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THE PUBLIC WORKS C..(U) NAVAL CIVIL ENGINEERING LAB
PORT HUENEME CA K J CANFIELD SEP 83 NCEL-TN-1678

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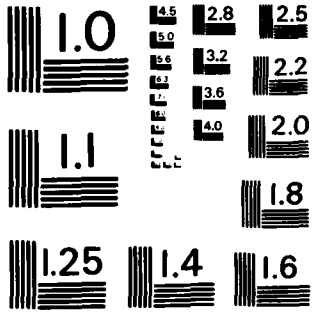

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AUTHOR: K. J. Canfield

DATE: September 1983

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NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

METRIC CONVERSION FACTORS

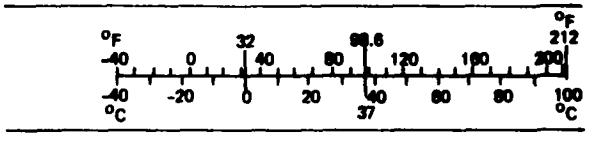
Approximate Conversions to Metric Measures

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		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	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 Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

Single-building energy controllers can be installed in many buildings to conserve energy. These systems can provide significant energy savings with limited investment. This report details the installation of a single-building energy controller in the Public Works Center building at Naval Weapons Center, China Lake, Calif. The controller was installed by NCEL and Public Works personnel in about 3 days, and is working very well. The reasons for the success are a reliable controller, a dedicated user (continued)

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and the patience and cooperation of the building occupants.

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Single-building energy controllers can be installed in many buildings to conserve energy. These systems can provide significant energy savings with limited investment. This report details the installation of a single-building energy controller in the Public Works Center building at Naval Weapons Center, China Lake, Calif. The controller was installed by NCEL and Public Works personnel in about 3 days, and is working very well. The reasons for the success are a reliable controller, a dedicated user, and the patience and cooperation of the building occupants.

CONTENTS

INTRODUCTION

Energy conservation measures can be implemented in buildings to reduce energy consumption significantly. One attractive measure is to utilize single-building energy controllers (SBEC). These SBEC can implement very complex energy conservation control strategies and can pay for themselves in a very short time period. This report discusses the installation of an Andover Controls Sunkeeper in the Public Works building at the Naval Weapons Center (NWC), China Lake, Calif. The installation of the Andover Controls Sunkeeper does not imply endorsement by the Government. The Sunkeeper is one of many different single-building controllers (see Ref 1*) and may be no better or worse than any other controllers with similar characteristics.

BACKGROUND

The energy crisis of 1973 and increasing energy costs have caused great emphasis to be placed on energy conservation. A variety of ways is feasible for government installations to meet their energy conservation goals. Many large facilities are installing large-scale, computerized Energy Monitoring and Control Systems (EMCS) to help meet their goals. These systems have many advantages, a few of which are: energy conservation with limited manpower, energy accountability, and improved operation and maintenance of heating, ventilating, and air conditioning (HVAC) systems. Unfortunately, these EMCS are expensive and require cooperation and dedication of facility operation and maintenance (O&M) personnel.

There are many smaller installations and single buildings that cannot justify a large-scale EMCS. Equipment that can provide significant energy savings in these small installations or single buildings can be divided into six categories: time clocks, duty cyclers, demand limiters, programmable controllers, micro-EMCS, and small EMCS.

Guide specifications have been prepared for small EMCS and micro-EMCS. A small EMCS would have at least a part-time operator, while a micro-EMCS would be installed and only rarely would changes in the operation of the system be made. Typical energy conservation control strategies that are implemented with these systems are: scheduled start/stop, optimized start/stop, duty cycling, demand limiting, day/night setback, and ventilation/recirculation.

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*1. J. Rees. Controlling energy consumption in single buildings, Naval Civil Engineering Laboratory, Contract Report CR 82.028. Atlanta, Ga., Newcomb & Boyd, Jul 1982.

DISCUSSION

The Naval Civil Engineering Laboratory (NCEL) started investigating SBEC in FY77. A survey of existing equipment identified timeclocks and demand limiters as the only readily available alternatives to large-scale EMCS. Unfortunately, timeclocks are readily defeated through tampering or setting them to worst-case conditions, and they require significant O&M effort. Demand limiters typically lack flexibility and are primarily aimed at saving money on demand charges. Government buildings are rarely demand-metered on a building-by-building basis, and demand limiters typically lack flexibility to respond to changing demand billing structures or to be incorporated into an EMCS.

Because no product was available that met the desired characteristics, a development program was initiated to provide a microprocessor-based unit that would provide scheduled start/stop and optimized start/stop energy conservation control strategies. A contract was awarded to develop an intelligent timeclock (ITC). The original plan called for one ITC to be installed in Building 560 at NCEL and another one in the Thompson Laboratory building at NWC, China Lake.

One ITC was installed at NCEL and did validate the concept of using microcomputer technology to implement energy conservation control strategies. The primary strategy implemented on the ITC was optimized start/stop, which used outside air temperature, inside building air temperature, and time to determine the "optimum" time to start/stop the HVAC equipment. The development and installation of the ITC is detailed in Reference 2.*

Unfortunately, the ITC was not as reliable or maintainable as desired, so the decision was made not to install the other ITC at China Lake and to replace the ITC at NCEL. The ITC at NCEL was replaced with a unit assembled using single-board computer technology. The development, installation, and experience on this unit are described in Reference 3.**

A slightly different approach was taken for the unit to be installed at China Lake -- the Center used one of the commercially available SBECs that had become available since the development of the ITC. The SBEC selected for China Lake was the Andover Controls Sunkeeper. This unit has an excellent reputation for reliability and user satisfaction. The Sunkeeper is user programmable using a very simple, but adequate, control language with the following syntax:

```
Do action; if any of the following conditions are met  GO TO LINE__
                    condition 1
                    condition 2
                    :
                    condition n
```

*2. D. Shiroma. EMCS modules/intelligent time clock (ITC), Civil Engineering Laboratory, Technical Note N-1588. Port Hueneme, Calif., Sep 1980.

**3. I. Sanchez. Utilizing the optimum start/stop control strategy for heating NCEL, Naval Civil Engineering Laboratory, Technical Note N-1663. Port Hueneme, Calif., Apr 1983.

or

Do action; if all of the following conditions are met GO TO LINE__
condition 1
condition 2
:
condition n

The Sunkeeper has the capability for 32 digital inputs (contact closures), 32 digital outputs (energize relays), and 32 analog inputs (temperature sensors).

A coordinated effort between NCEL and PWO China Lake resulted in the Sunkeeper being installed in the Public Works building instead of the Thompson Lab. The rationale behind this was to allow Public Works personnel to become familiar with using computerized energy conservation control strategies in their own building.

The Public Works building at China Lake has four large air handler units (AHU) that provide both heating and cooling to the building. PW personnel prepared the building by installing conduit between the location for the Sunkeeper and the motor control center for the air handlers. Two people from NCEL assisted China Lake personnel with the final installation of the Sunkeeper control unit, temperature sensors, and solid state interposing relays. A one-line diagram of the Sunkeeper installation is shown in Figure 1. The Sunkeeper was operational 28 October 1981.

NWC and NCEL personnel worked together to develop the control strategy for optimized start/stop and weekend/holiday shutdown. These control strategies were initially used on only one AHU on a trial basis and then the other three AHUs were added. In addition, NWC personnel have since implemented duty cycling.

The initial reaction to the Sunkeeper has been favorable, but that is not to say that there have not been problems. However, thanks to the dedication of the NWC Public Works personnel, telephone help from Andover Controls, and the cooperation of the building occupants, all problems have been overcome. In fact, the unit has been so successful that three additional Andover Controls units are being installed in other China Lake buildings. These other buildings are being monitored by NCEL in order to help determine the energy saved by implementing SBEC.

CONCLUSIONS

SBEC can help conserve energy in government buildings. Implementing a few energy conservation control strategies, such as scheduled start/stop, optimized start/stop, duty cycling, demand limiting, day/night setback, and ventilation/recirculation, can achieve significant energy savings. Strategies that have been successfully implemented at either NCEL or China Lake are: scheduled start/stop, optimized start/stop, deadband operation, weekend/holiday shutdown, and duty cycling. These strategies can be implemented by using a SBEC with temperature sensors and interposing relays in the HVAC control loops. Key ingredients for success are: (1) a good, reliable SBEC; (2) a dedicated, enthusiastic SBEC user; and (3) building occupants' patience and cooperation.

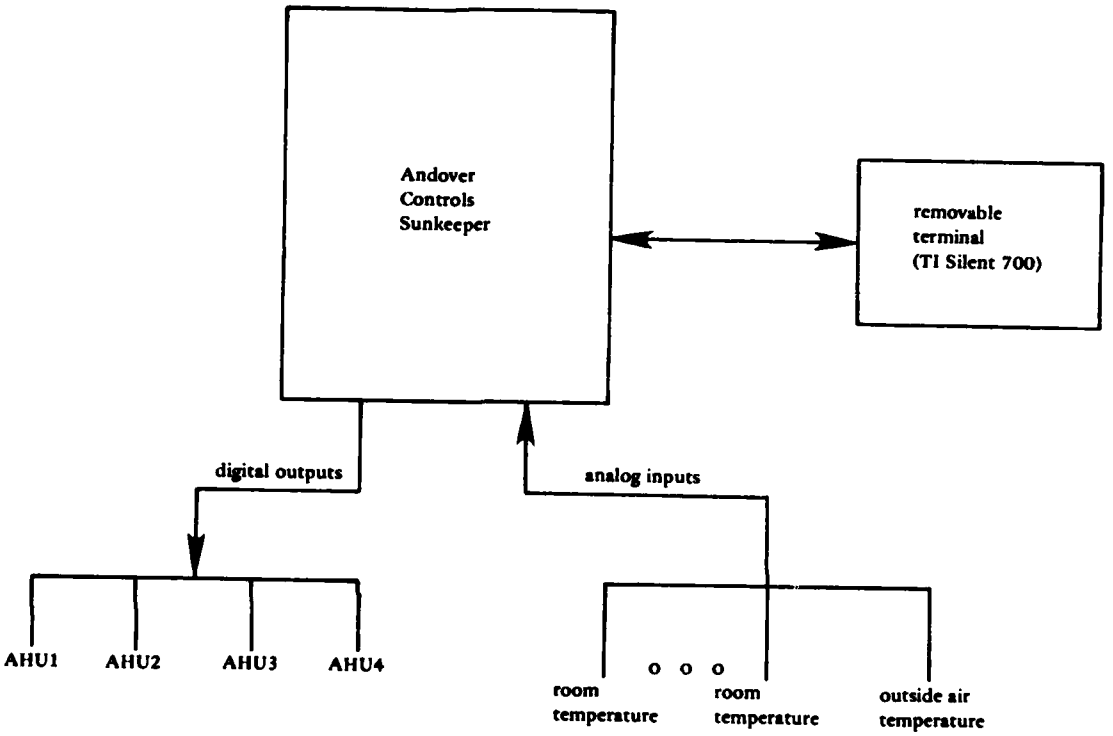

Figure 1. System one-line diagram.

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36 Hazardous/toxic materials management
37 Wastewater management and sanitary engineering
38 Oil pollution removal and recovery
39 Air pollution
40 Noise abatement
44 **OCEAN ENGINEERING**
45 Seafloor soils and foundations
46 Seafloor construction systems and operations (including diver and manipulator tools)
47 Undersea structures and materials
48 Anchors and moorings
49 Undersea power systems, electromechanical cables, and connectors
50 Pressure vessel facilities
51 Physical environment (including site surveying)
52 Ocean-based concrete structures
53 Hyperbaric chambers
54 Undersea cable dynamics

TYPES OF DOCUMENTS

85 Techdata Sheets
86 Technical Reports and Technical Notes
82 NCEL Guide & Updates
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83 Table of Contents & Index to TDS
84 Energy Forum
91 Physical Security

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