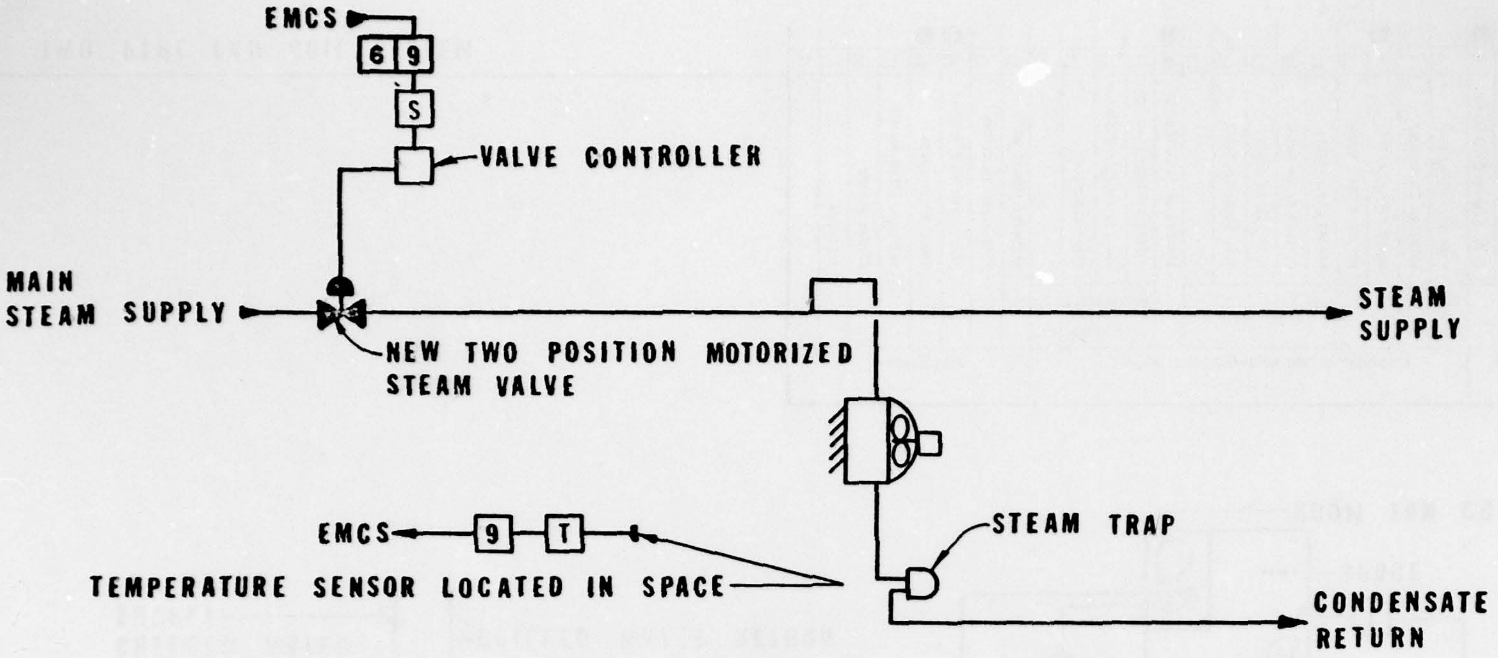
SCHEMATIC S—11



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
		O.A. LIMIT SHUTOFF	6	●
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

TWO PIPE FAN COIL SYSTEM

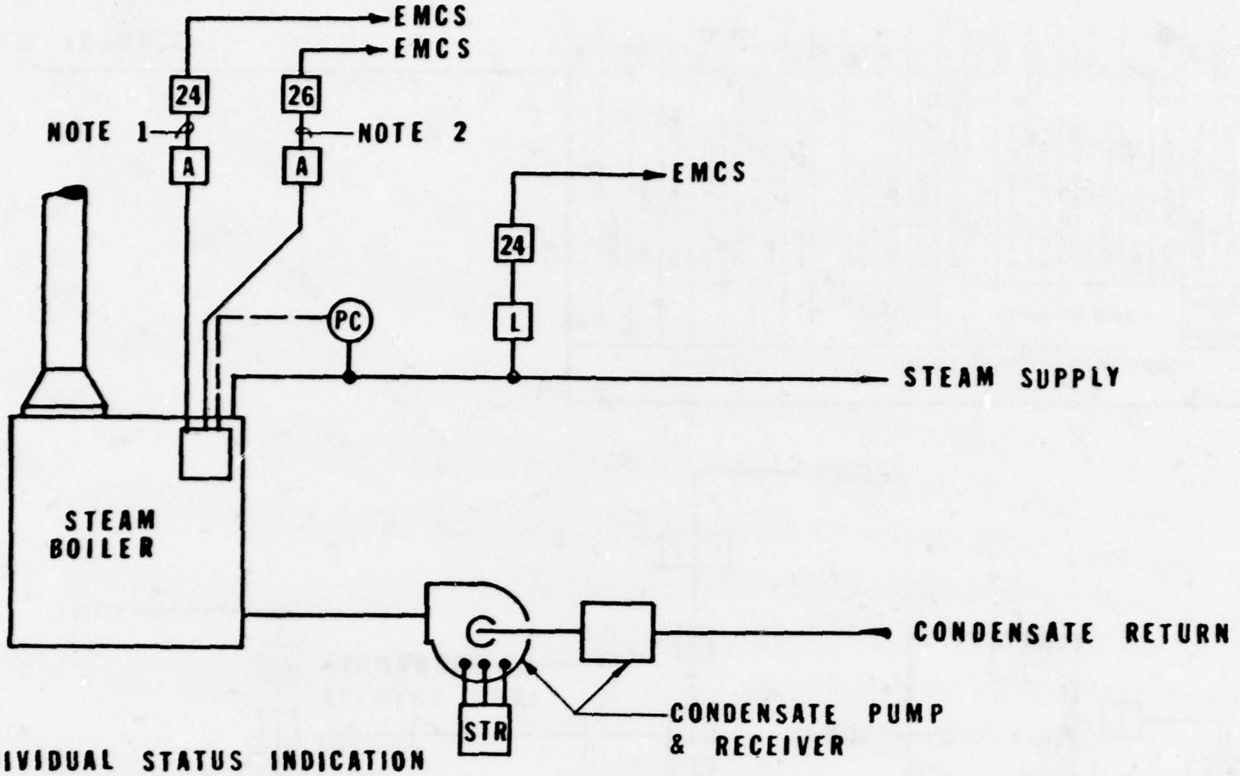
SCHEMATIC | S—12



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
		O.A. LIMIT SHUTOFF	6	●
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	
		TROUBLE DIAGNOSIS	24	
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

STEAM UNIT HEATER SYSTEM

SCHEMATIC | S—13

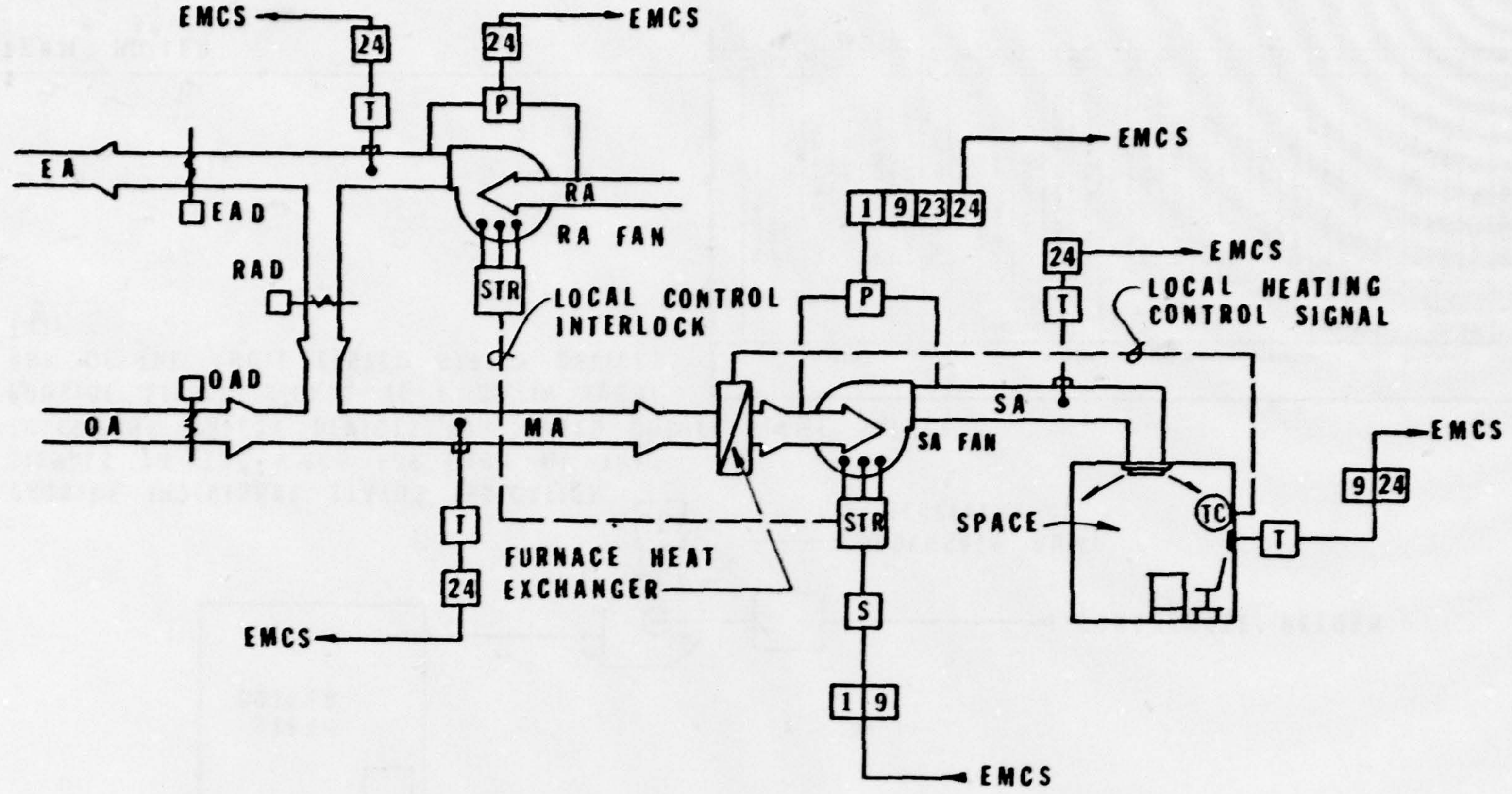


NOTES:

1. PROVIDE INDIVIDUAL STATUS INDICATION SIGNALS TO THE EMCS FOR EACH OF THE FOLLOWING SAFETY DEVICES: LOW WATER CUTOFF, FLAME SAFETY.
2. PROVIDE SINGLE SIGNAL TO EMCS IN EVENT ANY OF THE ABOVE LISTED SAFETY DEVICES TRIP.

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	●
		INTERCOM	27	
			28	

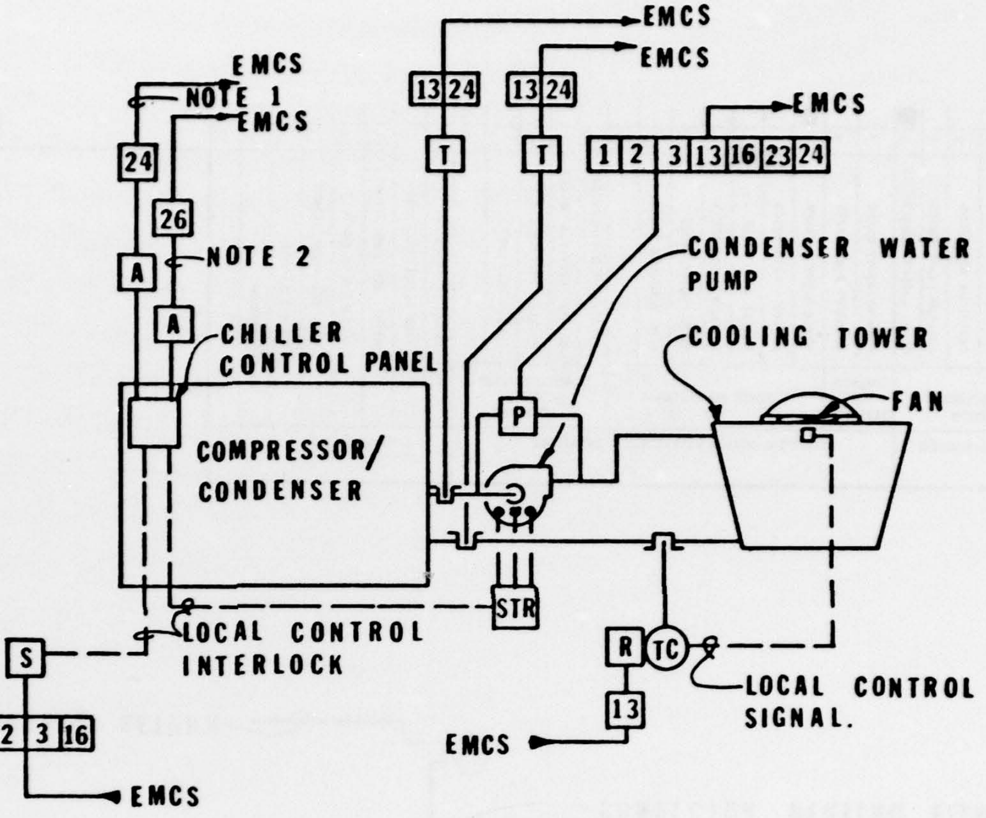
STEAM BOILER



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

DIRECT FIRED FURNACE

SCHEMATIC S-15



NOTE

1 PROVIDE INDIVIDUAL STATUS INDICATION SIGNAL TO EMCS FOR EACH OF THE FOLLOWING SAFETY DEVICES.

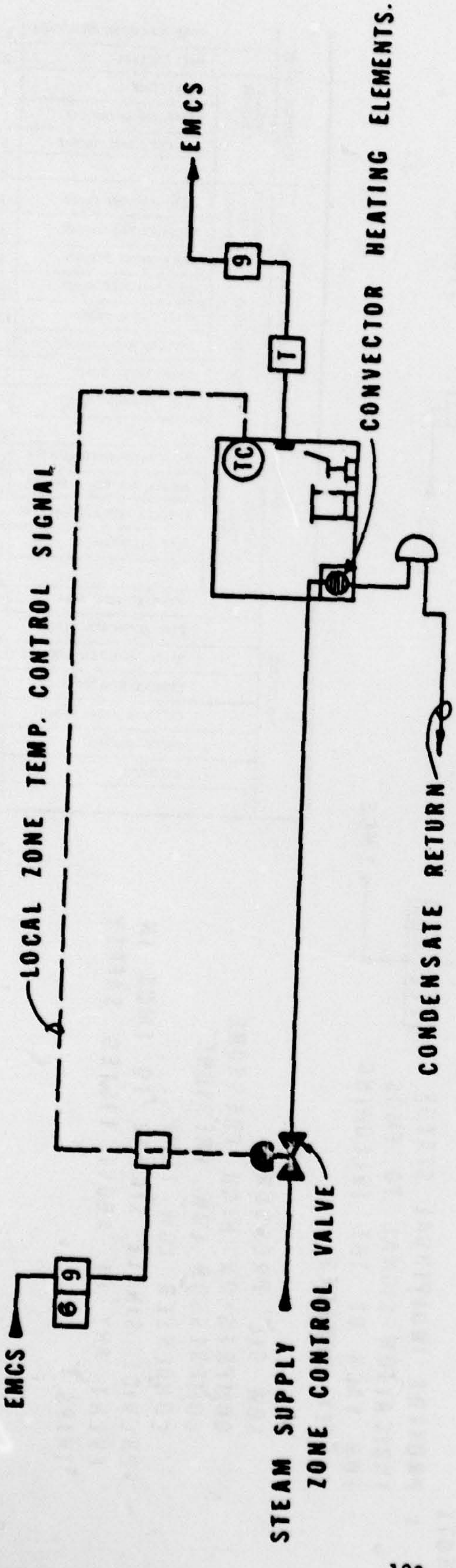
LOW OIL PRESSURE
COMPRESSOR HIGH PRESSURE
COMPRESSOR LOW PRESSURE
CONDENSER LOW TEMP.

2. PROVIDE SINGLE SIGNAL TO EMCS IN EVENT ANY OF ABOVE LISTED SAFETY TRIPS

EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	●
		DUTY CYCLING	2	●
	DEMAND LIMITING	START/STOP	3	●
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
			6	
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	●
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	●
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	●
		TROUBLE DIAGNOSIS	24	●
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	●
		INTERCOM	27	
			28	

DX UNIT, WATER COOLED

SCHEMATIC | S—16



EQUIPMENT ON/OFF		TIME SCHEDULED OPERATION	1	
		DUTY CYCLING	2	
	DEMAND LIMITING	START/STOP	3	
		GENERATOR OPERATION	4	
		CHILLER LIMIT ADJUST	5	
		O.A. LIMIT SHUTOFF	6	●
EQUIPMENT OPTIMIZATION DURING OPERATION	OUTSIDE AIR CONTROL	WARM UP/NIGHT CYCLE	7	
		ENTHALPY ECONOMIZER	8	
	TEMPERATURE RESET	SPACE NIGHT SETBACK	9	●
		HOT/COLD DECK RESET	10	
		REHEAT COIL RESET	11	
		CHILLED WATER RESET	12	
		COND. WATER RESET	13	
		O.A. SCHEDULE RESET	14	
			15	
		START/STOP OPTIMIZATION	16	
	CENTRAL PLANT OPTIMIZATION	BOILER PROFILE & SELECT	17	
		CHILLER PROFILE & SELECT	18	
		PUMP SELECTION	19	
			20	
MONITORING		SECURITY FUNCTIONS	21	
		FIRE ALARM FUNCTIONS	22	
		MAINT. RUN TIME REPORTS	23	
		TROUBLE DIAGNOSIS	24	
		CRITICAL AREAS ALARMS	25	
		SAFETY ALARMS	26	
		INTERCOM	27	
			28	

STEAM CONVECTOR HEATING SYSTEM

SCHEMATIC S-17

APPENDIX C - SAVINGS ANALYSIS DISCUSSION

FUNCTION: TIME SCHEDULED OPERATION

Simulate building loads and system operation using computerized energy analysis program. In initial run assume that systems run 24 hr/day, 7 day/week. In second run assume that systems run only during occupied hours plus one hour in the morning for warm up or cool down. Do not include fan KW in computer runs so that results are representative only of heating and cooling energy reduction. This heating and cooling energy savings can then be proportioned on a per cfm basis to other similar systems. Fan (or other auxiliaries) energy savings should then be added by multiplying the KW by the number of hours of shutdown for the system. Thus:

Cooling Savings = Difference in electrical consumption of computer analysis runs.
Heating Savings = difference in heating consumption of computer analysis runs.
Auxiliary Savings = HP x L x KW/HP x (8760 - H) x C

Where
HP = total fan motor nameplate horsepower
L = load factor
KW/HP = 0.746
H = number of hours of system operation
C = control efficiency factor

If the air handler is presently operating around the clock the above calculated savings may be used directly. If however the unit is currently started and stopped by a time switch, full credit can not be taken for the above savings for the EMCS. Determining what savings may be attributed to the EMCS becomes a function of the reliability of the time switch system. Time switches can be effective devices for the reduction of energy consumption, however, they have several disadvantages. They do not take into account holiday operation, seasonal changes, or daily weather variations. They are also easily tampered with, bypassed, or overridden. The pins which activate actions may slide, thus causing system operation and energy consumption at unnecessary times. They must be checked often to insure proper operation and must be reset manually everytime a power outage occurs for any appreciable time period. The EMCS is capable of performing the same operations as the time switches but without most of the difficulties described, since it is not within the reach of tampering, and system operations are monitored constantly by the console operator.

An exact method of analyzing the energy savings of an EMCS over a time switch system is not available. The survey of buildings indicates that some buildings with time switches are operating properly while others have been overridden or set improperly. With time clocks, a system that is operating properly one day may be operating improperly the next day. This is not true with the EMCS since modifications to operations must be made by the EMCS operators. For these reasons, the EMCS savings over time switches will be estimated by multiplying an efficiency factor times the heating, cooling, and fan savings estimated above. The efficiency factor will be assumed to equal 0.3 in analysis in this report.

FUNCTION: DUTY CYCLING

Assume the system may be shut down for an average of 10 minutes per hour. The savings resulting from this function are fan energy and outside air heating and cooling energy. Outside air loads are difficult to determine since they actually depend on space load conditions. If there is a net cooling load in the space, and the outside air is below 75°F, the outside air actually reduces energy consumption. Also actual outside air quantities may be very different from design quantities, with no practical means of determining what the actual quantity is. Therefore outside air load savings will be ignored in duty cycling analysis.

SKWH = HP x L x 10/60 x H x KW/HP
Where
HP = total motor nameplate horsepower
10/60 = fraction of time system is shut down
H = required annual hours of system operation
L = load factor
KW/HP = 0.746

FUNCTION: DEMAND LIMITING START/STOP

Assume that system can be shed 25% of time under peak load conditions.

S = HP x L x KW/HP x 0.25 x M
Where
HP = total motor nameplate horsepower of all motors in system
L = load factor
KW/HP = 0.746
M = number of months per year system operates

FUNCTION: START/STOP OPTIMIZATION

Assume an average of 1/2 hour of fan operation per occupied day may be saved by this function. Assume no net heating or cooling energy is saved.

S = HP x L x KW/HP x 0.5 x OD
Where
HP = Total fan motor nameplate horsepower
L = load factor
KW/HP = 0.746
OD = number of occupied days per year

FUNCTION: OUTSIDE AIR LIMIT SHUTOFF

Savings are derived from reduced hours of operation of auxiliary equipment and reduction of system losses (heat transfer thru pipe walls, leaking steam traps, etc.). Whenever the system loss savings can be identified they should be included in the analysis, however, generally it is not possible to reasonably estimate what those losses are. Auxiliary savings are derived from the shutting off of pumps, fans, etc. Whenever the outside temperature crosses limits which, according to the time of year, indicate the heating or cooling media which those auxiliaires are moving is not required, the auxiliaries may be shut down. Auxiliary savings are thus:

$SKWH = HP \times L \times KW/HP \times (HS + HW)$

Where

HP = nameplate HP of constant loads

L = load factor

KW/HP = 0.746

HS = hours in summer outside temperature is below summer limit

HW = hours in winter outside temperature is above winter limit

FUNCTION: MAINTENANCE RUN TIME

By scheduling maintenance based on actual operation, assume the EMCS is able to save one man-visit per year to the system being monitored by the EMCS. Assume this man-visit is 2 hours in duration.

S = 2 man hours

FUNCTION: ENTHALPY ECONOMIZER

Simulate building loads and enthalpy economizer operation with computerized building energy analysis program. In initial run assume that no economizer is operable, in second run simulate savings from conventional dry bulb economizer changeover, and in third run simulate savings from enthalpy economizer operation. All runs should be made assuming the system is operating the minimum number of hours necessary. Savings may be proportioned for similar systems on a per cfm basis.

FUNCTION: HOT/COLD DECK RESET

Simulate system operation with computerized energy analysis program. Program used should have simulation routines necessary to select the zones with the greatest demand and then calculate the necessary hot/cold deck leaving temperatures. In order to approximate the savings from this function, run the program once using constant deck setpoint temperatures and then a second time simulating variable deck temperature based on a discriminator control scheme.

FUNCTION: CHILLED WATER RESET

Assume approximately 1.5% efficiency increase may be obtained by increasing the average chilled water temperature 1°F. Assume the EMCS is capable of obtaining an average increase of 2°F. in chilled water temperature, thus a resultant savings of 3% of compresser and cooling tower fan energy should be realized. To conservatively approximate these savings, assume a loading of 1000 equivalent full load hours. Also assume an average consumption of 1 KWH/ton-hour. Savings resulting are:

S = T x 1000 hrs. x 1 KWH/ton-hr x 0.03
Where
T = chiller capacity, tons

FUNCTION: CONDENSER WATER RESET

Assume approximately 1.5% efficiency increase may be obtained by decreasing the average condenser water temperature 1°F. Assume the EMCS is capable of obtaining an average decrease of 3°F. in condenser water temperature, thus a resultant savings of 4.5% of compressor energy should be realized. To conservatively approximate these savings, assume a loading of 1000 equivalent full load hours. Also assume an average consumption of 1 KWH/ton-hr. Savings resultings are:

S = T x 1000 hrs x 1 KWH/ton-hr x 0.045
Where
T = chiller capacity, tons

FUNCTION: O.A. SCHEDULE RESET

Boiler temperature reset saves by reducing heat losses through the heating system and flue gases and by providing more exact control at the end use point. This last item provides savings by reducing overheating of spaces at less than maximum loads due to control valve insensitivity in those operating ranges. No exact means of quantifying these savings is known, however experience indicates these savings should be a function of the annual equivalent full load hours of boiler operation and the total capacity of the boiler.

S = EFLH x PECD x I
Where
S = annual savings, Therms
H = annual equivalent full load hours for boiler
PECD = efficiency increase
I = maximum heat transfer capacity of device, therms

FUNCTION: SAFETY ALARM

Assume total of 2 hours saved per year of occupant and maintenance personnel time in conveying alarm information.

S = 2 man-hours

APPENDIX D - ANALYSIS FORMS

SURVEY AND BUILDING DESCRIPTION FORM

Building Number: ______________________ Usage: ________________________

Gross Area Sq. Ft.: ________________________ No. Floors: ______________

Age of Building: _________________ Type Construction: ________________

Approx. Floor to Floor Height: __________________________________

% Glass in Exterior Wall: ______________________________________

Glass Shading: External __________________ Internal ________________

"U" Factor: Roof ____________ Wall ___________ Glass ______________

Critical Areas: ____

____

Notes: ____

____

PRIMARY SYSTEMS

Sys #__________

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:__________

Capacity:__________BTU/HR.
Pump HP:__________
Pump HP:__________
Comp HP:__________
Fan HP:__________
Other HP:__________

Operation (Annual)
Year Round
Summer Only
Winter Only
Other__________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other__________

Existing Controls:
Time Clock
O.A. Reset
Other:__________

Notes:

Sys #__________

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:__________

Capacity:__________BTU/HR.
Pump HP:__________
Pump HP:__________
Comp HP:__________
Fan HP:__________
Other HP:__________

Operation (Annual)
Year Round
Summer Only
Winter Only
Other__________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other__________

Existing Controls:
Time Clock
O.A. Reset
Other:__________

Notes:

Sys #__________

Type:
Boiler (HW) (STM)
Chiller (A/C) (W/C)
DX Unit (A/C) (W/C)
Central (STM) (CHW)
Other:__________

Capacity:__________BTU/HR.
Pump HP:__________
Pump HP:__________
Comp HP:__________
Fan HP:__________
Other HP:__________

Operation (Annual)
Year Round
Summer Only
Winter Only
Other__________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other__________

Existing Controls:
Time Clock
O.A. Reset
Other:__________

Notes:

SECONDARY SYSTEMS

Sys #__________

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other__________

CFM:__________
No. Zones:__________
Fan HP:__________
Capacity:__________BTU/HR
Pump HP__________
%OA:__________
Comp. HP:__________
Cond Fan HP:__________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other__________

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:__________

Notes:__________

Sys #__________

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (FU)
Unit Htr. (HW) (STM)
Fan Coil (2) (4) pipe
Convector (HW) (STM)
Other__________

CFM:__________
No. Zones:__________
Fan HP:__________
Capacity:__________BTU/HR
Pump HP__________
%OA:__________
Comp. HP:__________
Cond Fan HP:__________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other__________

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:__________

Notes:__________

Sys #__________

Type:
AHU (SZ) (TR)
(MZ) (HV)
(SP) (F
Unit Htr. (HW) (ST
Fan Coil (2) (4)
Convector (HW) (ST
Other__________

CFM:__________
No. Zones:__________
Fan HP:__________
Capacity:__________BTU/HR
Pump HP__________
%OA:__________
Comp. HP:__________
Cond Fan HP:__________

Operation (Daily)
1 Shift
2 Shift
3 Shift
Other__________

Existing Controls:
Time Clock
Economizer
Deck Reset
Other:__________

Notes:__________

SYSTEM SAVINGS - COST CALCULATIONS

Building No. __________ System No. __________ System Type __________

FUNCTION	SAVINGS CALCULATIONS (See _____ for Derivation of Constants)	SAVINGS				COST (Table ____)
		KW	KWH	THERMS	MH	
Time Scheduled Operation	Cooling: _______ (cfm/MBH) x _______ (Table ___) Heating: _______ (cfm/MBH) x _______ (Table ___) Auxiliaries: _______ HP x (8760 - _______) x ___ x ___	0 0 0	 0 	0 0	0 0 0	 Basic Functions $ __________
Duty Cycling	_______ HP x _______ Hrs x _______	0		0	0	
Demand Limiting	_______ HP x _______ Mo. _______		0	0	0	
Outside Air Temp. Limit	_______ HP x (_______ Summer + _______ Winter) Hrs x _______	0		0	0	
Start/Stop Optimization	_______ HP x _______ days x _______	0		0	0	
Run Time Recording						
H/C Deck Reset	Cooling: _______ (cfm) x _______ (Table ___) Heating: _______ (cfm) x _______ (Table ___)	0 0	 0	0 	0 0	$ __________
Enthalpy Economizer	_______ (cfm) x _______ (Table ___)	0		0	0	$ __________
Chilled Water Reset	_______ Tons x _______ FLH x _______	0		0	0	$ __________
Condenser Water Reset	_______ Tons x _______ FLH x _______	0		0	0	$ __________
Outside Air Temp. Reset	_______ FLH x _______ (MBH) x _______	0	0		0	$ __________
Safety Alarms		0	0		0	$ __________
	TOTALS FOR SYSTEM					$ __________

BUILDING SAVINGS - COST SUMMARY

Building #__________

SYSTEM NO.	SYSTEM TYPE	SAVINGS				COST
		KW	KWH	THERMS	MH	
	TOTALS					
		BUILDING CONNECT COST				
		TOTAL COST				

$$\text{ENERGY SAVINGS} = \frac{(\underline{\qquad\qquad}\ \text{KWH X 11,600}) + (\underline{\qquad\qquad}\ \text{THERMS x 100,000})}{\text{1,000,000 BTU/MBTU}} = \underline{\qquad}\ \text{MBTU}$$

$ SAVINGS = (_____ KW x $ _____/KW) + (_________ KWH x $ _____/KWH)
+ (____ THERMS x $_____/THERM) + (_____ MH x $ _____/MH) = $ ________

E/C RATIO = __________

PRIORITIZED BUILDING LIST

BUILDING NUMBER	SAVINGS					E/C	COST	CUMULATIVE COST	
	KW	KWH	THERMS	MH	$				
———	——	———	———	——	——	———	———		FIXED COST

ECIP ECONOMIC ANALYSIS SUMMARY

ACTIVITY & LOCATION ______________________________ P-______

TITLE OF PROJECT ______________________________ FY-______

INVESTMENT

1. PROJECT COSTS (Economic life of _____ years)
   - a. Project cost escalated to end of program year.... $______
   - b. Design costs not yet obligated .... $______
   - c. Total Project Cost (a + b) .... $______

SAVINGS

2. ANNUAL ELECTRICITY SAVINGS: KWH:______________
   - a. Equivalent energy: KWH x 0.0116 ....(MBTU's: $______)
   - b. Cost per KWH at end of program year .... $______
   - c. First year annual dollar savings (KWH x b) ...... $______
   - d. Differential escalation present worth factor .... ______
   - e. Discounted savings (c x d) .... $______

3. ANNUAL ENERGY SAVINGS (TYPE:______________MBTU's: ______)
   - a. Cost per MBTU at end of program year .... $______
   - b. First year annual dollar savings .... $______
   - c. Differential escalation present worth factor ..... ______
   - d. Discounted savings (b x c) .... $______

4. ANNUAL ENERGY SAVINGS (TYPE:______________MBTU's: ______)
   - a. Cost per MBTU at end of program year .... $______
   - b. First year annual dollar savings .... $______
   - c. Differential escalation present worth factor .... ______
   - d. Discounted savings (b x c) .... $______

5. ANNUAL OTHER-THAN-ENERGY SAVINGS (OR COSTS)
   - a. Labor .... $______
   - b. Material & Other .... $______
   - c. Total (a + b) .... $______
   - d. 10% Discount Factor .... ______
   - e. Discounted Other-than-energy savings (or costs) . $______

6. TOTAL FIRST YEAR ANNUAL SAVINGS (2c + 3b + 4b + 5c) .. $______

7. TOTAL DISCOUNTED SAVINGS (2e + 3d + 4d + 5e) .... $______

COST ESCALATION

Current Elec $______ x ______ x ______ x ______ x ______ = $______
rates Oil $______ x ______ x ______ x ______ x ______ = $______
as of Gas $______ x ______ x ______ x ______ x ______ = $______
______ ______ $______ x ______ x ______ x ______ x ______ = $______

RATIOS

8. DISCOUNTED SAVINGS/INVESTMENT RATIO (Line 7 ÷ 1c) .... ______
9. TOTAL MBTU SAVINGS ______ ÷ (Line 1a ÷ 1000) ..... ______
10. SIMPLE PAYBACK PERIOD (1a ÷ Line 6) .... ______ YRS

NOTE: For ETAP projects use line 1c in lines 9 and 10 in lieu of 1a.

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