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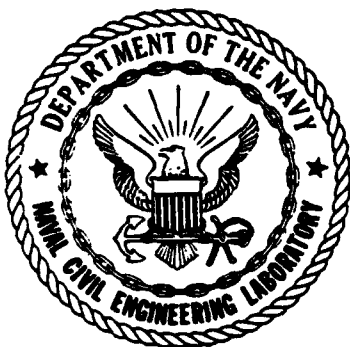
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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

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ENERGY MONITORING AND CONTROL SYSTEMS OPERATOR TRAINING -
Recommended Qualifications, Staffing, Job Description, and Training Requirements
for EMCS Operators

June 1982

An Investigation Conducted by
NEWCOMB & BOYD CONSULTING ENGINEERS
One Northside 75
Atlanta, Georgia

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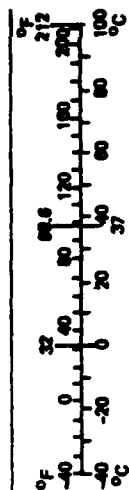
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
VOLUME				
tblsp	tablespoons	5	milliliters	ml
fl oz	fluid ounces	15	milliliters	ml
c	cups	30	milliliters	ml
pt	pints	0.24	liters	l
qt	quarts	0.47	liters	l
gal	gallons	0.96	liters	l
ft ³	cubic feet	3.8	liters	l
yd ³	cubic yards	0.03	cubic meters	m ³
		0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Mon. Publ. 288, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10.288.

Approximate Conversions from Metric Measures

When You Know	Multiply by	To Find	Symbol
LENGTH			
millimeters	0.04	inches	in
centimeters	0.4	inches	in
meters	3.3	feet	ft
meters	1.1	yards	yd
kilometers	0.6	miles	mi
AREA			
square centimeters	0.16	square inches	in ²
square meters	1.2	square yards	yd ²
square kilometers	0.4	square miles	mi ²
hectares (10,000 m ²)	2.5	acres	
MASS (weight)			
grams	0.036	ounces	oz
kilograms	2.2	pounds	lb
tonnes (1,000 kg)	1.1	short tons	
VOLUME			
milliliters	0.03	fluid ounces	fl oz
liters	2.1	pints	pt
liters	1.06	quarts	qt
liters	0.26	gallons	gal
cubic meters	36	cubic feet	ft ³
cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)			
Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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21. ABSTRACT (Continue on reverse side if necessary, and identify by block number) This report includes a review of: (1) Operator training provided by EMCS contractors, (2) the requirements for training by the Tri-Service Specifications, and (3) the present operation of several functioning EMCS installations. From the information gathered, recommendations were made in regard to qualifications, staffing, job description, and		

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training requirements for a competent EMCS operator.

It is recommended that training be given in four phases: (1) Shop Rotation, (2) EMCS Operator Training Course, (3) Vendor Training, and (4) On-the-Job Training.

Detailed objectives, course outline, and manual outline for the proposed EMCS Operator Training Course are provided in Section 3 of this report.

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1.0 BACKGROUND INFORMATION

The goal of any vocational training course is to expand the students' knowledge and skills to a level at which he or she can perform the duties of a particular job. In order to develop an appropriate curriculum for EMCS training, we felt we needed to examine the actual tasks performed by working operators and then determine the qualifications that should be required of an entering trainee. Based on this information, course objectives which will produce the desired effect can be more easily defined.

To determine the needs for EMCS operator training and to assist in development of an effective training course, we gathered background information from visits to four functioning EMCS installations, as well as from discussions with EMCS manufacturers. We also reviewed the Tri-Service EMCS specifications and technical manual. The following sections include a summary of our findings.

1.1 Discussions with EMCS Manufacturers

Eight manufacturers were contacted for their opinions on the subject of EMCS operator training. A log of these discussions is included in the Appendix A.1. The manufacturer's training has primarily been developed based on the course content and schedule required by the Tri-Service Specifications. There were conflicting opinions as to whether training as outlined by the Specs is sufficient, but the manufacturers leaned more strongly toward the opinion that it is not.

The training presently being provided is system and site specific and focuses on the operation of the computer hardware. There was consensus among the manufacturers that system-specific training, hands-on experience, and an understanding of the energy savings functions are important. One manufacturer mentioned the need for a review of HVAC systems.

Another manufacturer felt that the personnel coming into the training were underqualified for the job. Some of the manufacturers use a simulator which is connected to the actual system being installed. Two of them have programmed instruction which prompts the trainee through a session on the terminal; one through software interfaced to a terminal and the other by cassette tape.

1.2 Comments on a Review of EMCS Literature

The Tri-Service Specifications, CEGS 13947-13949, NFGS 13947-13949, or FCGS 13947-13949, Section 6.3, lists the topics to be covered in operator training as follows:

- a. General EMCS architecture.
- b. Operation of computer and peripherals.
- c. System initialization procedures.
- d. Operator commands.
- e. Operator diagnostics.
- f. Color graphics generation.
- g. Failure-recovery procedures.
- h. Report formats.
- i. Alarm formats.

All these topics, except perhaps color graphics generation, should be covered in the training. Color graphics generation is not included among the operator tasks in Section 13.9 of the Specs, and it probably should be done by the EMCS programmer, supervisor, or senior operator. Generally, the initial graphics are generated by the contractor upon installation of a new system and few subsequent graphics are added.

Based on some manufacturers' operator training outlines which we reviewed, it appears that they over emphasize the EMCS architecture and software. The operators do not need to know how the computer works, but how to operate the peripheral equipment. For this reason, and because the candidate operators have limited knowledge of energy conservation

strategies, this phase of the training has not been very effective. This may also explain why some manufacturers feel that the training required by the Tri-service specifications is not adequate.

Below is a list of operator console tasks listed in section 13.9.1 of the Tri-Service specs for large systems, CEGS-13947, NFGS-13947, FCGS-13947. The same list appears in the specs for the medium and small systems, but task j. is not applicable to most small systems.

- a. Request a display of any digital or analog point, or any group of related points in the system.
- b. Startup and shutdown selected systems or devices.
- c. Initiate reports.
- d. Request graphic displays.
- e. Modify time and event scheduling.
- f. Modify analog limits.
- g. Adjust setpoints of selected controllers.
- h. Select manual or automatic control modes.
- i. Enable and disable individual points; disabling shall take precedence over all other actions.
- j. Enable and disable individual FIDs.
- k. Enable and disable individual MUX or IMUX panels.
- l. Point definition.

These tasks are a sufficient set of operator interactions from which a subset of applicable interactions may be chosen for a specific installation. There has been a question about the need for tasks j. and k. We recommend that they be retained as part of the operator interactions. In the event of an electronics problem in a MUX or FID it would be useful if the operator could disable the unit immediately at the operator console to prevent overload of the system with erroneous signals, rather than wait for a technician to turn off the panel in the field.

1.3 Observations from Site Visits

As part of the data collection effort for the EMCS Operator Training Course, we visited four operating EMCS sites. In support of the Tri-Service concept, the visits were planned to include a system being operated by each of the major uniformed services. Sites visited included: Ft. Eustis (Army), U.S. Naval Academy (Navy), Camp Lejeune (Marine Corps), and Charleston AFB (Air Force). To ease the task of comparing and contrasting the existing situations, we sought answers to following standard set of questions:

- o Who is the manufacturer of the system?
- o When was the system designed?
- o When was the system installed?
- o When did the system become operational?
- o How many points are in the system?
- o Does the system conform to the Tri-Service guide specification?
- o What was the system design concept, i.e., monitor, control, maintenance, etc.?
- o What type of operator interface does the system have?
- o Were there any major problems with the design?
- o What is the system operating schedule?
- o How many trained operators work the system?
- o What is the background of the operators?
- o How were the operators trained initially?
- o Was this initial training adequate?
- o How are replacement operators being trained?
- o Does an EMCS operator position description exist?
- o What are the operator's actual duties?
- o Where do you think the EMCS Operator Training Course would fit in an overall training program?
- o Do you have any suggestions for content of such a course?

Answers were obtained through observation and lengthy conversations with design engineers, supervisors and EMCS operators. In every instance, the people at the sites were friendly, helpful and informative. Detailed site visit reports are included in Appendix A.2 to this report. This section contains a more analytical discussion of the results of the EMCS site visits.

Ft. Eustis comes closer to a model situation than any other EMCS site we visited. The system was designed and implemented with support from every echelon of management, from Base Commander to Supervisor of Utilities. Maintenance management capabilities were included in the initial design, so the EMCS is an integral part of base utilities maintenance operations. The EMCS operator communicates with maintenance shop supervisors and crews during normal working hours. At other times the operator has the additional responsibility of dispatching maintenance mechanics in response to trouble calls. The capabilities of the computer and the operators are well used.

When operators were recruited from the maintenance divisions on the Ft. Eustis post, emphasis was placed on hiring people who were interested in the systems concept of HVAC operation and were willing to work in an office environment. The move from utilities maintenance to EMCS operation was treated as a promotion. As a result the Ft. Eustis system has had competent operation of the EMCS and little attrition of operators. This has not been the experience of EMCS installations where a move to the EMCS control room has felt like a punishment to the new operators.

At Annapolis the operator works under direction of the main heating plant shift supervisor, who is located in the heating plant, far removed from the EMCS control room. None of the supervisors have training on or familiarity with the EMCS. The only other person who seems to have an interest in or knowledge of the EMCS is the design engineer in charge of energy projects, but he has no authority over the operation

of the system. So in contrast to Ft. Eustis, the EMCS is not used to the extent it could be and therefore is probably not achieving the energy or monetary savings it could.

Camp Lejeune was the only site visited that hired operators with computer backgrounds and trained them in the operation of HVAC systems. It was also the only site which has a position for an EMCS programmer. The programmer, who was with the system since its installation, was highly regarded. He has recently moved on to another job and the utilities engineer is having a difficult time replacing him. This has been the experience of other installations which have attempted to fill their operator positions with computer oriented personnel. These positions do not provide enough interest nor do they pay adequately to compete in the computer job market.

At nearly all of the sites visited, both in the course of this investigation and in previous studies, the most proficient EMCS operators are those who have a background in HVAC. That is not to say that candidates with other backgrounds cannot be trained to be good operators; however, the essence of the EMCS operator's job is operation of an HVAC system. Perhaps the title "EMCS Operator" is a misnomer, and the position should be more correctly described as "HVAC Operator" or "Utilities Operator." While it is true that the operator uses a sophisticated EMCS with its digital computer as a control medium, the EMCS, from the operator's standpoint, is merely a tool, much the same as an oscilloscope or ratchet wrench. Thus, it is far more important for the operator to understand the operation of the HVAC system, than that of the EMCS.

Response to the need to train candidate EMCS operators was remarkably similar at the installations visited. In almost every case, trainees were assigned to the various utilities maintenance divisions for periods of up to a year. During these assignments, candidates would accompany experienced HVAC maintenance people into the field on trouble

calls, and learn about HVAC system operation. Another effective field training situation is one in which trainees can observe actual installation of the EMCS "points" on the HVAC systems by contractor personnel. This approach of shop cross-training is essential to a broad understanding of the utility systems which might be connected to the EMCS; however, it is not by itself sufficient. EMCS installers are not in most cases fully acquainted with HVAC operation themselves, and are not well qualified to teach others. HVAC maintenance personnel do not necessarily understand HVAC on the system level. Furthermore, while this type of field training is applicable to training of the initial group of operators, unfortunately, supervisors will seldom have the luxury of being able to put a replacement operator in the field for a year. Neither can the trainees benefit from seeing an EMCS being installed. Therefore, additional training that focuses on HVAC operation at the system level and an understanding of the interaction of the HVAC equipment and the EMCS is needed.

2.0 RECOMMENDATIONS

The following sections include recommendations with regard to job description, qualifications, staffing, and training for EMCS operators.

2.1 Job Description

Based on the site visits, a study of the TM5-815-2/AFM 88-36/NAVFAC DM-4.9 and CEGS/NFGS/FCGS 13947-13949, and a review of job descriptions written for numerous EMCS sites, a typical job description for the operator of a large, medium, or small EMCS follows:

An EMCS operator monitors and controls the operation of a large number of utility and building environmental systems through the use of centralized control equipment. During normal operations, he monitors, via a CRT console, operation of HVAC systems and utility equipment to ensure they are functioning as designed under applicable energy saving routines. He is able to operate a CRT computer terminal or other control panel, dedicated printers and other peripheral devices such as magnetic tape and flexible disk storage systems. He is able to enter or modify system parameters such as time or event schedules and controller setpoints; make nonscheduled starts and stops of equipment or disable field panels when required for routine maintenance or other unforeseen occurrences; initiate reports, such as trend logs, energy consumption summaries, and maintenance run-times. He is able to restart the system after a power failure and bring it up to full operation. He is able to shut down the system in the proper sequence.

The operator performs operator-type maintenance on all EMCS equipment located in the central console room. He

may also perform sensor and FID testing in the field and replace memory boards in the FIDS.

In situations where the EMCS detects an unexpected change in some monitored operating parameter or equipment status and signals an alarm condition, the operator must be able to diagnose the probable cause of the alarm. Having determined the cause, he must then take the proper course of action to correct the alarm condition, either through the computer terminal or by calling the appropriate maintenance supervisor and if necessary, shut down the affected system in a prescribed manner to prevent equipment damage.

The operator ensures the best energy efficiency in operation of HVAC systems and utility equipment by monitoring and logging appropriate system parameters, adjusting dampers, valves and control point settings to determine and establish the best operational setpoints. In some installations, he may be expected to make recommendations for maintenance, repair, modification, or replacement of equipment based on system operational analysis of data received in the alarms, system readouts, and logging trends. He may also answer service calls during non-duty hours of the service call desk. He annotates appropriate office logs, forms, etc. to reflect up-to-date information and maintains printout files for use by other operators and the EMCS supervisor.

A job description for a small system operator would be the same with the deletion of those items not applicable to the system.

2.2 Staffing Requirements

Necessary support for an EMCS includes master control room operation, software maintenance, and repair of EMCS components. At present, few military bases have maintenance personnel versed in digital electronics; therefore, we recommend that repairs to the computer electronics be handled under contract with the EMCS vendor. Programmers are not required for small systems or systems which only have start/stop and monitoring capabilities. Programming support is usually readily available from the EMCS vendor. In fact, because of the difficulty in hiring and retaining computer oriented personnel, a dedicated EMCS programmer may not be the best solution. A senior operator or EMCS systems manager could take on the programming duties.

Staffing of the master control room by operators should be a minimum of 8 hours per day, 5 days per week, by one operator. For larger systems, staffing should be 24 hours per day, 7 days per week by rotation of 5 operators. At two of the sites visited, the control rooms were sometimes staffed by two operators during normal working hours. This should be necessary only for very busy, large systems which need a second operator to take care of daily schedule changes or maintenance records, while the first is responding to alarms and service calls. We recommend the 40 hour per week staffing for installations which function primarily as sophisticated timeclocks. For these systems, critical alarms need to be transferred to a night service desk or security office during off duty hours. We recommend 24 hour staffing for more complex systems with optimization or maintenance management functions.

Pay for EMCS operators at various sites ranges from GS-5 to GS-9 and WG-10 to WG-11. The operators need to have a broader knowledge of utility operations than field mechanics. In some cases EMCS operators have quite a bit of responsibility in the overall maintenance scheme. Therefore, we recom-

mend that they be paid slightly more than the maintenance personnel at a particular facility. We also feel that the operator should be classified under a unique job description for EMCS operator, rather than some other existing utilities position.

2.3 Qualifications and Background

We recommend that potential EMCS operators have at least a high school education and field experience or technical schooling in HVAC or a related field. It is preferable to train an HVAC oriented individual in the operation of computer equipment than to train a computer oriented person in HVAC operation. Understanding of HVAC operation is a more important aspect of the job than an understanding of computers. Also, computer oriented individuals are more likely to move elsewhere to more interesting or lucrative jobs.

Care should be taken in the selection of potential EMCS operators. Many maintenance mechanics would not be happy in an inside office job. Recruitment from maintenance shops or screening of applicants must be done with this fact in mind. Operators also will be more satisfied in their job if the value of the EMCS is recognized by appropriate management personnel.

2.4 Training Requirements

The recommended program for training candidate EMCS operators consists of four phases.

- o Maintenance Shop Rotation
- o EMCS Operator Training Course
- o Vendor Training
- o On-the-Job Training

The first phase of EMCS operator training should be rotation through utilities maintenance divisions for a period of several months. Candidate operators, who are hired with

no shop maintenance experience or HVAC technical schooling, should attend the EMCS Operator Training Course prior to shop rotation, rather than following it. This phase of training will familiarize the operator with location and operation of the actual equipment that the EMCS monitors and controls. In the case of a new installation, this training logically should occur during the construction of the system. The trainee's can learn a great deal by seeing the EMCS controls being installed and calibrated.

The EMCS operator training course should be the second scheduled training phase for EMCS operator candidates. The objective of this course is to provide operators with an understanding of the use of an EMCS for the energy efficient operation of HVAC equipment and other utilities. They must be trained to interact with the EMCS energy conserving routines, to recognize and respond to alarms, and to understand the concept of fine tuning the system to maximize energy conservation. The operator also needs to be made aware of his role as a public relations agent for the EMCS in his interactions with other base personnel. A detailed description of the course is presented in Section 3.0.

This type of training course will fill a knowledge gap, that is, a lack of candidate operator understanding of HVAC operation at the system level. This course will be based on the HVAC systems and EMCS designs and energy-conserving routines contained in the Tri-Service EMCS Guide Specifications and EMCS Technical Manual.

Due to funding limitations, most base EMCS installations are acquired in phases over several years. An attempt is made to design each phase so that it effectively integrates the existing EMCS with the proposed expansion. Experienced operators, with knowledge of the spectrum of available energy-conserving routines beyond those existing in the current system they operate, can provide valuable input to the new design. In many situations it is noted that operators intimately associated with the peculiarities of a given

HVAC installation are able to provide recommendations for new EMCS capabilities better than outside design engineers. Thus it is appropriate that the course cover all of the capabilities contained in the Tri-Service publications. Operators will get site-specific information in the subsequent phases of their training, as described below.

The third phase of EMCS operator training should be the EMCS vendor's schooling on the equipment being installed at the site. This training will include how to operate the vendor's brand of EMCS equipment, and how to interface with vendor's energy conservation routines. It should not include detailed instruction on computer electronics or software as some manufacturers have done in the past. These topics should be reserved for maintenance and programming personnel. Details of vendor training are discussed in Section 6.0 of the EMCS Specifications, NFGS-13947, FCGS-13947, CEGS-13947 and in Section 1.1 and 1.2 of this report. This training is normally intended to train candidate operators on how to manipulate the vendor's system, and does not teach the broader topics of HVAC system operation and general EMCS capabilities. Because the candidate operators will have already completed the generic introductory training course, they will be able to focus their attention on learning the specific installed system, and learning efficiency will be improved.

The final phase of EMCS operator training will be on-the-job training (OJT). It will complete the relationship between the classroom oriented training in phases two and three, and the actual HVAC and EMCS hardware at the specific site. This last phase of training will be totally site-specific. The OJT phase will occur during the 30-day operational acceptance test for a new installation and after the EMCS has been placed in full operation. In the case of training for an existing installation, candidate operators might alternate working shifts in the EMCS control room and working shifts in the utilities maintenance shops as part of the first phase of training.

EMCS operator training programs reviewed to date have been extremely lengthy (1 to 2 years), and have not incorporated adequate training in HVAC operation at the system level. The training program recommended in this report overcomes both of these shortcomings. This training program starts with hands-on experience with the HVAC systems (shop rotation), continues with a very generic approach to HVAC system operation and EMCS capabilities (the EMCS Operator Training Course), proceeds through more specific training on the manufacturer's equipment (vendor training), and ends with hands-on training with the installed EMCS system (OJT). This whole training cycle could be completed in about six months, including the one-week EMCS Operator Training Course, 2-3 weeks for Vendor Training, and up to 6 months in Shop Rotation and OJT.

2.5 Need And Requirements For Training Device

2.5.1 Introduction

This section contains discussion on the needs and requirements for a training device to be used in conjunction with the EMCS Operator Training Course. In order to meet the course objective, candidate operators will be instructed and trained in the systems concept of HVAC operation, including methods of control for the various types of HVAC systems; in the concept of automated and optimized HVAC system control with an EMCS, including what the capabilities of EMCS are; and in the manipulation of interactive computer terminal equipment. This type of instruction and training cannot be effectively accomplished without the use of a hands-on training and demonstration device.

2.5.2 Functional Requirements

The demonstration and training device will be used in two different modes. At times the device will be used by the instructor to demonstrate techniques, capabilities, and results as a part of the lecture series. At other times the device will be used by the students in hands-on laboratory sessions for practice and for performance testing at the end of the course. In Sessions 11 and 12 of the course schedule described in the course outline, the device will be used to demonstrate and practice operator manipulation of an interactive computer terminal; various operator interface techniques such as command line mnemonics, menu penetration, and interactive graphics; and operation of peripheral devices such as floppy disk drives and a printer. In Sessions 13-17, the instructor will use the training device to demonstrate

interaction with the energy conservation routines contained in the EMCS Technical Manual. The device must accommodate parameter entry, and simulate interaction of the EMCS routine with the HVAC system as well as represent energy savings. In Session 18, the trainees will operate the device to practice the actions and observe the reactions described by the instructor in the previous four sessions. In Sessions 19-21, extensive use will be made of the device by the instructor to demonstrate HVAC system operation, and the diagnosing of and response to alarm conditions. In Sessions 22-23, the trainees will use the device for hands-on practice of the operations demonstrated by the instructor in the three previous sessions. The device will be used in Session 24 to demonstrate the printing of logs and reports. Finally, the training device will be used in Sessions 26 & 27 to administer performance tests as described in the course outline.

2.5.3 Technical Requirements

The EMCs Operator Training Course may be presented at either individual EMCS installation sites, or at a central location with attendees from several sites. Class sizes may vary from seven students in the former case, to 35 students in the latter. In order to facilitate taking the course to presentation sites, the trainer will have to be transportable. Several trainer units will be required to support course delivery at central locations. Likewise, the device should be able to fulfill all of its functions in a stand-alone mode, i.e., it should not be dependent on a host computer for its operation. To enable easy viewing of the device CRT screen in the demonstration mode, provision should be made for a standard video interface. In this way, video monitors can be hooked to the device to provide multiple close-up views of the screen. The training device must be able to simulate, in a satisfactory manner, operation of HVAC

systems, energy conservation routines, and resultant energy savings, log and report printing, and alarm diagnosis and correction. The trainer must be capable of demonstrating different types of operator interfaces, such as CLM, menu penetration and interactive color graphics.

2.5.4 Hardware Description

The Chromatics color graphics stand-alone computer system should be capable of accommodating the requirements described above. This equipment was used in developing and implementing a man-machine interface demonstration device for interactive color graphics as a control technique. With appropriate software it should also function well as a trainer and demonstration device for the course. To meet the requirements for the course, the Chromatics computer would have to be equipped with an interactive touch screen, CP/M operating system, and a standard video interface, in addition to its hardware based color graphics generation capability. Peripheral devices would include floppy disk drives and a line printer. Since the major work with the hardware configuration has already been accomplished, development efforts for the trainer would involve mostly software generation.

3.0 EMCS OPERATOR TRAINING COURSE DESCRIPTION

This course is the second of a series of four recommended training vehicles intended to prepare qualified applicants to serve as EMCS operators. In accordance with the sample job description included with this report, the objective of this course is to provide candidate operators with an understanding of the use of an EMCS for energy efficient HVAC System operation, and to train them to perform, in a generic way, in three functional modes.

1. Normal HVAC system operation, including entering parameters for the various energy conservation routines that are listed in the EMCS Technical Manual.
2. Recognition of and response to alarm conditions occurring in HVAC systems that are listed in the EMCS Technical Manual.
3. Understanding the concept of fine tuning or "tweaking" the system to maximize energy conservation.

Table 1 contains the proposed schedule for the operator training course. Each class session is scheduled to be 55 minutes in length, to allow for a short break between classes. In order to meet the training objectives described above, the candidates will have to be instructed in the systems concept of HVAC operation, including methods of control for the various types of HVAC systems. While the candidates may understand very well maintenance and/or operation of certain HVAC components, such as pumps, or generators, few will have knowledge of overall HVAC system operation, particularly with the goal of energy conservation.

Once an understanding of HVAC system operation is established, the concept of automated and optimized HVAC system control with an EMCS will be introduced. This will involve teaching what an EMCS is and what it can do, focussing more on what it does and less on how it does it. For instance, candidates will be taught about the types of energy conserving programs available, how they interact with HVAC systems, and what inputs are required from the operator. There will be no attempt, however, to get into the software routines themselves, to explain how they function. Use of the EMCS as a tool for HVAC control will be emphasized, to make the EMCS transparent to the operator. Finally there is a need to overcome the mystique associated with computers by providing hands-on practice in computer terminal manipulation as a part of the training course. Trainees will have laboratory sessions where they will have the opportunity to interact with a training device simulating operation and trouble-shooting on an HVAC system through an EMCS.

TABLE 1

EMCS Operator Training Course Schedule

<u>DAY</u>	<u>SESSION</u>	<u>TITLE</u>
MON	1	Course Introduction and Pretest
	2	Introduction to HVAC Concepts
	3	HVAC Systems Description
	4	HVAC Systems Description
	5	HVAC Systems Description
	6	HVAC Systems Description
TUE	7	HVAC Systems Description
	8	HVAC Systems Description
	9	Introduction to EMCS
	10	Operator Interaction with EMCS
	11	Operator Interaction with EMCS
	12	Operator Interaction with EMCS
WED	13	EMCS Functions
	14	EMCS Functions
	15	EMCS Functions
	16	EMCS Functions
	17	EMCS Functions
	18	Laboratory I

EMCS Operator Training Course Schedule (Con't)

<u>DAY</u>	<u>SESSION</u>	<u>TITLE</u>
THU	19	System Operation and Alarm Analysis
	20	System Operation and Alarm Analysis
	21	System Operation and Alarm Analysis
	22	Laboratory II
	23	Laboratory II
	24	Trend Logs
FRI	25	Review for Test
	26	Administer Written and Performance Test
	27	Administer Written and Performance Test
	28	Review test

3.1 Operator Training Course Outline

SESSION 1. Course Introduction and Pretest

Content

The objectives of the course will be presented and discussed. A class schedule and an abbreviated course outline will be distributed to each student. A written pretest, identical to that given at the end of the course, will be administered. The pretest results will serve as a gauge point for measuring the amount of information retained by the students, and will give the instructors an indication of the student's level of knowledge with regard to HVAC systems and their associated controls.

Learning Objectives

As a potential EMCS operator/supervisor, be able to list and describe the objectives of the training course.

SESSION 2. Introduction to HVAC Concepts

Content

A general introduction to the need for energy conservation and how consumption can be reduced through computerized monitor and control of HVAC systems. A review of basic HVAC concepts with an emphasis on the interactions between system components and the effect of one system on another.

Learning Objectives

As a potential EMCS operator/supervisor, be able to:

1. Explain the need for energy conservation.
2. Explain the basic concepts of HVAC system operation.

SESSIONS 3-8. HVAC Systems Description

Content

Description of each of the HVAC systems contained in the EMCS Technical Manual (TM5-815-2/AFM 88-36/NAVFAC DM-49), with the aid of a schematic-like diagram of the system, including the configuration of the system, what the system is designed to do, and how that system is controlled. Information on pneumatic and electric controls, actuators, sensors, controllers and safety overrides will be included where appropriate. Discussion of some ways to conserve energy in the operation of the system.

Learning Objectives

Given a schematic-like diagram of an HVAC system, be able to:

1. Identify the type of system.
2. Explain what the system is designed to do.
3. Describe control methods for the system.
4. Describe at least one way to conserve energy during system operation.

SESSION 9. Introduction to EMCS

Content

Discussion of what on EMCS is, what its intended purpose is, how the EMCS connects to and controls an HVAC system via "points", and what other types of equipment may be controlled by an EMCS. Use of the EMCS as a tool to control other systems will be emphasized. The discussion of the need for base personnel to be educated about the function of the EMCS and the operator's role in this process.

Learning Objectives

As a potential EMCS operator/supervisor, be able to:

1. Describe what an EMCS is.
2. Explain the purpose of an EMCS.
3. Describe how the EMCS connects to the HVAC system.
4. Explain how the EMCS provides for monitor and control of the HVAC system.

SESSIONS 10-12. Operator Interaction with EMCS

Content

Discussion of the architecture of a large/medium EMCS system, describing each component and its function. Demonstration of operation of control room equipment, such as the interactive CRT terminal, floppy disk drive, and printer. Demonstration of operator control actions on the CRT terminal using the keyboard, numerical keypad, and touch-activated screen of the EMCS Operator Training Device.

LEARNING OBJECTIVES

1. Given an EMCS architecture diagram from the Technical manual, be able to:
 - a. Describe the architecture of an EMCS.
 - b. Identify the components of the EMCS and explain what each component does.
2. Using the EMCS operator Training Device, be able to:
 - a. Operate an interactive CRT computer terminal using keyboard, numeric key pad, and touch screen.
 - b. Operate a floppy disk drive.
 - c. Operate a printer.

SESSIONS 13-17. EMCS Functions

Content

Description of each of the energy conservation routines contained in the EMCS Technical Manual and the Guide Specifications, including its application, operation, interaction with the HVAC system, how energy is saved, and required operator inputs. The EMCS Operator Training Device will be used as a teaching aid to demonstrate operator interaction with the routines and subsequent energy savings.

Learning Objectives

Given a list of energy conservation routines from the EMCS Technical Manual, for each routine be able to:

1. Describe what the routine is designed to do.
2. Explain how the routine conserves energy and what is the relative energy savings through its use.
3. List and describe the inputs required from the EMCS operator for operation of the routine.

SESSION 18. Laboratory I

Content

Using the EMCS Operator Training Device, and with guidance from the instructor, students will call up energy conservation routines, enter necessary parameters, and observe resultant energy savings.

Learning Objectives

Using the EMCS Operator Training Device, be able to:

1. Call up any energy conservation routine.
2. Explain and enter the inputs required for operation of that routine.

SESSION 19-21. System Operation and Alarm Analysis

Content

Demonstration and discussion of types of alarms which might be encountered by an EMCS operator, using the EMCS Operator Training Device, for HVAC systems contained in the EMCS Technical Manual. Discussion of identification of critical alarms, diagnosing the cause of the alarm, and corrective actions that should be taken. For purposes of testing, specific pre-planned examples will be used in these sessions.

Learning Objectives

Observing the CRT screen of the EMCS Operator Training Device, or paper reproductions thereof, be able to:

1. Describe the alarm condition presented.
2. Determine if the alarm is critical.
3. Diagnose the cause of the alarm condition.
4. Describe prescribed corrective actions.

SESSIONS 22-23. Laboratory II

Content

Using the EMCS Operator Training Device, and with guidance from the instructor, students will practice identification of alarm conditions, diagnosis of conditions which caused the alarm, and taking corrective actions.

Learning Objectives

Using the EMCS Operator Training Device, be able to:

1. Describe the alarm condition presented.
2. Diagnose the cause of the alarm condition.
3. Enter the proper corrective commands on the operator terminal.

SESSION 24. Trends Log and Reports

Content

Presentation of examples of trend logs and reports and how these records can be used for HVAC system trouble-shooting, maximizing energy savings, and maintenance management.

Learning Objectives

As a potential EMCS operator/supervisor, be able to:

1. Explain how a trend log can be used to trouble-shoot an HVAC system problem.

2. Explain how trend logs and/or reports can be used to increase energy conservation.
3. Explain how reports can be used for maintenance management.

SESSION 25. Review for Test

Content

Instructor will review all material covered during the week course which might appear on the written test.

SESSION 26-27. Administer Written and Performance Test

Content

The written test is identical to the pretest administered during the first hour of the course. Comparison of each student's grade on the second test with that from the previous test should give some indication of information learned and retained from the course. The performance test will be conducted using the EMCS Operator Training Device. Students will be given sample tasks, such as set point adjustment, or scheduled start/stop time changes, and must correctly perform the task on the device. Additionally, students will be given sample alarm conditions and be expected to correctly identify the alarm condition, diagnose the cause for the alarm condition, and take corrective action using the trainer.

Learning Objective

Students should reach the level of standard prescribed for the course. If the standard is not initially obtained, the student will review the course material, and at a later date, will retake the test administered by the supervisor at the base facility.

SESSION 28. Review Test

Content

Instructor will review the written test with the class to reinforce the material presented and clear up any areas of confusion with the students.

3.2 EMCS Operator Training Manual Outline

3.2.1 Table of Contents

INTRODUCTION

CHAPTER 1. HVAC SYSTEMS

- Section 1. Basics of HVAC Systems
- Section 2. Control Concepts
- Section 3. Configuration and Operation of
Typical HVAC Systems

CHAPTER 2. ENERGY MANAGEMENT AND CONTROL SYSTEMS

- Section 1. Introduction to EMCS
- Section 2. Operator Interaction with the EMCS
- Section 3. EMCS Functions

CHAPTER 3. SYSTEM OPERATION

- Section 1. Alarms
- Section 2. Optimization of Energy Savings

APPENDICES

- A. Glossary
- B. Sample Log Trends and Reports
- C. Notes and Handouts

3.2.2. Summary of Contents

INTRODUCTION

Objectives of the training course and manual, definition of Energy Management and Control Systems, and a discussion

of the need for energy conservation and its potential accomplishment in buildings through EMCS.

CHAPTER 1. HVAC SYSTEMS

Section 1. Basics of HVAC Systems

Basic concepts of heating, ventilating, and air conditioning. Included will be discussions of building envelopes, internal loads, primary, secondary and unitary systems. Heat transfer concepts will be discussed only to the extent that is required to understand the basic operation and energy consumption of HVAC systems.

Section 2. Control Concepts

A basic treatment of the concept of control loops including the functions of sensors, actuators, and controllers.

Section 3. Configuration and Operation of Typical HVAC Systems

Presentation of each type of system most commonly controlled by an EMCS including a schematic, a description of the configuration, an explanation of its intended function and how it is achieved, and applicable control mechanisms.

CHAPTER 2. ENERGY MANAGEMENT AND CONTROL SYSTEMS

Section 1. Introduction to EMCS

Description of the configuration of an EMCS and how it connects to HVAC and other utility systems.

Section 2. Operator Interaction with the EMCS

Detailed description of the functions of the EMCS components with which the operator directly interacts. Discussion of the type of "points" which may be included in an EMCS for monitoring and control of various systems.

Section 3. EMCS Functions

Definition and description of each of the EMCS application programs in terms of what it is designed to do, how it conserves energy, the inputs and outputs required for application to typical systems, and a comparison of the relative amounts of potential energy savings.

CHAPTER 3. SYSTEM OPERATION

Section 1. Alarms

Discussion of the types of alarms that might be encountered and how one diagnoses the causes. Discussion of those alarms that might be critical, why, and what precautions need to be taken in the event of a critical alarm.

Section 2. Optimization of Energy Savings

Discussion of the possibilities of improving energy savings by adjusting setpoints, changing time constants, etc., and the use of monitoring points and log trends to determine the best setpoints and energy saving strategies.

APPENDICES

A. Glossary

List of HVAC, controls, and EMCS terms and their definitions.

B. Sample Log Trends and Reports

To be referred to as examples during the course and for future reference by the operators on the job.

C. Notes and Handouts

Blank paper will be provided for notes and space left for addition of handouts passed out in class.

APPENDIX A.1

PROJECT: EMCS Operator Training Course
L23/NJT/bec 81-0057
81N196

SUBJECT: Discussions with Manufacturers

10/21/81 Spoke with Henry Hoge of HSQ Technology, Inc. by telephone. He agreed to send some information on their operator training course along with the EMCS pricing information. Received outlines for Operator Training, Maintenance Training, and Engineer Training October 23, 1981.

10/23/81 Spoke with Hal Yeger of Honeywell by telephone. No behavioral objectives were spelled out in development of their operator training course. Instead the course was based on the time schedule and course goals listed in the Tri Service Specs Section 6.3. He feels that five days for the initial training limits the course to very light instruction and that the operator needs to know far more than what is called for in the Specs. Other points which Hal made are:

- The Honeywell training is very system specific.
- Emphasized the need for instruction to be oriented to the specific site and hardware.
- His experience at various EMCS sites was that what was expected of the operators varied considerably.
- Need to teach about the energy saving programs (i.e. duty cycling, night setback)
- They use a Delta 5600 with some FID's and MUX's tied to it and a simulator which simulates several points for training.

10/23/81 Spoke with Ed Mechler of Brown Boveri-Compuguard by telephone. He has not been with the company long and is learning EMCS; his background is process control. At this point they have no existing training manuals and have just begun development of a simulator.

He felt more emphasis needs to be placed on computer knowledge and that possibly an introduction to programming should be included in the training. He felt the goals of the operator training should be:

1. Ability to describe the HVAC system and computer system and how they interact.
 - a. Major components of computer and what it does
 - b. Major components of HVAC systems and what they do
2. Knowledge of what to do in instance of an alarm and be able to execute in a simulation environment.
3. Introductory knowledge of computers.

11/18/81 Spoke with Vick Jones of Oak-Adec by telephone. He said we were welcome to attend any of their training sessions. He agreed to send an outline of their course. Pertinent comments which he made are:

- They consider two levels of operators. The first is a general day-to-day operator with possibly some hardware maintenance duties. The second is more knowledgeable of software. The level I operator could be trained in a 5-day class.
- They use an interface demonstrator with the system on site as a training device. The device runs through a training program which prompts the trainee through typical operator procedures.
- In his training experience he has found that most people being trained have no computer experience, but most have some knowledge of HVAC systems. They often are from the physical plant and may be plumbers or electricians, not just HVAC repairmen.

11/18/81 Spoke with Mike Adelman of Staefa Control Systems, Inc. training department by telephone. At this time they have not developed an operator training course, only

one for system's managers. Only experience he has had with operators is a site visit.

11/30/81 Spoke with Don Hewitt of Computer Science Corporation by telephone. He said he would see about sending some written information. Pertinent comments he made were as follows:

- The personnel coming into the training are underqualified for the job.
- Requirements for training as laid out in the Specs are much less than what is necessary
- Felt that exposure to the three "generic" modes of MMI as proposed at our November 19-20 meeting would be more than the students could handle in the allotted time.
- What they now include in the training is
 1. Small amount of HVAC review
 2. Introduction to conservation functions
 3. Very little about programming
 4. Hot start/warm start/cold start of system
 5. Data entry

but all are very system specific

11/30/81 Spoke with George Futas of Johnson Controls by telephone. He feels the multi-phase training as designated by the Specs is good. He feels the best arrangement is 2 or 3 days with half the time on the system itself for the first phase, then several weeks on-the-job training, then back to school for the final phase. He promised to send some information with the EMCS pricing.

11/30/81 Spoke with Steve Schillinger of Advanced Electrical Applications, Inc. by telephone. Their training consists of 3 or 4 days of self taught instruction by way of a cassette tape which prompts the student at the terminal. He feels that understanding closed loop and

open loop control and hands-on experience are the most important aspects of training. He will check and see if there is some appropriate written material that he can send to help us.

11/30/81 Spoke with Harris Bynam at the Honeywell Atlanta regional office. He gave us a listing and summaries of training packages that Honeywell has developed. He said we are welcome to go back to peruse the material in the training library and borrow any of the slides and possibly copy text with his permission. He also gave us copies of an Energy Management Simplified workbook which may be useful. A Delta 1000 Training Course will take place in Atlanta January 12-14. We are to call the week before if interested in sitting in on the course or talking with the instructor.

APPENDIX A.2

EMCS Operator Training Course
Site Visit Report
Ft. Eustis, Virginia
January 11, 1982

Contacts: John Roth, DDEH, Ft. Eustis
Martin D. Ritchie, Supervisory Engineering
Technician
Gene Mahoney, Utilities System Controller

The Energy Monitoring and Control System at Ft. Eustis, Virginia, was designed in 1974, installed over the period 1975-77, and became fully operational in 1978. Phase III, now being installed, will enlarge the system to 20,000 points. The system is a Johnson Controls JC/80, including a monochrome CRT for the operator's console, a graphic slide projector, and three printers. The printers are dedicated to three separate functions: alarms and actions taken by the operator; trend logs and reports; and maintenance management reports. Phase III will add a color graphics CRT which will replace the slide projector, and intelligent field interface panels for buildings being added to the system.

The control center is staffed 24 hours a day, 7 days a week, by a rotating team of five operators. The operator position is rated at a WG-11 pay scale, which carries somewhat better wages than the field mechanics. Often two operators are scheduled for simultaneous duty during the day shift. Their immediate supervisor is the Supervisory Mechanical Engineering Technician, a GS-09 employee who is responsible for planning and conducting the remote operation of utility plants and systems and also supervises the field mechanics. There is no computer programmer on staff dedicated to the EMCS; all software revisions are made by Johnson Controls.

Four of the five operators have been in that job position since the installation of the first phase of the system. They were selected from the Utilities Division and "...were

essentially the cream of (the) operator and mechanic staff. Each console operator was required to be extremely fluent in the operation and/or maintenance of one utility plant or system and was required also to be knowledgeable of at least one other plant and system. Job applications were screened and each applicant went through intensive personal interview in which detailed technical questions were asked. Of the four, three came from the central heating plant section and one came from the sanitation branch. The one from the sanitation branch is a retired military NCO with extensive background in electronics, controls, and utility plants and systems."

The operators were trained through a combination of schooling on the system by Johnson Controls, rotation through all the utilities maintenance shops over a one year period, and on-the-job experience in the control room. Those interviewed at Ft. Eustis feel that the year of rotation of the operators through the various maintenance shops during the initial construction of the EMCS was crucial to the competence of the EMCS operators.

The primary tasks performed by the operators are changing start/stop schedules, adjusting setpoints and alarm limits, load shedding from the console for the purpose of demand limiting, responding to alarms, and establishing maintenance tasks based on alarms which cannot be corrected from the terminal. In addition, during the night shift daily maintenance management reports are generated, maintenance task times updated, and calls to the "trouble desk" are answered. At all times, the operators keep a written log of events which occur and actions taken.

Due to organizational structure of the division under which the EMCS falls, it and the operators are an integral part of the maintenance as well as the operation of the base HVAC and utility systems. With the help of walkie-talkies they directly dispatch maintenance crews during the night

shifts and communicate with them during repair of malfunctions at all times. According to established procedures, weekly occupancy schedules of classroom buildings are sent directly to the operators for revising equipment start/stop schedules. The operators have a significant amount of responsibility and autonomy.

EMCS Operator Training Course
Site Visit Report
U.S. Naval Academy
Annapolis, Maryland
January 12, 1982

Contacts: Jeff Hall, EMCS Engineer
Bill Dial, Senior Operator

The Energy Monitoring and Control System at the Naval Academy has been in operation since 1974. The system is a Johnson Controls JC/80-45 including a black and white CRT for the operator's console, two (2) graphic slide projectors, and two (2) printers. The original system was strictly start/stop and monitoring functions. In 1975, capability for enthalpy economizer control, temperature resets, optimized start/stop chiller optimization, and demand limiting were added. The system monitors a 7,000 ton chiller plant and controls 74 air handlers. The EMCS does no maintenance management nor does it monitor the central heating plant.

The control center is staffed 24 hours a day, 7 days a week by five operators on rotating shifts. They are classified as chiller plant operators at the WG-5 level. Two operators are on duty during the day shift. Each operator is supervised by the respective maintenance shop supervisor for the particular shift. There is no dedicated EMCS programmer on staff nor software documentation; all software maintenance is done by Johnson Controls.

The operators have a variety of backgrounds including computer operating/programming and work in the Naval Construction Battalion. In the selection of operators, the importance of total systems orientation is emphasized. Those interviewed also felt that operator candidates should have at least a high school education and that a refrigeration background is desirable.

Primary tasks performed by the operators are reprogramming start/ stop schedules, responding to alarms, monitoring points, manually operating the chillers, and physical inspection of systems not included in the EMCS. The operators actually spend a good portion of shift time making rounds through mechanical rooms of buildings not connected to the EMCS. Upon return to the control room they respond to any alarms which have been recorded on the alarm printer. All maintenance requests generated by the EMCS must go through the shift maintenance supervisor. Although run time totalization is included in the software it is not used for maintenance management. The operators are capable of taking down the computer when necessary, but it is part of the Johnson maintenance service contract to bring the system back on line and reload programs.

Unlike Ft. Eustis, the Annapolis system is not an integral part of the maintenance and operation of base utility systems. It is used primarily for monitoring and time clock functions with minimal optimization. The demand limit load shedding has even been discontinued because the equipment connected to the system draws negligible power compared to the Naval communication center which shares the electricity.

EMCS Operator Training Course
Site Visit Report
Camp LeJeune, North Carolina
January 25, 1982

Contacts: Fred Cone

Junior Johnson, Utility Maintenance Engineer

The 600 point CSC system, installed in 1978 or 1979, is used primarily for demand limiting, control of steam valves to individual buildings, and monitoring of the sewage lift stations and swimming pools. The system is connected to about 70 buildings, which are all occupied 24 hours per day. Each building has its own 25-30 ton air conditioner for cooling, and is heated by steam from 8 centralized boiler locations. The EMCS has start/stop control of the building chillers but no reset capabilities and does no monitoring or control of the boiler plants. The system equipment consists of a MODCOMP computer, FTS field panels and Motorola radio frequency control of housing units. A second increment will add 2200 points in 90 buildings and four steam plants.

Presently, one operator staffs the control room eight hours a day, five days a week. Outside of these hours, watch standers at the maintenance trouble desk will respond only to alarm buzzers triggered by high water levels at the sewage lift stations. When the second increment comes on line, five or six operators will monitor the system twenty-four hours a day, seven days a week on rotating shifts. Four additional persons were hired and trained in preparation for installation of the second increment; however, due to an interruption in the installation of the system, the new personnel have been placed in other positions. The EMCS operator trainees had electronics or computer operator backgrounds and were trained on site in HVAC system operation.

Camp Lejeune's training plan includes hands-on experience for a minimum of:

- o 10 weeks on the overall operation of the computer system;
- o 10 weeks on the maintenance of remote EMCS equipment;
- o 8 weeks on the operation of a central water treatment plant;
- o 10 weeks at the base steam and hot water plants;
- o 4 weeks on operation of a sewage treatment plant;
- o 5 weeks on operation of central air conditioning;
- o 5 weeks on the operation of heating equipment.

A second year of on the job training in the computer room follows, supplemented by some classroom instruction. Mr. Cone and Mr. Johnson emphasized that the operators benefit by seeing the installation of the system. The operator on duty stated that the classroom operator training course would be the most useful prior to the maintenance shop rotation by helping the trainee focus on the relevant aspects of the many things to which he or she is exposed in the field.

Other EMCS support personnel, supervised by the utility maintenance engineer, included a programmer and an electronics repairman. Those interviewed felt that much more can be accomplished with the system with their own programmer than with software support supplied by the contractor. Another electronics repairman will be added upon completion of the second increment. Central gear is maintained through a maintenance contract, but all field control devices, MUX's and FID's are maintained by base personnel. Operators are hired at a GS-5 pay level advance to GS-6 after one year of training, and to GS-7 after a second year. The programmer is hired at a GS-9 level.

Tasks performed by the operator include monitoring points, responding to alarms, taking radio calls from the

field, updating inventory information, making seasonal changeovers, and printing reports. The system has a variety of reports providing maintenance management and energy consumption data. When operators receive alarms that indicate a condition which cannot be corrected at the operator console, they contact the appropriate shop supervisor to request a field check.

In summary, the EMCS system at Camp LeJeune appears to be well managed and well utilized, especially considering the limitation that all systems under control operate twenty-four hours a day. They use the system for maintenance management including inventory control and unlike any of the other sites visited, they employ a programmer and hire operators with computer/electronics rather than HVAC backgrounds.

EMCS Operation Training Course
Site Visit Report
Charleston AFB
January 26, 1982

Contact: Charles Parnell, Deputy Chief of Operations

A Honeywell Delta 2000, including only monitoring points, was installed as a maintenance tool in 1971. In 1974, energy management capabilities were added to the system with the addition of a 10 channel Honeywell demand limiter and expansion to 1200 points in 65 buildings. The system is now capable of start/stop and demand limiting, but no night setback or optimal start/stop. The system consists of the Delta 2000 computer, graphics slide projector, alarm printer, log trend printer, 63 data gathering panels, the demand limiter, and a Motorola 10-tone demand limiting system with receivers at the base housing air conditioner compressors. The base's central steam plant is not included on the system and large chillers are only monitored, not controlled by the EMCS.

Presently, one operator staffs the control room eight hours a day, five days a week. At night and on weekends, alarms are monitored by the service call desk. Present duties of the operator include responding to alarms, troubleshooting difficulties with trend log reports, monitoring temperatures, checking for correct on/off status of equipment, adjusting bypass damper position, directing maintenance requests to the shop supervisors, and monitoring radio reports of the service call technicians. Training was conducted entirely in-house on the EMCS itself. Past and present operators have had backgrounds in air conditioning and heating maintenance and most have had associate degrees.

Long range goals for future expansion include 24 hour staffing by 5 operators on rotating shifts. Mr. Parnell said

he will probably seek new hirees who have air conditioning training from local technical schools. He has found that personnel from the maintenance shops do not want to be transferred to the inside office job of EMCS operator. Also an EMCS supervisor will be hired whose duties will include overseeing the work of the operators, maintaining optimum energy saving strategies, and some programming.

DATE
FILME
8-8