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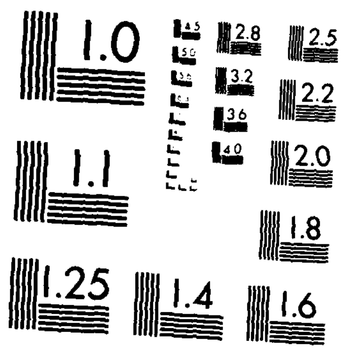

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CR 83.001

NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
CHIEF OF NAVAL MATERIAL
NAVAL FACILITIES ENGINEERING COMMAND

ENERGY MONITORING AND CONTROL SYSTEMS INSPECTION GUIDELINES

December 1982

An Investigation Conducted by
KLING-LINDQUIST, INC.
Engineers
Philadelphia, Pennsylvania

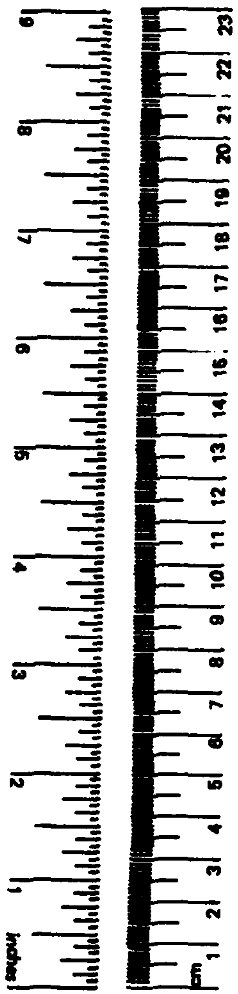
N62474-81-C-9379

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

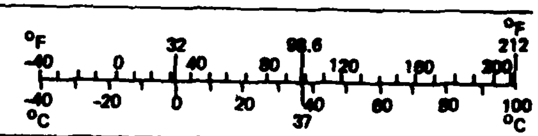
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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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This report presents guidelines which can assist the inspector in conducting an inspection of energy monitoring and control system (EMCS) hardware and software during the construction and testing phases of the EMCS project. These guidelines present construction management considerations, describe the inspection sequence for a generic EMCS during the construction —

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period, and provide an overview of the tests to be conducted in the factory and on-site.

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TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 General.

This report presents guidelines which can assist the inspector in conducting an inspection of Energy Monitoring and Control System (EMCS) hardware and software during the construction and testing phases of the EMCS project. These guidelines present construction management considerations, describe the inspection sequence for a generic EMCS during the construction period, and provide an overview of the tests to be conducted in the factory and on-site.

More detailed descriptions of factory and on-site test procedures are presented in separate volumes to this report:

CR83.002 - EMCS Factory Test Procedures
CR83.003 - EMCS Performance Verification and Endurance Test Procedures

The Appendices in this report provide additional background information:

Appendix "A" - Abbreviations and Definitions
Appendix "B" - Applicable Publications
Appendix "C" - Partial List of EMCS Inspection Items

In general, the Inspection Guidelines and Test Procedures are applicable to each size configuration of EMCS (large, medium, small and micro). There are, however, some areas of the guidelines that are applicable only to specific EMCS configurations. For example, all references to the Central Communications Controller (CCC) are only applicable to a large EMCS. It is important, therefore, that the Inspector review all contract requirements to determine how the Inspection Guidelines and Test Procedures relate to the EMCS to be installed.

CHAPTER 2

OVERVIEW OF EMCS

2.1 General.

An Energy Monitoring and Control System is a computer-based process control system that can manage the operation of energy consuming equipment such as:

- Fans
- Pumps
- Chillers
- Boilers
- Lighting Systems

Typically, an EMCS can:

- Monitor and report on equipment performance
- Control equipment operation
- Report on equipment in alarm condition

The actual functions of an EMCS will vary according to the monitoring and control requirements of the facilities and systems interfaced to the EMCS. Small facilities are likely to have an EMCS with relatively simple control and reporting functions. Larger facilities with large numbers of systems and equipment tend to have a more complex EMCS.

2.2 EMCS Size Configurations.

As indicated earlier, the functions of an EMCS will vary according to the monitoring and control requirements of the facility. In developing Guide Specifications for an EMCS, the Government has identified four basic EMCS size configurations:

- Large
- Medium
- Small
- Micro

According to the Guide Specifications, a large EMCS is the most sophisticated system, while a micro EMCS has considerably fewer requirements. One gauge of the relative EMCS size is the number of points (sensor or control devices) connected to the EMCS. A given size EMCS can control a wide range of points. The EMCS configuration required for the actual job is identified in the contract documents.

Examples of buildings that would use the various size configurations include:

Large EMCS	- Large Military Installations University Campuses Industrial Complexes
Medium EMCS	- Military Installations Large Hospitals Colleges Factories
Small EMCS	- Small Military Installations (such as Reserve Centers) Civil Works Sites Hospitals
Micro EMCS	- Reserve Centers Single Buildings

2.3 EMCS Hardware/Software Overview.

EMCS hardware refers to the equipment required for the system to perform its monitoring and control functions. Examples of EMCS hardware include:

- Computer equipment
- Printers
- Operator's Console
- Data Transmission Media and Equipment
- Field Equipment

EMCS software refers to the programs or machine instructions necessary to operate the EMCS hardware.

Examples of EMCS software include:

- Programs to operate the system
- Programs which enable the operator to communicate with the system
- Programs that control equipment for energy conservation

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Inspection is required for EMCS software and hardware since both are essential to the performance of the system. In general, EMCS hardware is inspected in the field prior to software inspection. A more detailed review of inspection is covered in a latter chapter on Inspection.

2.4 EMCS Hardware.

EMCS equipment is grouped into three basic categories:

- Master Control Room Equipment
- Data Transmission Lines and Equipment
- Field Equipment

a. Master Control Room.

The Master Control Room (MCR) contains the computer equipment and associated peripheral devices that provide overall EMCS operation and perform energy management functions. Figure 2-1 illustrates typical MCR equipment for a large EMCS.

The Central Control Unit (CCU) is the computer that contains the necessary programs to operate the complete EMCS and to communicate with the field equipment that performs the monitoring and control functions. The operator's console enables the operator to request information on monitored equipment, initiate control programs, and perform other EMCS operations. For example, the operator would enter commands through the operator's console to request information on the status of a fan or request a graphic display of an air handling system.

The printers provide a permanent record of information requested by the operator or required in the computer programs. Typical reports generated on a printer include alarm reports and reports that list hourly electric demand.

Information on the status of monitored and controlled equipment is stored on devices such as hard disks and magnetic tapes. These devices also contain the EMCS programs.

Information that flows between the Master Control Room and the field passes through communications link termination equipment. This equipment converts the electrical signals generated by the central computer into signals that can be transmitted over the data transmission media (DTM). This process also works in reverse. That is, signals generated by the field equipment are converted to signals that can be transmitted over the DTM and understood by the communications link termination (CLT) equipment located in the MCR. The CLT primarily consists of modulators/demodulators (Modems) or similar type of equipment which converts data signals into electrical signals (and vice versa) compatible with the CCU.

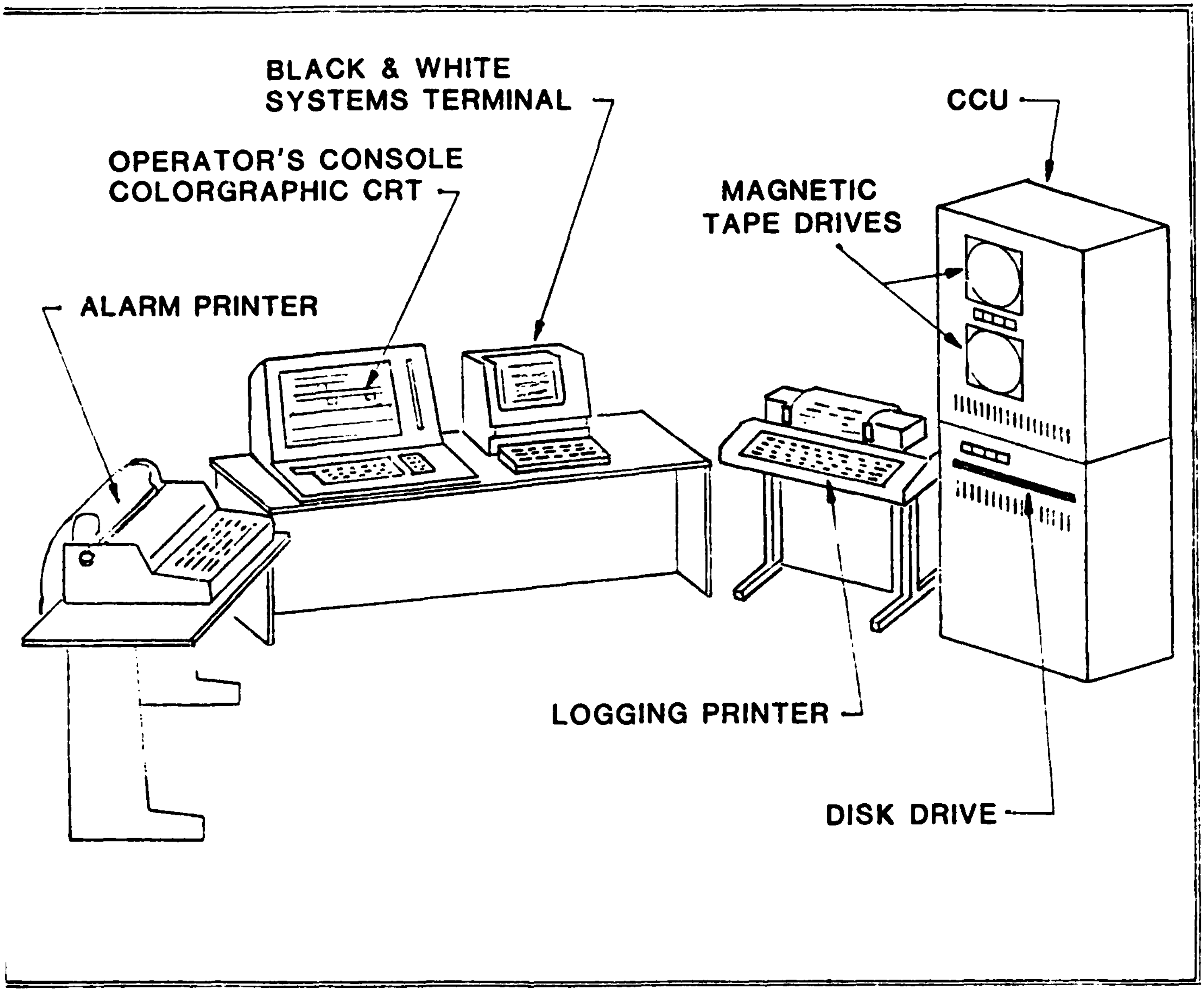


FIGURE 2-1 : MASTER CONTROL ROOM EQUIPMENT

b. Data Transmission Media.

The MCR equipment requires a means of communicating with the field equipment. This is accomplished through the data transmission media (DTM), which provides the physical link between the MCR and the field equipment. Telephone lines, coaxial cables, and FM tranceivers are examples of data transmission media.

c. Field Equipment.

The field equipment is located in the vicinity of the equipment being monitored and controlled by the EMCS. In large building complexes, field equipment is typically located in each building connected to an EMCS. EMCS field equipment may include:

- Field Interface Device (FID°)
- Multiplexer (MUX*) Panel
- Intelligent Multiplexer (IMUX) Panel
- Data Terminal Cabinet (DTC)
- Instrumentation and Controls

Figure 2-2 illustrates a typical configuration of this equipment. Actual EMCS equipment requirements are identified in the contract documents.

The FID° is a computer based device that controls and monitors the equipment connected to it. The FID° transmits data to the Master Control Room (MCR) and carries out instructions received from the MCR on specific monitoring and control functions. The MCR can therefore communicate with the sensors and controls through the FID° and its associated MUX's* and IMUX's.

The FID° also has the capacity to perform limited monitoring and control functions in a "stand-alone" mode (no communication with the MCR). This capability is called distributed processing and enhances the reliability of the EMCS.

The MUX* panel is a device that transmits signals from the FID° to the sensors and controls (and vice versa). This device is used to determine each point status or value and to execute commands. The MUX* enables the FID° to communicate with any point monitored and controlled by the FID°. The MUX* may be housed inside the FID° or may be remotely located. There may also be more than one MUX* per FID°.

IMUX panels are similar to MUX* panels, except the IMUX will only report on sensor data that has changed since the last report.

TYPICAL FIELD EQUIPMENT CONFIGURATION

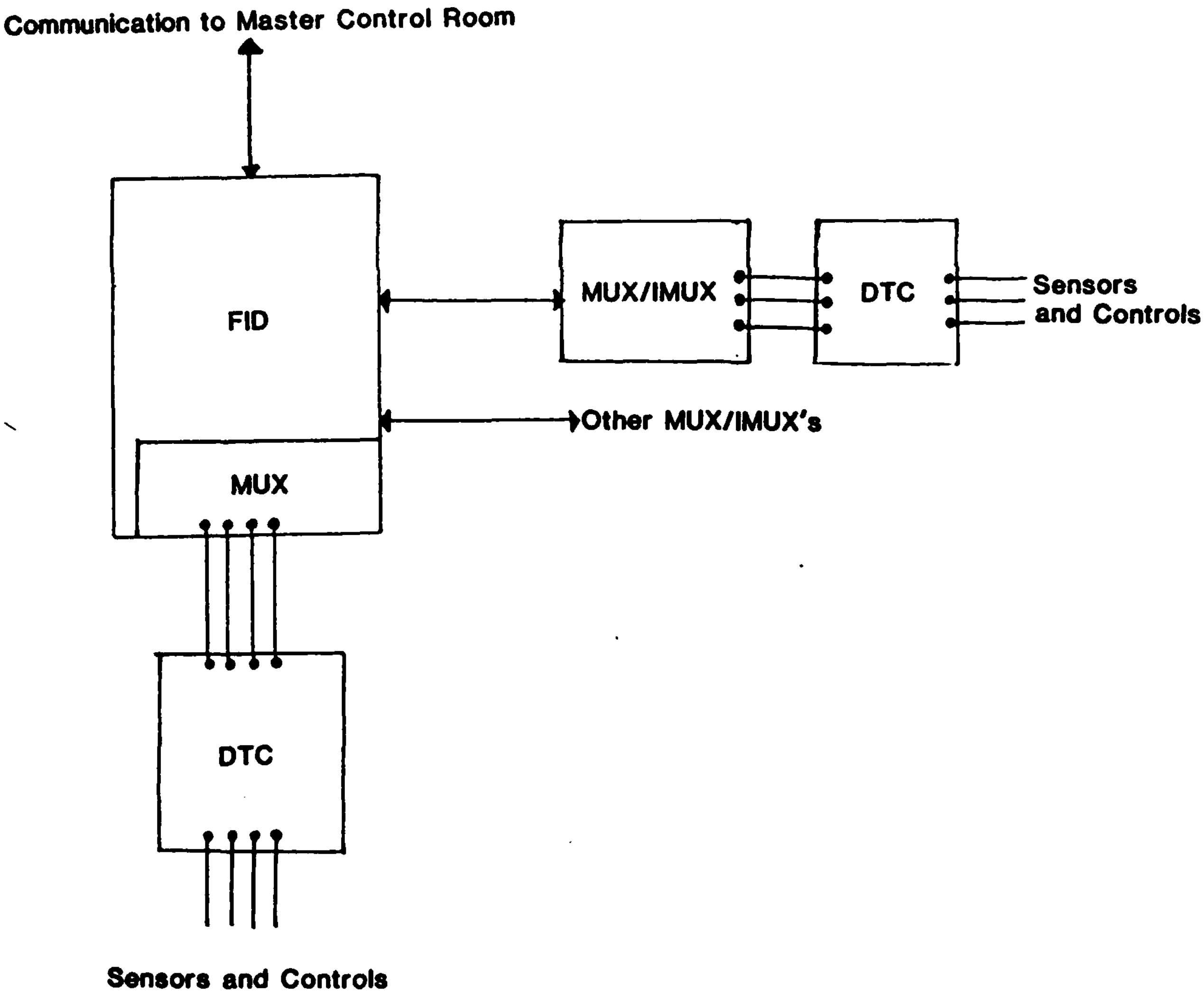


FIGURE 2-2

In a large or medium EMCS, the IMUX performs only monitoring functions. In a small and micro system, the IMUX frequently provides both monitoring and control functions.

The Data Terminal Cabinet (DTC) provides the cross connection point between the FID°/MUX*IMUX and the sensors and controls. All wiring connected to the FID°/MUX*/IMUX is terminated in the DTC. All wiring from the sensors and controls are also terminated in the DTC.

The sensors and controls are the devices that collect the data on connected equipment and control the equipment in accordance with instructions received from the FID°/MUX*/IMUX. The Guide Specifications present accuracy requirements for sensors and response time requirements for the operation of controls. In the event of a FID°/MUX*/IMUX failure the controls must fail in the manner shown in the contract documents.

2.5 EMCS Software.

EMCS software provides the necessary intelligence for the EMCS to operate. There are three basic types of software implemented in the system:

- System Software
- Command Software
- Application Software

System software is generally provided by the CCU manufacturer. This software controls the operations of the computer.

Command software is provided by the EMCS supplier. This software enables the operator to issue commands through the operator's console. Typical commands likely to be issued include requests for information on any point or group of points, commands to start up or shut down equipment, commands to modify alarm limits on analog points such as temperature or pressure, and commands to request printouts of specified information.

Application software is provided by the EMCS supplier. This software issues the instructions for controlling energy consuming equipment based upon specific conditions (such as temperature and humidity) and upon specific parameters (such as time of day). This software is designed to improve energy efficiency in the facility. Typical application programs include programs for equipment start-up or shutdown, duty cycling, and electrical demand control.

°Large/Medium/Small EMCS
*Large/Medium EMCS

CHAPTER 3

SENSORS AND CONTROLS FOR EMCS

3.1 General.

The purpose of this chapter is to describe the sensors and controls that are commonly used in an EMCS. This chapter will focus on pneumatic, electric and electronic devices.

Typical performance characteristics for sensors and controls are presented in this chapter for illustration. The inspector must refer to the contract documents to determine actual sensor and control performance requirements for the EMCS project.

3.2 Review of Automatic Control.

Automatic control involves the use of equipment (automatic controller) to maintain a variable at a desired value (set point). The types of control action that are encountered in EMCS applications are:

- Two-position or on-off: Relays, switches.
- Proportional: Single input controller.
- Proportional with automatic reset: Two or three input controllers.

Process parameters are the values that are controlled. For example, typical process parameters include temperature, pressure, flow, level, dewpoint, KWH consumption and KW demand. The devices which are required to obtain these values include:

- Temperature sensors
- Temperature switches
- Relative humidity sensors
- Dewpoint sensors
- Pressure sensors
- Pressure switches
- Flow metering
  - Direct
  - Indirect
- KWH Transducer

°Large/Medium/Small EMCS
*Large/Medium EMCS

A control loop, or the action in a control loop, includes the following components:

- The set point - "Where we want to go"
- Input - "Where we are"
- Controlled or manipulated device - "What we use to get there"
- Controlled variable - "What is being controlled"

This control loop is shown diagramatically in Figure 3-1, where the set point is the desired value of the controlled variable (the controller setting).

A control loop can be classified as "open loop" or "closed loop". An open loop system has no measurement of the controlled variable. In a closed loop system, the control variable is measured and compared with the set point. The components of a closed loop system include:

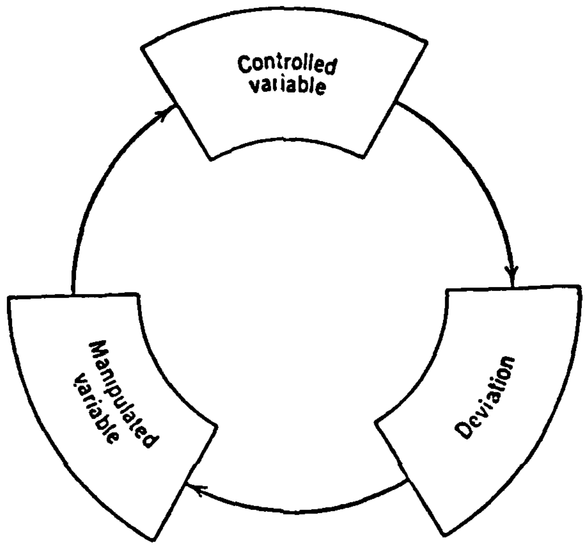
- The Input - a measurement of the actual value of the controlled variable (the sensor value).

- The deviation - the difference between the set point and the input or measured variable (frequently called the error signal).

- The controlled or manipulated device - a final element, such as a valve or damper.

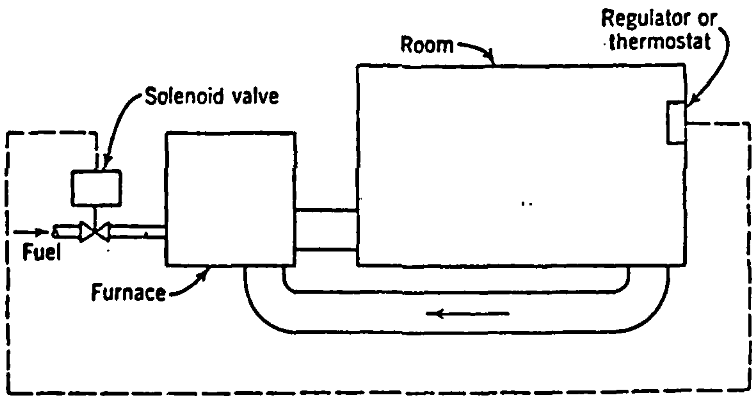
- The controlled variable - the process parameter to be controlled, such as temperature and pressure.

An example of a closed-loop action is the control of a home-heating system (Figure 3-2). Suppose the temperature of the home is to be maintained at 72°F. This temperature is the desired value or set point. A thermostat is installed on an inside wall of the home to measure the room temperature (the controlled variable). If the measured room temperature falls below the set point, a switch is energized to fire the furnace. The flow of fuel to the furnace is the manipulated variable. Warm air from the furnace is delivered to the room, and the room temperature increases. When the temperature in the room reaches the desired set point of 72°F, the fuel to the burner is turned off. The cycle is repeated when the room temperature falls below the set point.



Action in a closed loop.

FIG. 3-1



Home-heating control.

FIG. 3-2

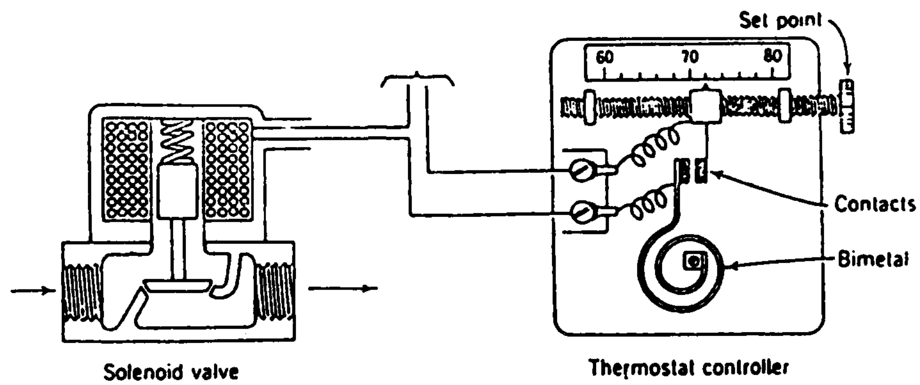
3.3 Automatic Controller.

An automatic controller is a device that is used to maintain a controlled variable at a desired value. In a two-position thermostatic controller, (Figure 3-3), the desired value is set on the adjusting knob and the existing temperature is measured by the bimetallic strip. When the temperature increases above the set point, the contacts open. When the temperature is below the set point the contacts are closed. This type of control is called two-position or on-off control (Figure 3-4). Two-position control is also used to start and stop a ventilating fan motor. Any two-position controller needs a differential to prevent hunting or too-rapid cycling. This differential is the difference between the setting at which the controller operates to one position and the setting at which it changes to the other position.

Improved control action can be achieved with proportional control action. In proportional control action, there is a relationship between the input variable and the controlled output. Thus, the action of the controlled variable is repeated and amplified in the action of the final control element. Figure 3-5 shows the process control action with proportional control. The proportional band in the control system is the range through which the process must change for the controller to traverse the full range of its output (the throttling range). Figure 3-5a is a schematic of a receiver controller (RC) that operates a hot water valve in proportion to discharge air temperature. As the discharge air temperature increases above the set point, the RC gradually closes the valve. The valve is completely closed when discharge air temperature equals or exceeds the maximum value of the throttling range. If the discharge air temperature falls below the set point, the RC will gradually open the hot water valve.

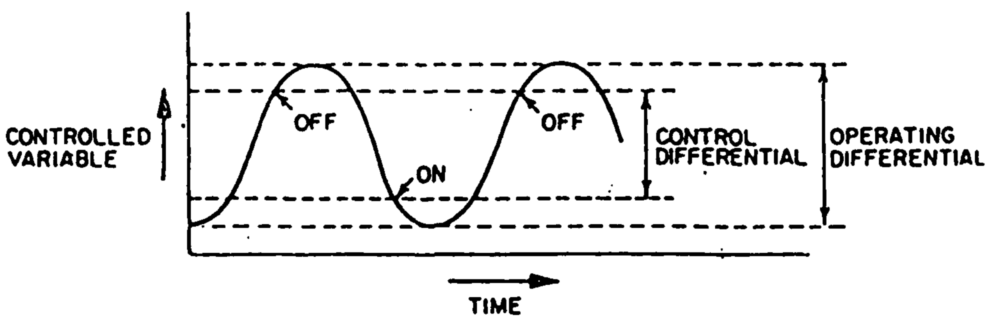
3.4 Pneumatic Controller.

Pneumatic controls are powered by compressed air. Typically, compressed air is maintained at a pressure of 20 pounds per square inch (PSIG), although higher pressures are occasionally used for operating very large valves or dampers. Pneumatic devices are inherently modulating, since air pressure is easily provided with infinite variation over the control range. Figure 3-6 shows an example of a pneumatic controller and 3-7 shows how this controller is connected into a control system.



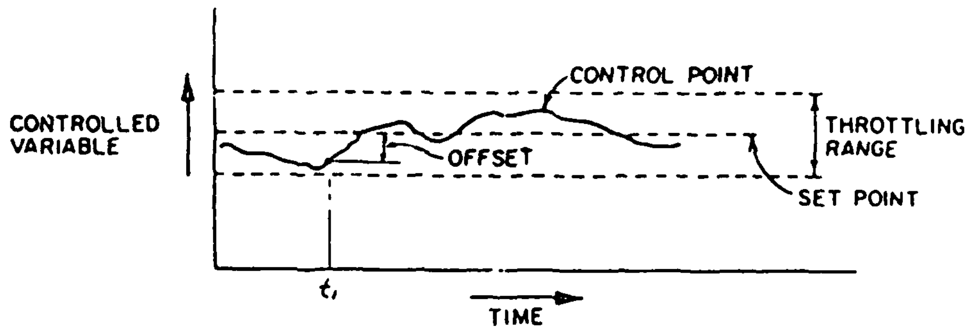
TWO POSITION THERMOSTAT CONTROLLER

FIGURE 3-3



TWO POSITION CONTROL

FIGURE 3-4



PORPORTIONAL CONTROL

FIGURE 3-5

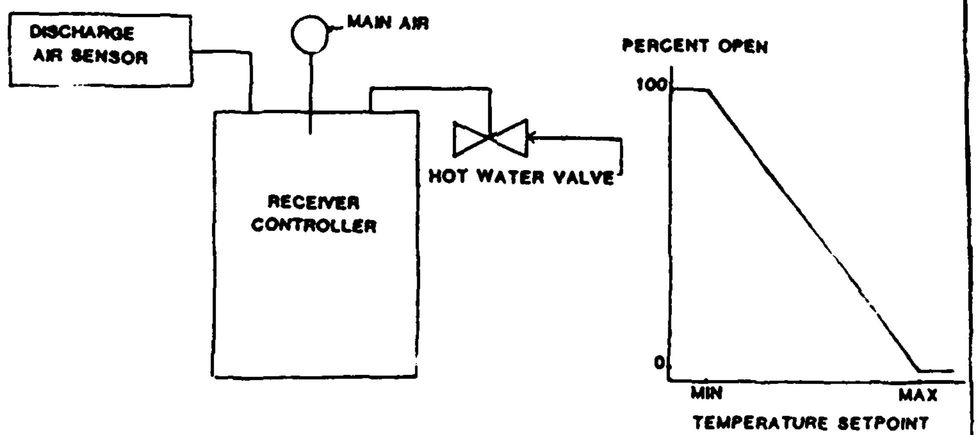
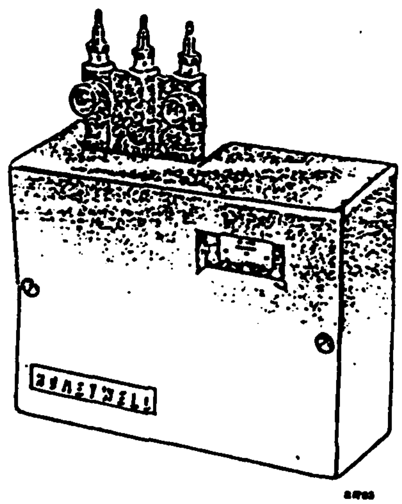
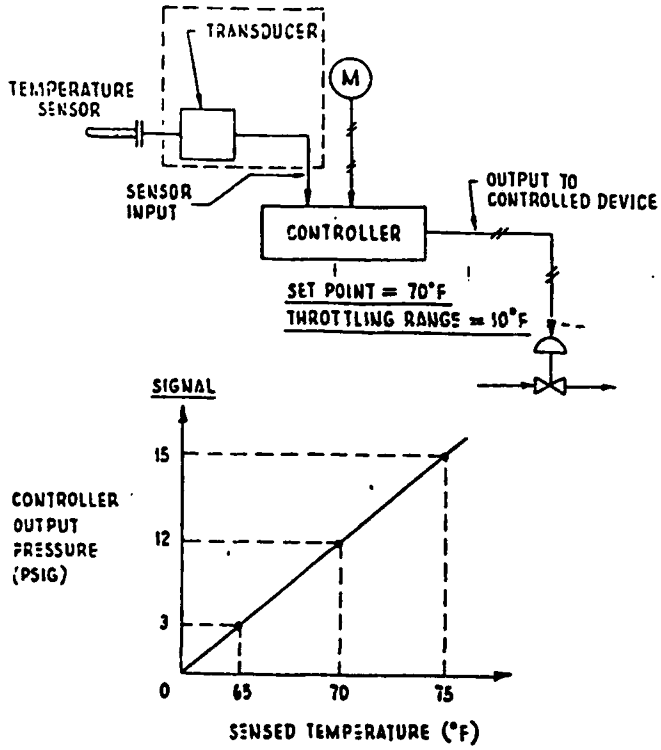


FIGURE 3-5a



PNEUMATIC PROPORTIONAL ACTION CONTROLLER

FIG. 3-6



PNEUMATIC CONTROL SYSTEM

FIG. 3-7

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The pneumatic controller is typically mounted on a panel or other surface and requires:

- A source of clean, dry compressed air to provide the operating energy.
- A sensing device to detect and measure the controlled variable.
- Output port to connect the controlled device.

3.5 Controller with Reset.

In various applications, such as multizone air handling units and hot water boilers, it is desirable to change the set point of the temperature controller as other system parameters change. Other parameters may be outside temperature or differential temperatures within the system. Figure 3-8 is an example of a control loop with reset.

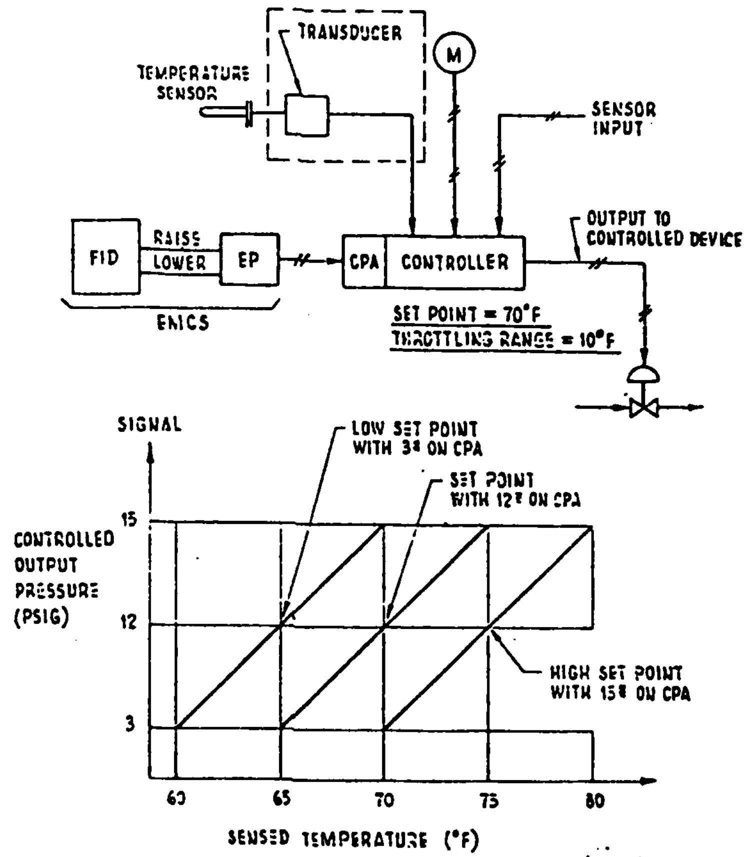
When reset control is required, the set point of the controller is adjusted by the EMCS. This requires the addition of a control point adjustment (CPA) port to the pneumatic controller and additional interface equipment. In Figure 3-8, the EMCS controls the output of the electric to pneumatic (EP) converter. The EMCS generates electrical signals of various intensities to control the operation of the electric motor in the EP. The electric motor will, in turn, operate a pneumatic regulator, and therefore control the value of the pneumatic signal from the EP that is applied to the CPA terminal of the pneumatic controller.

Typically, the set point of a controller can be varied by ± 10% of the temperature sensor span from set point.

3.6 Sensor Accuracies

Sensor accuracies are given as percentages of the full scale range of the sensor. Readout accuracies are expressed as end-to-end accuracies which include sensor accuracies, transducer and EMCS accuracies, and the accuracy of the readout itself. It is the responsibility of the contractor to allocate, in the EMCS, the inherent errors introduced at each step of the signal processing in order to obtain the required end-to-end accuracy from sensor reading to console display. Conditioning is required for all types of sensors so that the output from the sensor is compatible with the EMCS input requirements. Conditioning may be accomplished through hardware or software. Proper measurements over the projected range of measurements can then be maintained with the required accuracy. Conditioning circuits may be installed inside the FID°/MUX*/IMUX or mounted separately with the sensors. The contract documents determine what sensors are required, and indicate range, accuracy and repeatability.

°Large/Medium/Small EMCS
*Large/Medium EMCS



PNEUMATIC CONTROL SYSTEM WITH RESET

FIG. 3-8

3.7 Temperature Sensors

Typical temperature measurements include:

- Duct air temperature
  - Return air
  - Mixed air
  - Supply air
- Space temperture
- Outside air dry bulb, dew point or humidity

- Hot water temperature
- Chilled water temperature

The most common types of measuring devices for temperature include:

- Resistance temperature detector (RTD)
- Thermocouple
- Thermistor

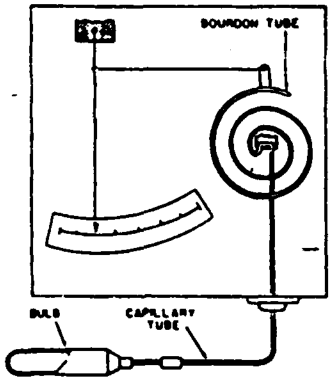
Figure 3-9 shows typical temperature sensors.

The resistance temperature detectors are based upon the property that the resistance characteristics of certain metals vary with the change in temperature. Platinum and nickel are the most common types of metals used as RTD's. RTDs are typically used to monitor a temperature range of -30° to +500°F with an interchangeability of ± 0.1% at the specified reference temperature. Some advantages of RTD's include:

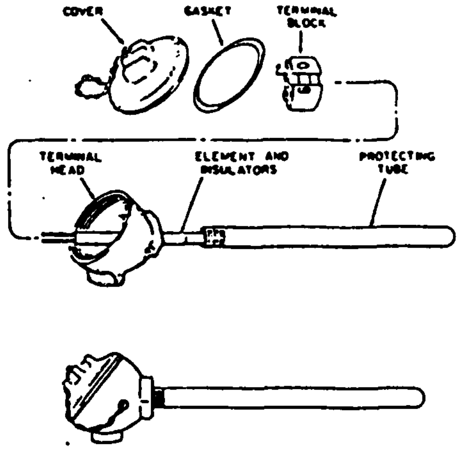
- High accuracy
- Ability to measure narrow temperature spans (10°F)
- Repeatability
- Fast response
- Good interchangeability

Some disadvantages include:

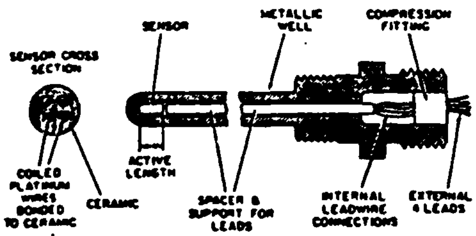
- Cost
- Some forms are fragile



FILLED SYSTEM



THERMOCOUPLE



RESISTANCE TEMPERATURE DETECTOR (RTD)

FIG. 3-9

A thermocouple (T/C) - consists of a junction of two dissimilar metals. The heating of these metals causes a small EMF (Voltage) to be generated. The change in voltage is, therefore, a measurement of the temperature change. The various types of thermocouples include:

Type J (Iron-Constantan) - Measuring 320° to 1400°F
Type K (Chromel-Alumel) - Measuring 310° to 2500°F
Type E (Chromel-Constantan) - Measuring 320° to 1830°F
Type T (Copper-Constantan) - Measuring 310° to 750°F

Of the four listed, type "K" is the most linear of the T/C's and type "E" has the highest voltage per degree farenheit. Some advantages of thermocouples are their small size, low cost and ruggedness. The disadvantages are a 70°F minimum temperature span, and the need for a unique calibration for each temperature range. For EMCS applications, thermocouples (type E, K, R, or T) are typically used to monitor temperatures exceeding 500°F.

Thermistors are semi-conductors made from specific mixtures of pure oxides of nickel, manganese, copper, iron, and other metals. These devices exhibit large physical changes in resistance characteristics as temperature changes take place.

a. Temperature Switch.

A temperature switch is a device that opens or closes contacts at the operating temperature setting. For EMCS applications, a typical accuracy for temperature switches is ± 1 percent of their operating range.

b. Mounting.

Temperature sensors should be installed with the proper housing for temperature measurement in rooms, ducts and piping. Figure 3-10 shows a sensor mounted in a duct or plenum with a junction box for housing the connecting wiring.

Temperature sensors installed on piping requires different mountings depending on the size of the pipe.

The example shows sensor installations for small and large piping. Large piping in this case means pipe sized 4" and larger. In both cases a well is mounted in the piping and the temperature sensor mounted inside of the well.

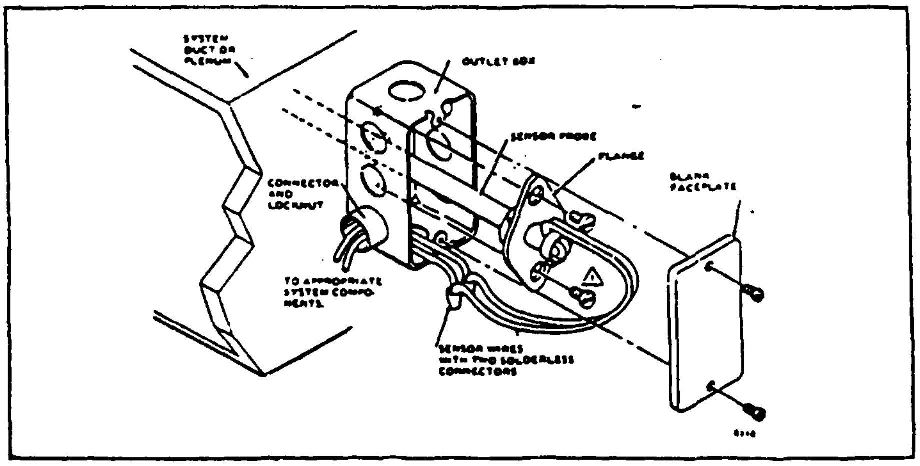

SYSTEM DUCT OR PLENUM
OUTLET BOX
SENSOR PROBE
FLANGE
BLANK FACEPLATE
CONNECTOR AND LOCKNUT
TO APPROPRIATE SYSTEM COMPO- NENTS
SENSOR WIRES WITH TWO SOLDERLESS CONNECTORS

FIG. 3-10

3.8 Pressure Sensors

Pressure sensors use the deformation of material to measure pressure. Figure 3-11 shows examples of the various types of pressure sensing elements that may be used. These elements are used in the pressure transmitters and switches shown in Figure 3-12. The diaphragm is a flexible plate, sealed in a container so that fluid cannot leak past it. A force applied to one side will cause the diaphragm to move or flex.

A bellows is a diaphragm which is joined to the container by a series of convolutions (folds) so that a greater degree of movement may be obtained.

The bourdon tube is widely used in pressure gauges and other pressure instruments. It consists of a flattened tube bent into circular to spiral form. One end is connected to the pressure source and the other end is free to move. As pressure is increased the tube tends to straighten out.

This movement may be used, through an appropriate linkage, to position an indicator or actuate a controller.

The three basic types of pressure measurements include:

- Gauge
- Absolute
- Differential

A gauge pressure sensor measures pressure referenced to local atmospheric pressure and is vented to atmosphere. When the pressure port is exposed to atmosphere, the transducer will indicate zero PSIG.

An absolute pressure transducer measures pressure referenced to vacuum. When the pressure port is exposed to atmosphere, the transducer will indicate approximately 14.7 PSIA.

A differential pressure (DP) measures the difference between two pressures applied to its high and low pressure ports.

Pressure is usually expressed in "pounds per square inch". For very low pressures, "inches of water" or other units may be used.

For EMCS applications, a typical accuracy for pressure sensors is $\pm$ 2 percent of their operating range.

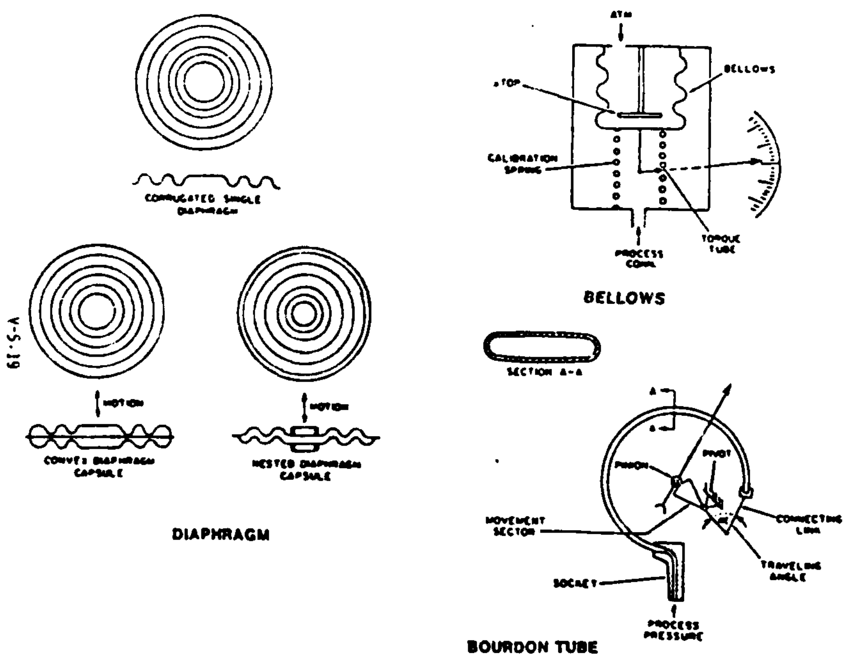


FIG. 3-11

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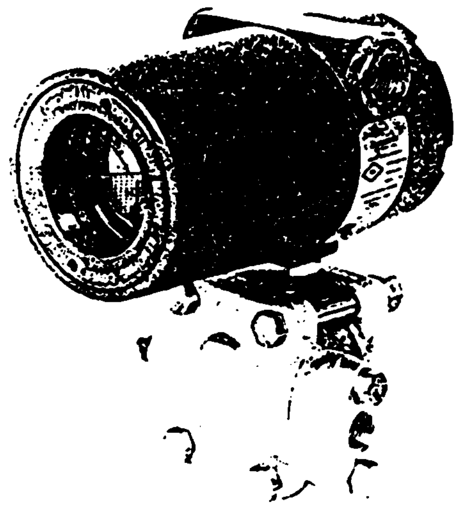
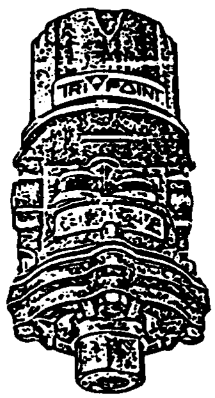
PRESSURE TRANSMITTER





Pressure Switch

FIG. 3-12

A pressure sensor will provide a pressure measurement on a continuous output signal proportional to the pressure. A pressure switch operates the same way as a thermostat, by opening or closing a set of contacts at a selected pressure setting.

3.9 Dew Point Sensors.

Dew point is the temperature at which the moisture in the air starts to condense. Dew point sensors and their corresponding transmitters use a saturated-salt lithium chloride solution to determine dew point. The corresponding signal can be converted into relative humidity when used in conjunction with a dry bulb sensor. Figure 3-13 shows a typical dew point sensor and transmitter. For EMCS applications, a typical accuracy for dew point sensors is ± 3.5°F from 15°F to 85°F dew point.

3.10 Relative Humidity Sensors

Relative humidity is the ratio of the amount of water vapor present in the air to the amount of water vapor present in saturated air at the same temperature. Figure 3-14 shows a typical relative humidity sensor.

Relative humidity sensors are used to measure the percent relative humidity in spaces, ducts, or outside air (OA). Figure 3-14 illustrates a typical duct mounted humidity sensor and transmitter. Humidity sensors should be shielded against the effects of solar heating and rain. Relative humidity sensors accuracy typically have a ± 5 percent accuracy from 20 to 80 percent relative humidity.

3.11 Flow Sensors

Flow measurement for EMCS is used to monitor and/or control:

- Steam flow
- Water flow
- Air flow
- Condensate flow
- Boiler fuel flow

Flow of liquids and gases can be indirectly or directly measured in the flow path. The selection of the type of flow meter to be used in the EMCS is based on the range of flows for the media to be sensored.

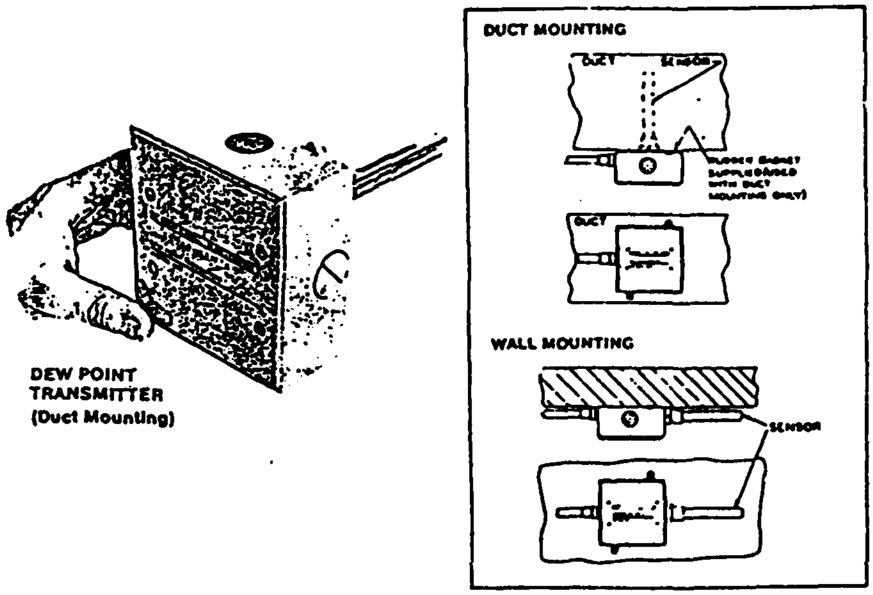


FIG. 3-13

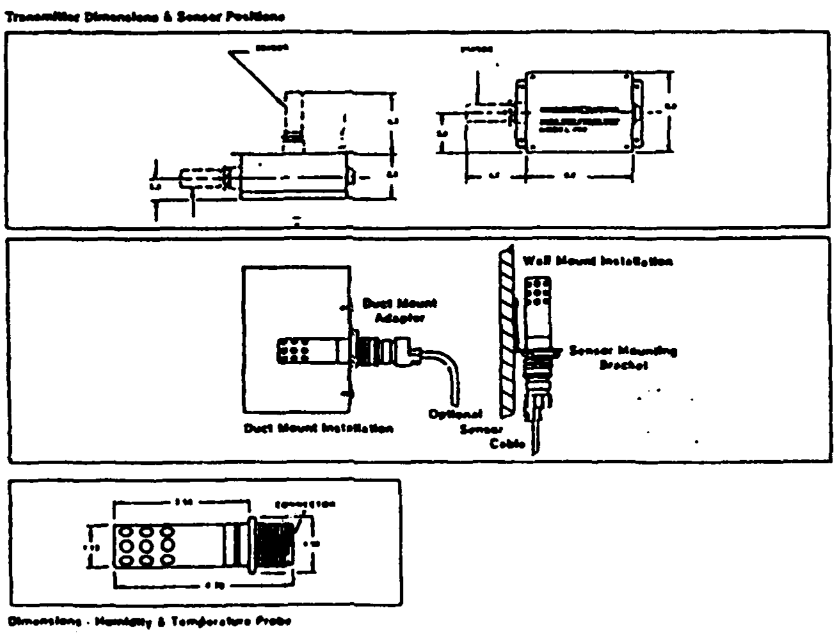


FIG. 3-14

Figure 3-15 illustrates various types of flow meters.

Direct metering measures the fluid flow by measuring the volume of the fluid in a given period of time. Examples of this type of metering include:

- Turbine meter
- Magnetic flow meter
- Positive displacement meters

Indirect metering measures flow by using a differential pressure obtained by measuring a pressure drop across a restriction. This pressure drop is a function of the quantity of fluid passing through the pipe. Various types of primary flow elements are: Orifice plates, flow nozzles, venturi tubes, and averaging annular type pitot tubes. The pressure drop has to be converted to flow using a conversion table for each pipe size.

The actual flow measurement calculation as a result of indirect or direct measurements may be performed in the EMCS, or by a flowmeter accessory whose output is linear and proportional to the flow measured. In either case the output signal has to be compatible with EMCS.

The most common types of flow measuring sensors encountered with EMCS include:

- Concentric orifice plates
- Venturi tube
- Pitot tubes
- Turbine flow meters

a. Concentric Orifice Plates.

The concentric orifice plates can be used to measure steady flow of clean liquid, vapor, or gas. Flow is determined by measuring the pressure drop across the orifice. The resulting difference in pressure, or pressure drop provides input to the formula for flow rate. One major advantage of the orifice plate is the accurate predictability of the contraction of the flow stream. However, the resulting pressure drops can be quite large for a given flow.

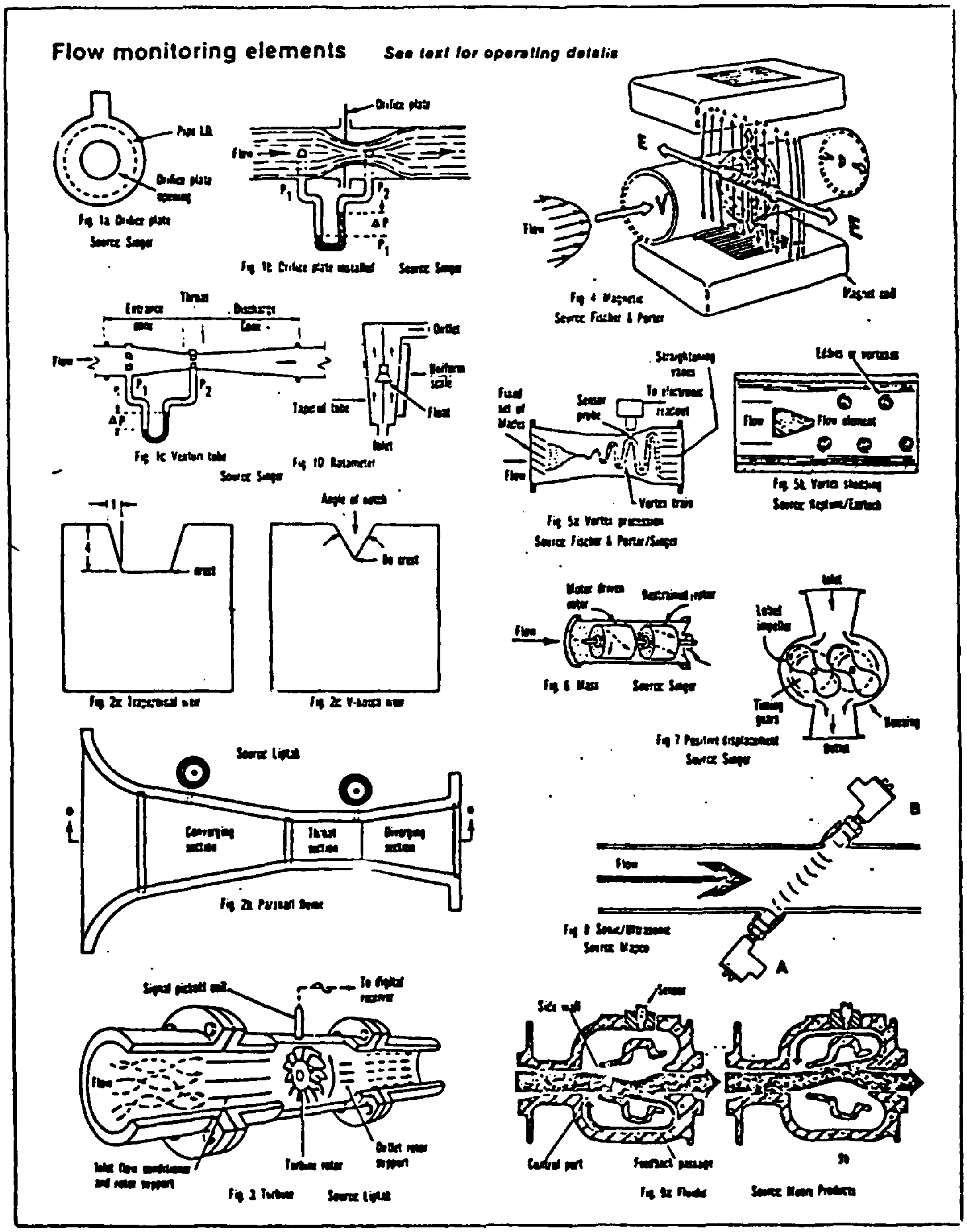

Flow monitoring elements
See text for operating details
Fig. 1a Orifice plate
Fig. 1c Venturi tube
Fig. 4 Magnetic
Magnet coil
Fig. 5a Vortex precession
Fig. 5b Vortex shedding
Fig. 6 Mass
Fig. 7 Positive displacement
Fig. 2c V-notch weir
Fig. 2b Parshall flume
Converging section
Throat section
Diverging section
Fig. 8 Sonic/Ultrasonic
Fig. 3 Turbine
Turbine rotor
Fig. 9a Fluidic
Control port
Feedback passage

FIG. 3-15

For EMCS applications, a typical accuracy for flow measurements using concentric orifice plates is ± 1.0 percent of full flow. Figure 3-16 shows an example of orifice flow measurement fundamentals.

b. Venturi Tube.

The venturi tube, like a flow nozzle, will handle approximately 60 percent more flow than the orifice plate, with the same pressure drop as the orifice plate. For equal flows, the pressure drop of the venturi tube is only 10 to 20 percent of the pressure drop of an orifice plate. The venturi tube is capable of measuring any fluid flow which an orifice plate or flow nozzle can measure. Venturi tubes can be used for gas flow measurement when suspended particles are in the stream. For EMCS applications, a typical flow measurement accuracy using venturi tubes is ± 1.0 percent of full flow. Figure 3-17 shows an example of a venturi tube.

c. Pitot Tubes.

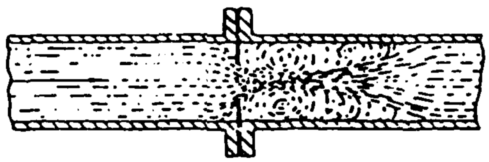
Pitot tubes (Figure 3-18) have a single sensing point and have poor accuracy, particularly at low velocities. The annular pitot tube senses dynamic pressure at multiple sensing ports distributed along the sensing tube to provide a single output of the average flow. Static pressure is measured by a port which faces downstream at the centerline of the pipe. The pitot tube sensor must have approximately 50 pipe diameters of straight pipe upstream. A major advantage is the ability to mount the pitot tube into an existing line under pressure with "hot tap" methods. For EMCS applications, a typical flow measurement accuracy using pitot tubes is ± 2.0 percent of full flow.

d. Turbine Flow Meter.

A turbine flow meter (Figure 3-19) uses the moving fluid to turn a turbine rotor. Turbine flow meters supply flow quantity information via a precisely known number of pulses for a given volume of fluid displaced. The relationship is linear for a given flow rate and viscosity. The turbine flow meter can be mounted in-line with the pipe or mounted into existing piping by hot-tap methods. For EMCS applications, a typical flow measurement accuracy using a turbine flow meter is ± 1.0 percent of full flow.

The other types of flow sensors include:

- Flow nozzles.
- Magnetic flowmeters.
- Vortex shedding meters.
- Γ ɔpler type ultrasonic.



Flow through orifice

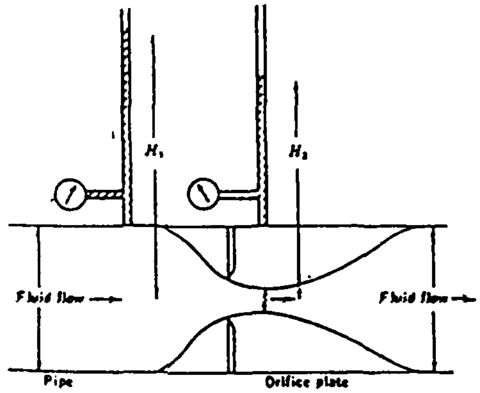


FIG. 3-16

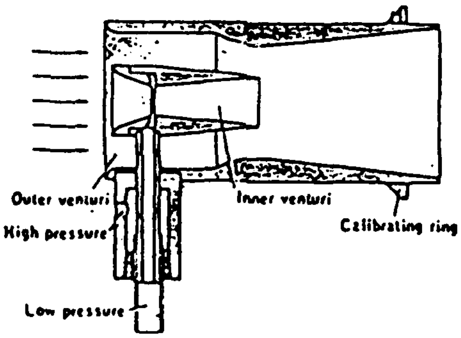
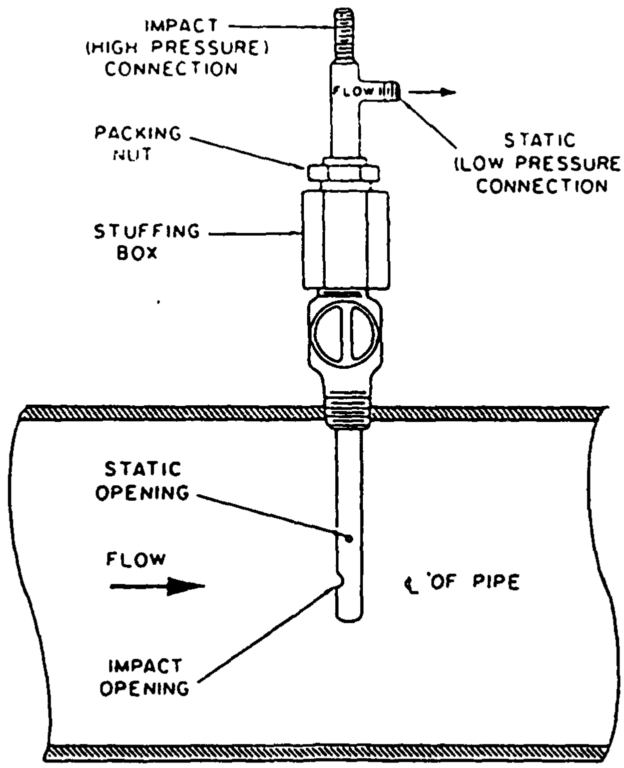


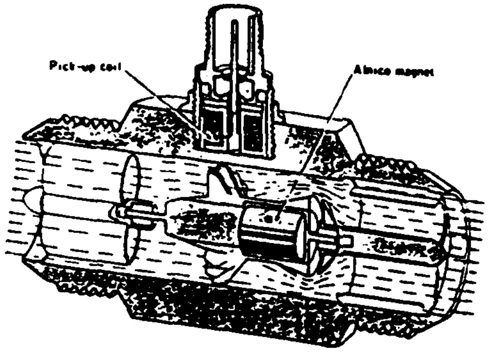
FIG. 3-17

VENTURI TUBE

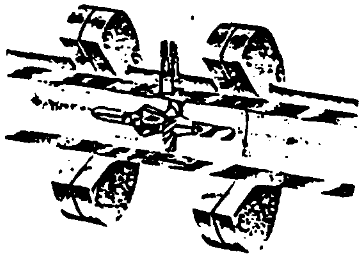


Pitot tube

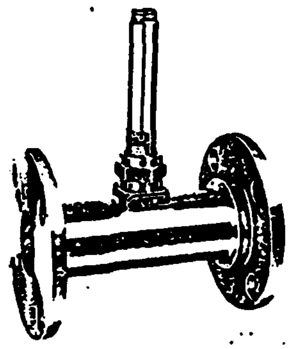
FIG. 3-18



This flowmeter provides a digital output with a frequency directly proportional to flow. (Potter Aeronautical Corp.)



Cutaway view of a flanged meter used in industrial applications. (Potter Aeronautical Corp.)



A target-type flowmeter. (Ramapo Instrument Co.)

FIG. 3-19

3.12 Position Sensors.

Position sensors are designed to measure the position of such devices as valves and dampers which modulate from open to closed position (and vice versa).

Figure 3-20 is a schematic of a position indicating sensor that uses a potentiometer to measure the damper position. The wiper arm on the potentiometer is attached to the damper road, causing the wiper arm in the potentiometer to rotate. As the damper rod rotates, a change in the position of the wiper arm on the potentiometer causes a change in resistance. The change in resistance is measured by the analog input and converted in software to damper position.

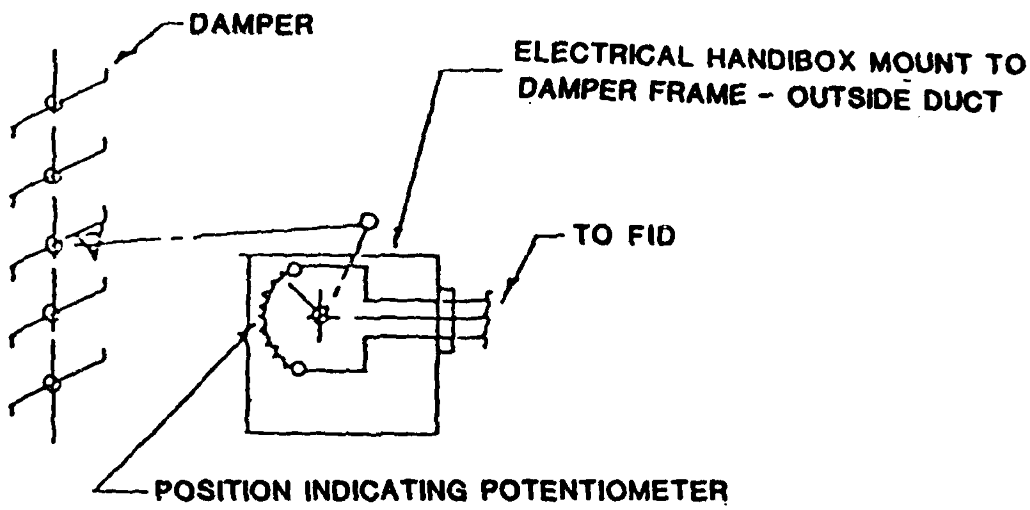
A position indicating potentiometer can also be used to measure valve position. In this case, the wiper arm is connected to the valve stem. As the valve stem moves the wiper arm moves causing a change in resistance which is also measured by the analog input.

3.13 Electrical Power and Demand Sensors

Electrical power (measured in watts) can be directly measured with potential transformer (PT) and current transformers (CT). The PT and CT outputs are either connected to a watt-hour meter or a kilowatt demand meter, or to the EMCS where the energy consumption is calculated. Figure 3-21 shows an example of power measurements.

When electrical power demand is calculated from direct power measurements, a contact closure is required to indicate the start of each demand period, when a fixed demand period is used by the utility comapny. There is no requirement for a start of demand period signal for sliding window demand periods and other special demand measuring schemes used by the Electric Utility Companies.

For EMCS applications, electrical energy consumption and electrical demand sensors typically have an accuracy of $\pm$ 0.25 percent of reading from full lag to full lead power factors.



ALTERNATE DAMPER LINKAGE ARRANGEMENT

FIGURE 3-20

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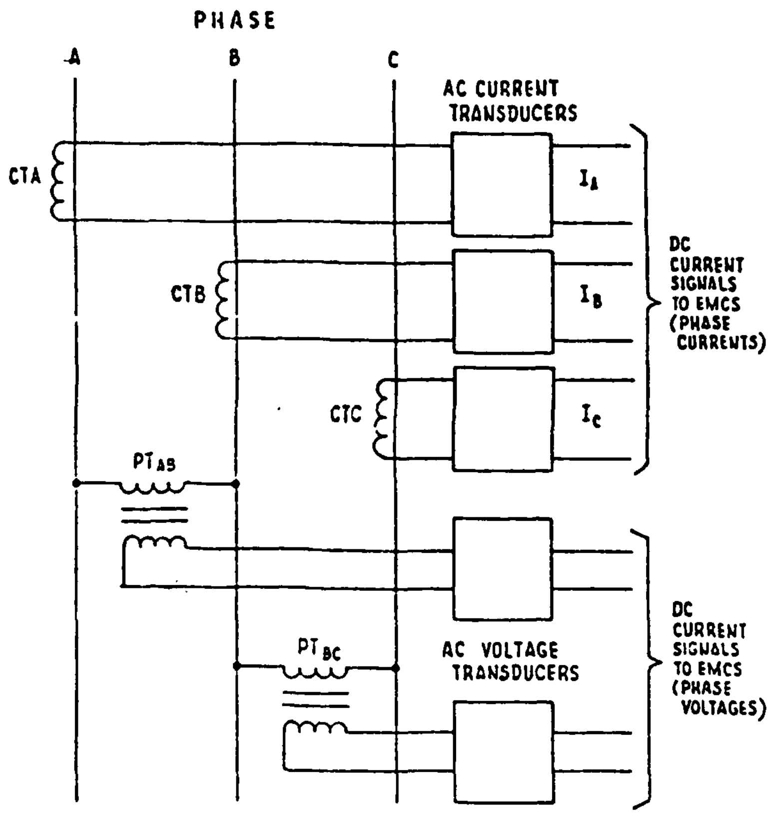


PRIMARY POWER MEASUREMENT

FIGURE 3-21

3.14 EMCS Interfaces.

The addition of the EMCS requires the addition of interface circuits to the HVAC system. These interfaces may be electrical/electronic or pneumatic.

a. Electrical/Electronic interfaces.

Electrical/electronic interfaces include:

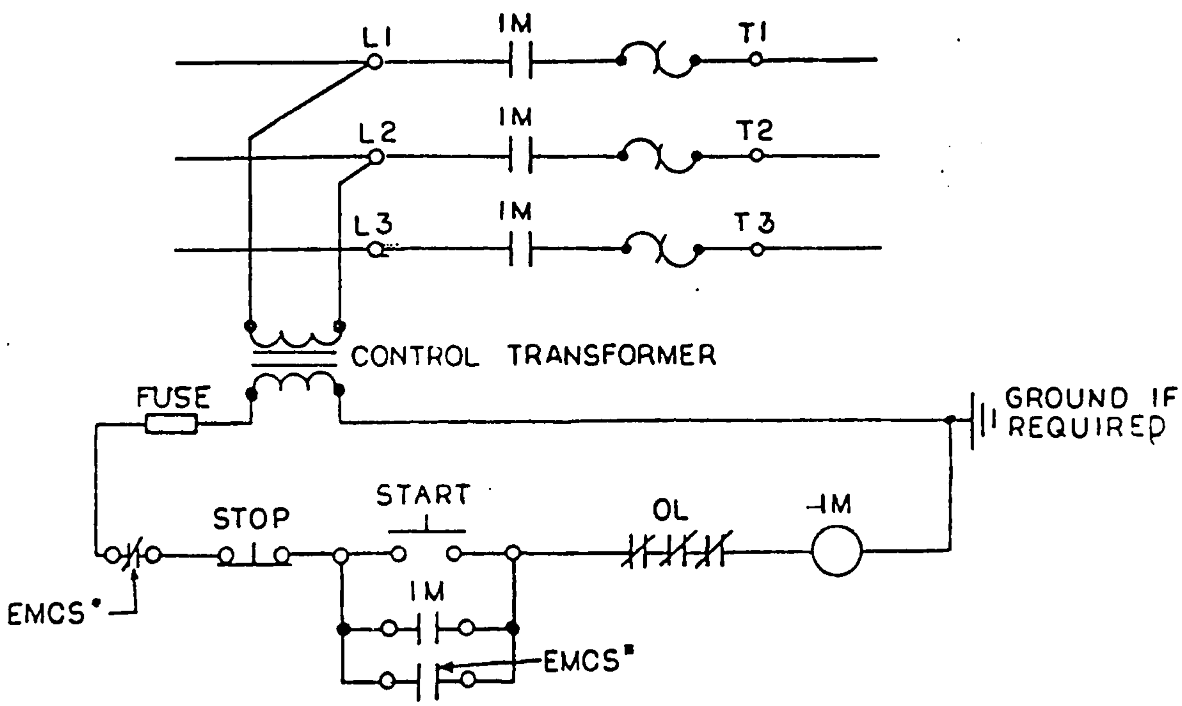
- Analog input representing a temperature or pressure
- Analog output
- EMCS output contact closure or opening to operate local control loop circuits

The three most common types of control circuits are:

- Momentary pushbutton
- Start/stop selector
- Hand-off-auto select

Momentary pushbuttons are incorporated into a basic "three wire" control circuit (Figure 3-22) for starting a motor. The EMCS provides a second set of start/stop contacts so that the motor may be started remotely. The start contact is wired in parallel with the local start pushbutton and the stop contact in series with the local stop pushbutton. Safety interlocks are required to be operative in either local or EMCS control. In the event of a failure in the EMCS, the motor may be selected to:

- Remain in the last condition
- Go to on condition
- Go to off condition



MOTOR STARTER W/LOW-VOLTAGE CONTROL CIRCUIT & EMCS INTERFACE

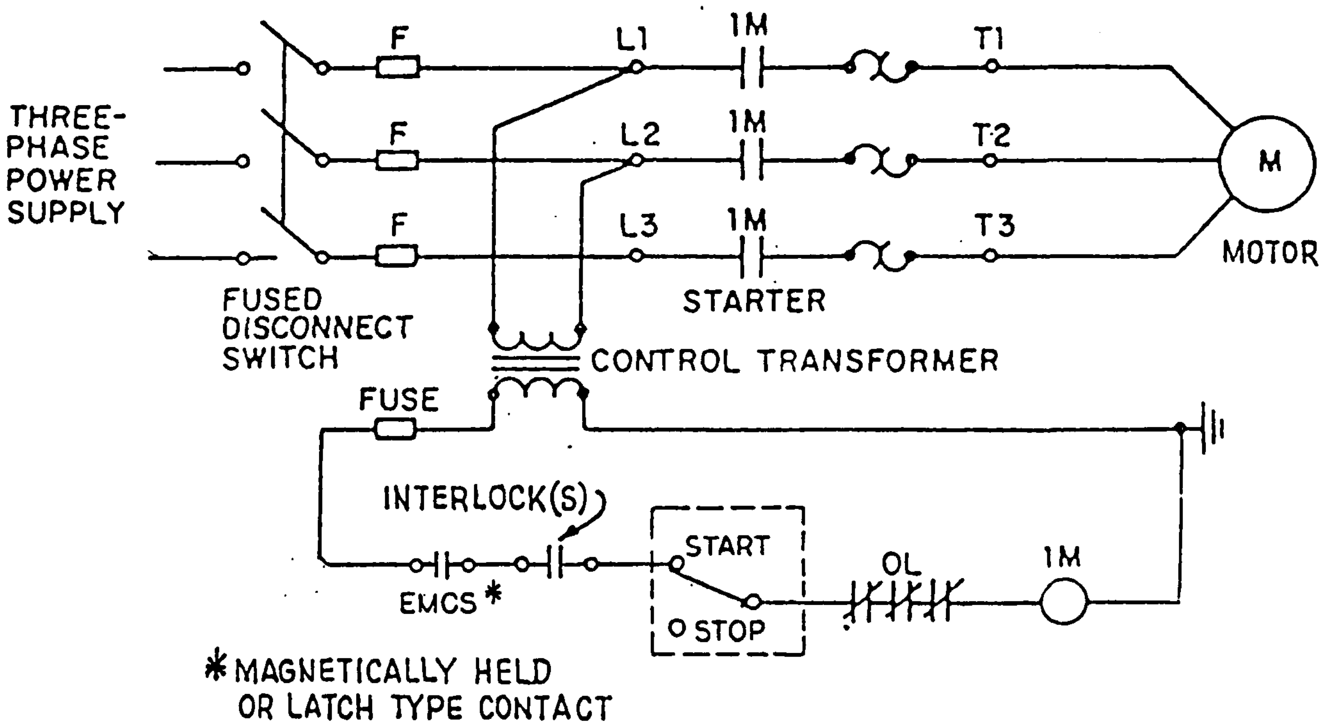
FIGURE 3-22

A two-wire start/stop selector (Figure 3-23) will normally involve just an open/close contact. This is similar to turning a light on and off in a room. In this case, the start/stop contact is maintained. The safety interlocks are connected in series so they are operative at all times. In the event of an EMCS failure, and the start/stop selector is in the start position, the motor may be selected to:

- Remain in the last condition
- Go to on condition
- Go to off condition

The hand-off-auto (HOA) selector is a variation of the start/stop circuit (Figure 3-24), where the motor is allowed to run in the hand or manual position. The auto position then allows complete control by the EMCS. The interlock(s) are operative at all times. The EMCS may control the motor only if the HOA switch is in the auto position. In the event of a failure the motor may be:

- Remain in the last state
- Go to on condition
- Go to off condition



START-STOP SELECTOR

FIGURE 3-23

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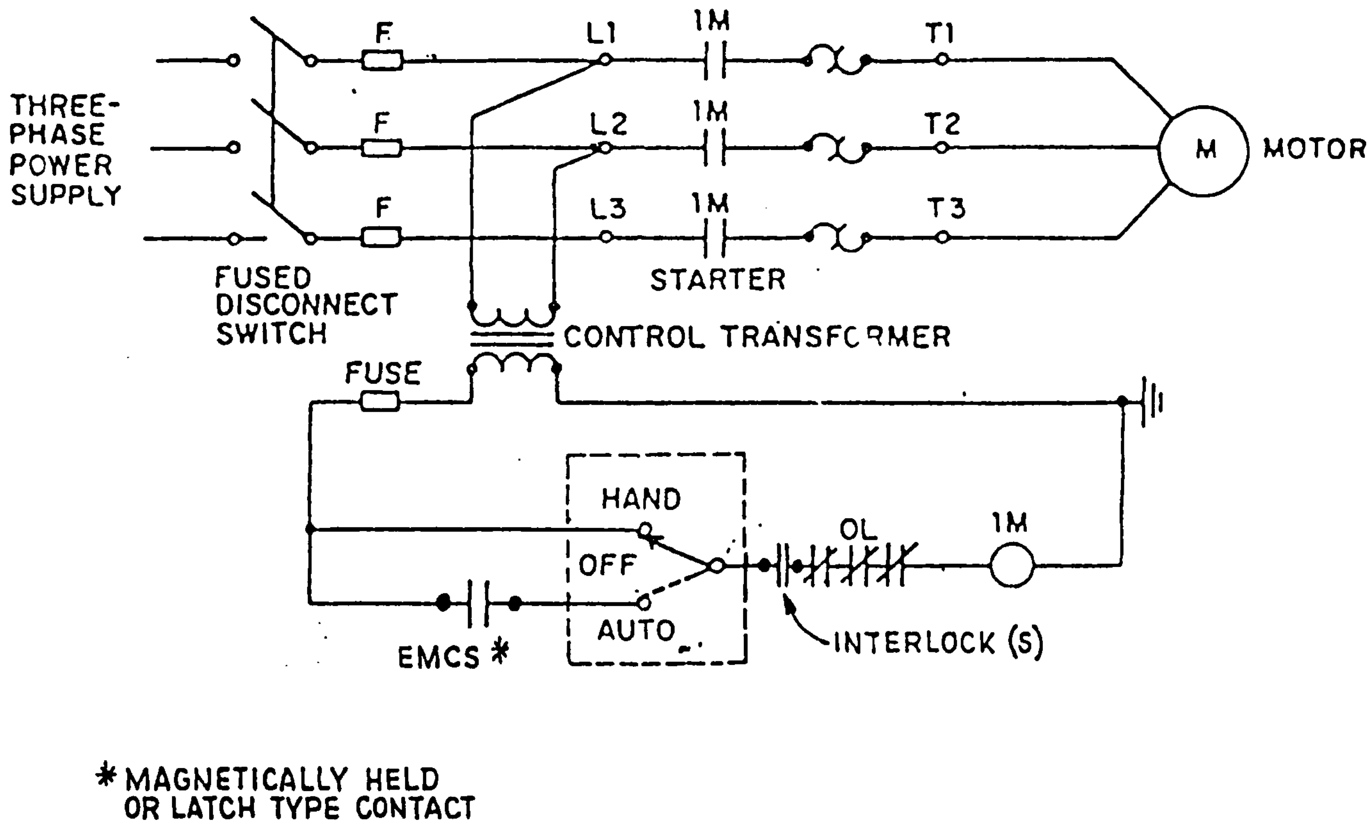


HAND-OFF-AUTO SELECTOR

FIGURE 3-24

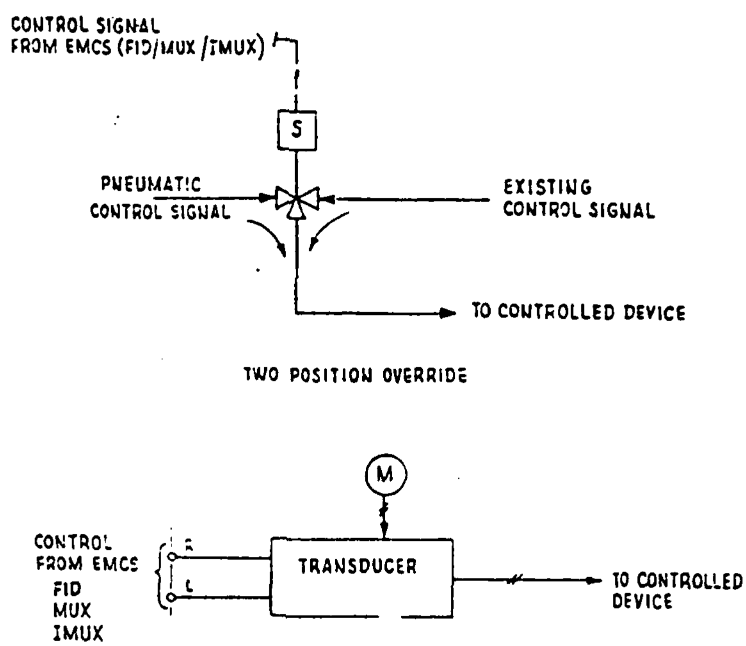
b. Pneumatic Interface (Transducer).

A pneumatic interface (Figure 3-25) requires an electrical output signal from the EMCS, such as, a contact closure or analog signal, but the output signal is used to operate an interface that converts the electrical signal to a pneumatic signal. Pneumatic interfaces include:

- Electronic output from EMCS to operate an EP (Solenoid Valve)
- Electronic output from EMCS to generate two-position override; for finite changes to controller set point
- Electric-pneumatic transducer: Modulating for CPA

In a "two-position override" circuit, a three-way solenoid operated valve (E-P) is energized in order to change the magnitude of the control signal to the controlled device. The new value is a fixed increment that will provide a minimum or maximum value to the controlled devices.

If continuous control is required, then an EP transducer is used to convert signals from the EMCS to a proportional pneumatic signal.



PNEUMATIC INTERFACE

FIGURE 3-25

CHAPTER 4

EMCS INTERFACE TO MECHANICAL AND ELECTRICAL SYSTEMS

4.1 General.

EMCS field equipment installation may require modification of existing mechanical/electrical equipment or the installation of new equipment. Such requirements are identified in the contract documents.

The purpose of this chapter is to describe typical mechanical and electrical systems the inspector is likely to encounter in the field and to show how these systems interface with EMCS sensors and controls.

4.2 Environmental Systems.

The most common types of environmental systems that are monitored and controlled by the EMCS include:

- Single Zone Air Handling Units.
- Terminal Reheat Systems.
- Multizone System.
- Dual Duct System.
- Variable Air Volume Systems.
- Induction Systems.
- Fan Coil Units.
- Unit Ventilators.
- Unit Heaters.
- Perimeter Radiation Systems
- Chilled Water System.
- Hot Water System.

Some, or all, of this equipment can be monitored and controlled by the EMCS. The EMCS can also control lights and monitor air and/or water conditions, such as temperature, humidity and flow rates, at various points throughout the installation. This information is a necessary input to the EMCS for the implementation of energy management programs.

4.3 EMCS Interface with a Typical Environmental System.

EMCS interfaces to an environmental system can be categorized as follows:

- Analog input for measuring process conditions.
- Status (digital) inputs to determine the state of various pieces of equipment.
- Control outputs (digital) for directing the required action of equipment.
- Control output (analog) for changing controller set points.

Figure 4-1 illustrates the EMCS interfaces with a typical single zone system.

a. Analog Inputs.

The analog measurements for this system shown in Figure 4-1 include:

- Return air temperature.
- Return air relative humidity.
- Outside air temperature.
- Outside air relative humidity.
- Mixed air temperature.
- Supply air temperature.

The return air temperature and humidity, and the outside air temperature and humidity are used if enthalpy control is required for the system. Sensors for these measurements must be installed and connections, either pneumatic or electric/electronic, made between the sensors and the EMCS (FID°/MUX*/IMUX).

Temperature sensor mounting is shown in Figure 4-2. Figure 4-3 shows an example of a humidity sensor.

The temperature sensor is typically a three wire Resistance Temperature Detector (RTD). The connections between the RTD and the FID°/MUX* are shown in Figure 4-4.

The signal from the humidity sensor shown is electrical, and is connected to the FID°/MUX* with a pair of wires in a similar manner as the RTD. In this case, however, only two wires are needed, not three as shown.

°Large/Medium/Small EMCS
*Large/Medium EMCS

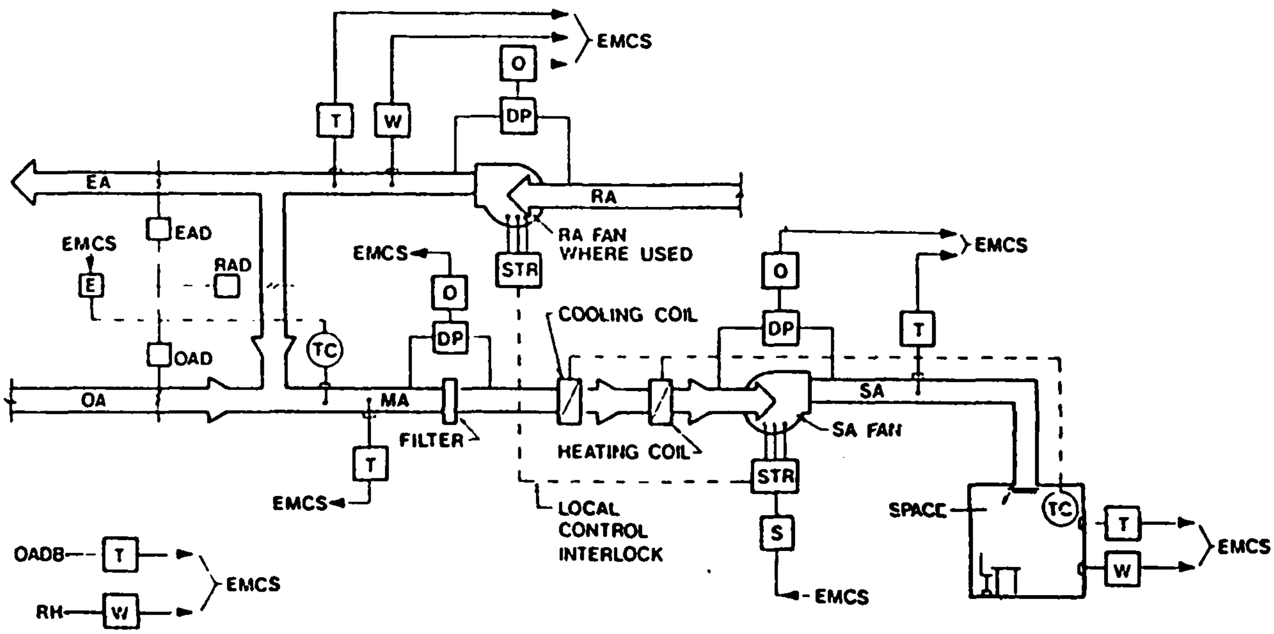
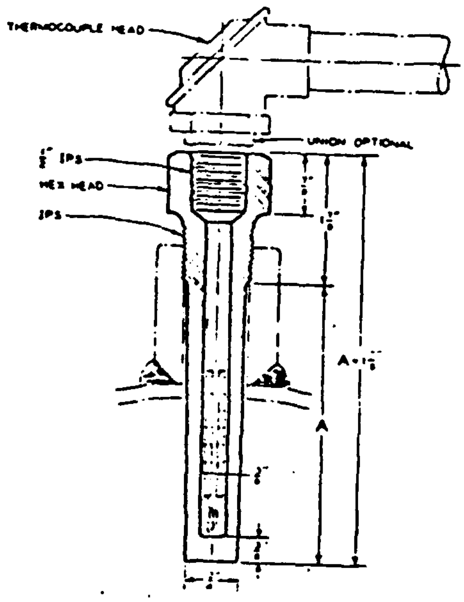
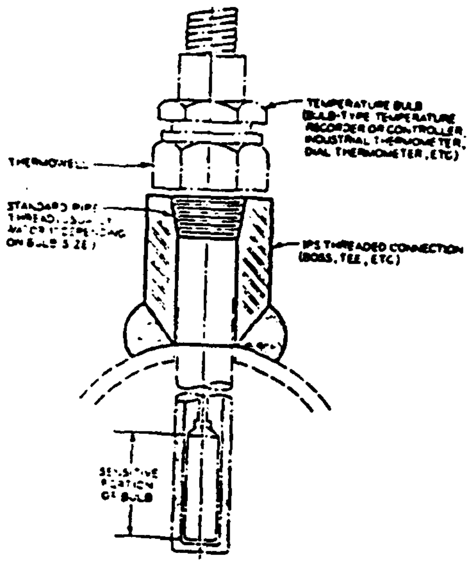


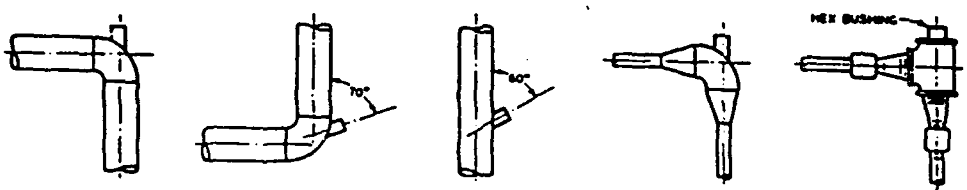
Figure 4-1 Single zone AHU



Thermowell ¾-In. Screwed.

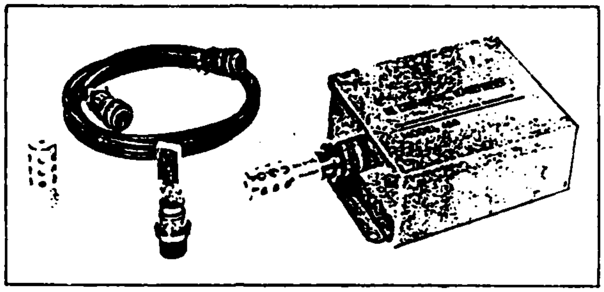


Installation for Temperature Bulb.

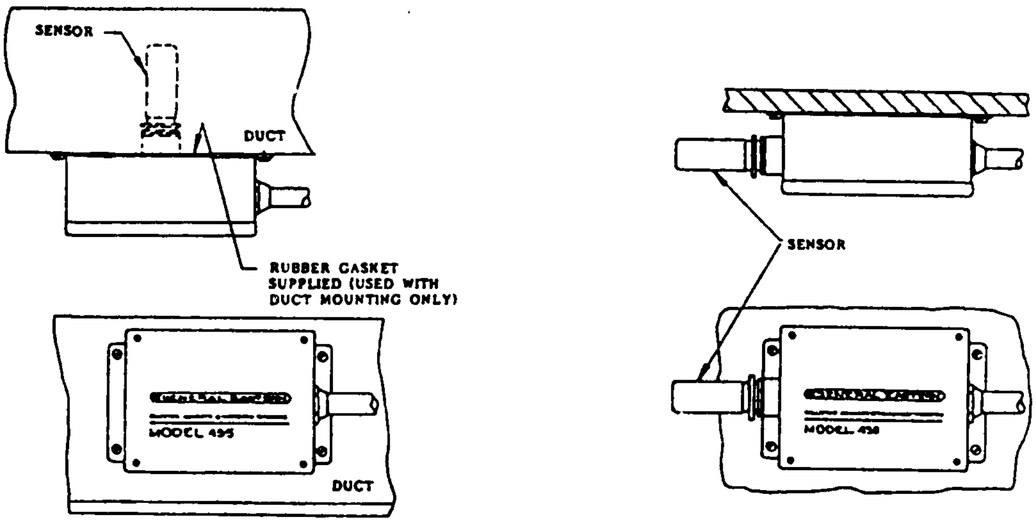


Thermowell Installation for Small Lines.

Figure 4-2



Model 455 Transmitter for wall mounting



DUCT MOUNTED

WALL MOUNTED

Figure 4-3

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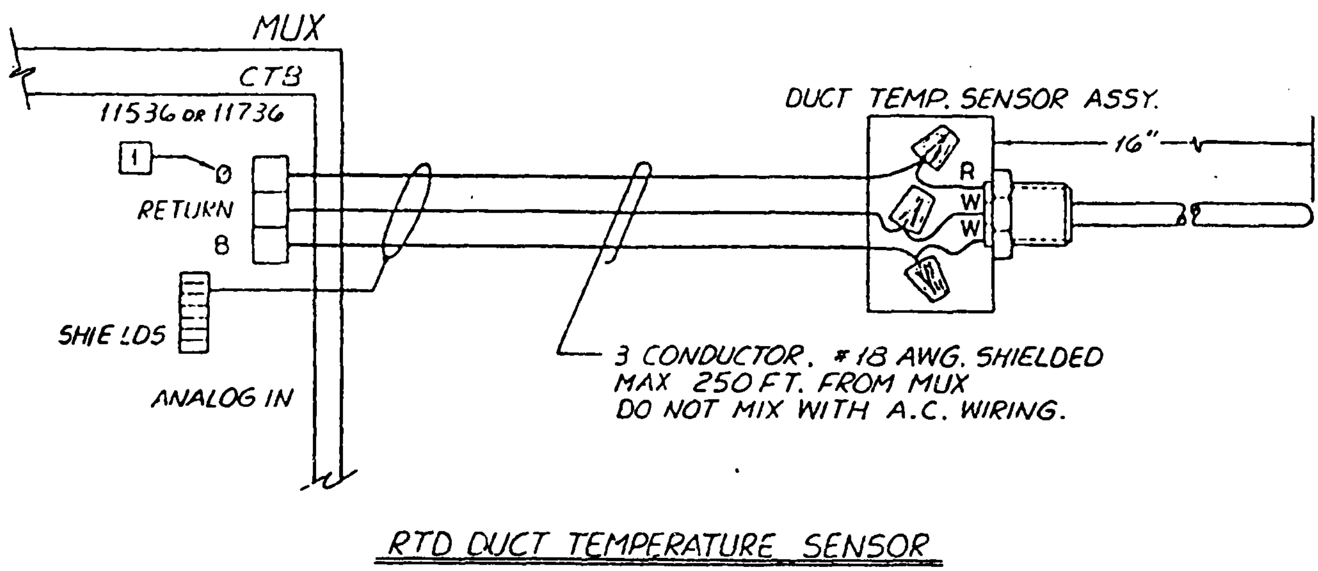

MUX
CTB
11536 OR 11736
1
0
RETURN
8
SHIELDS
ANALOG IN
DUCT TEMP. SENSOR ASSY.
16"
R
W
W
3 CONDUCTOR. # 18 AWG. SHIELDED
MAX 250 FT. FROM MUX
DO NOT MIX WITH A.C. WIRING.
RTD DUCT TEMPERATURE SENSOR

Figure 4-4

b. Status Inputs (Digital).

In order to provide control of the air handling system the EMCS must be able to turn the supply and return air fans on and off. The EMCS requires a positive indication that the fans are either on or off. Fan run-status, as shown in Figure 4-5, can be measured with a differential pressure switch connected between the suction and discharge of the fan. In this manner, when the fan is on, a differential pressure equivalent to the fan head is created. The resulting status signal is input to the EMCS. A fan air flow switch installation is shown in Figure 4-6.

In a similar manner, the pressure drop across the fan input filter is measured and a status signal is transmitted to the FID°/MUX* when the pressure drop exceeds the pressure setting.

c. Control Outputs (Digital).

Fan start-stop control is accomplished by interfacing with the local controls as shown in Figure 4-7. In this circuit, the EMCS control signals are designed to operate in the same manner as the local startstop pushbuttons. An alternate wiring method, shown in Figure 4-8, also requires an interface with the local controls, but only one output signal from the EMCS.

The interfaces described above all require wiring to be run between the FID°/MUX* and the local controls. The local control may need to be replaced or merely rewired to suit the new control applications.

Figure 4-1 indicates that dampers are being used to control air flow in air handling units. The damper operators are typically spring loaded, pneumatic piston cylinder combinations. The EMCS interface to dampers is typically through a three-way valve as shown in Figure 4-9. If the valve "V" is not energized, the output from the controller will modulate or control the damper. When the valve "V" is energized, pressure "P1" is applied to the damper. This may be a minimum position setting or a particular setting for the damper. In this manner, when the EMCS so dictates, the damper is moved to a fixed setting. When it is required to know the exact damper position, a position indicating potentiometer is added to the damper as shown in Figure 4-10.

d. Control Outputs (Analog)

Analog control output may be an analog current out, such as 4-20 mA dc, that will operate a control device such as a control valve. An analog control output may also be a digital pulse that is used to operate a motor. The motor may in turn be used to adjust the set point of a controller.

°Large/Medium/Small EMCS
*Large/Medium EMCS

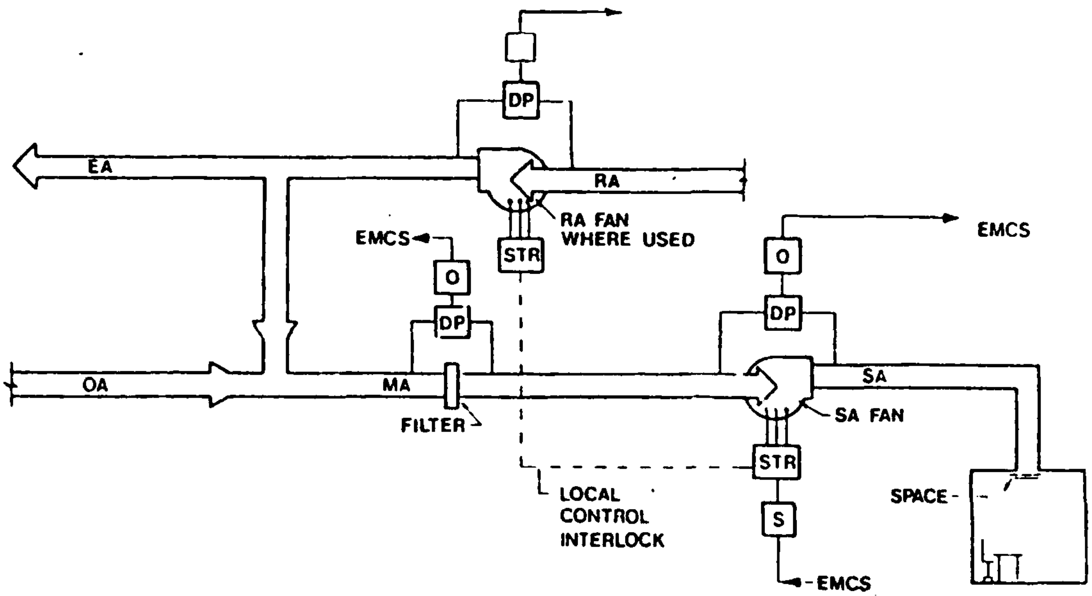
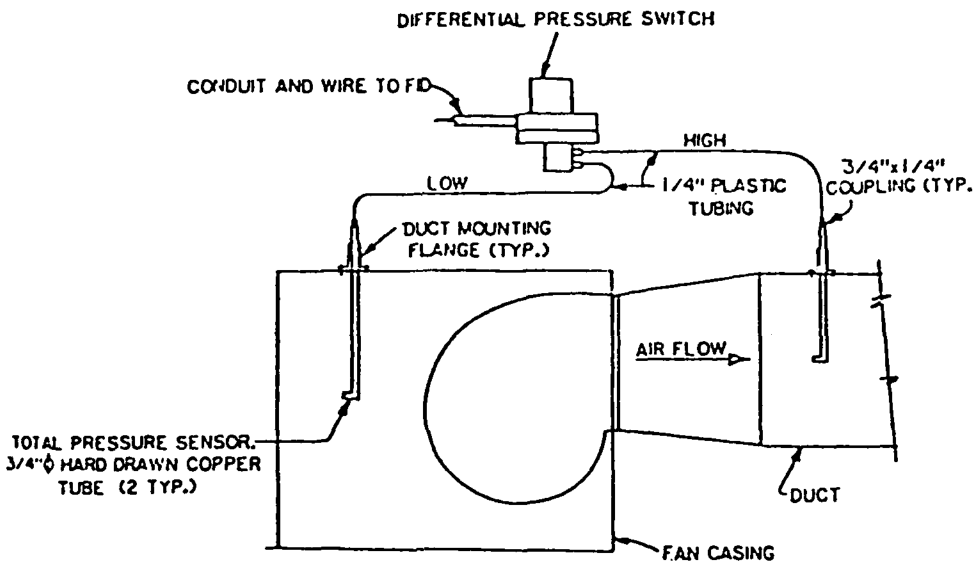

DP
EA
RA
RA FAN
WHERE USED
EMCS
STR
O
EMCS
O
DP
DP
OA
MA
SA
FILTER
SA FAN
STR
LOCAL
CONTROL
INTERLOCK
SPACE
S
EMCS

Figure 4-5



FAN AIR FLOW SWITCH INSTALLATION

Figure 4-6

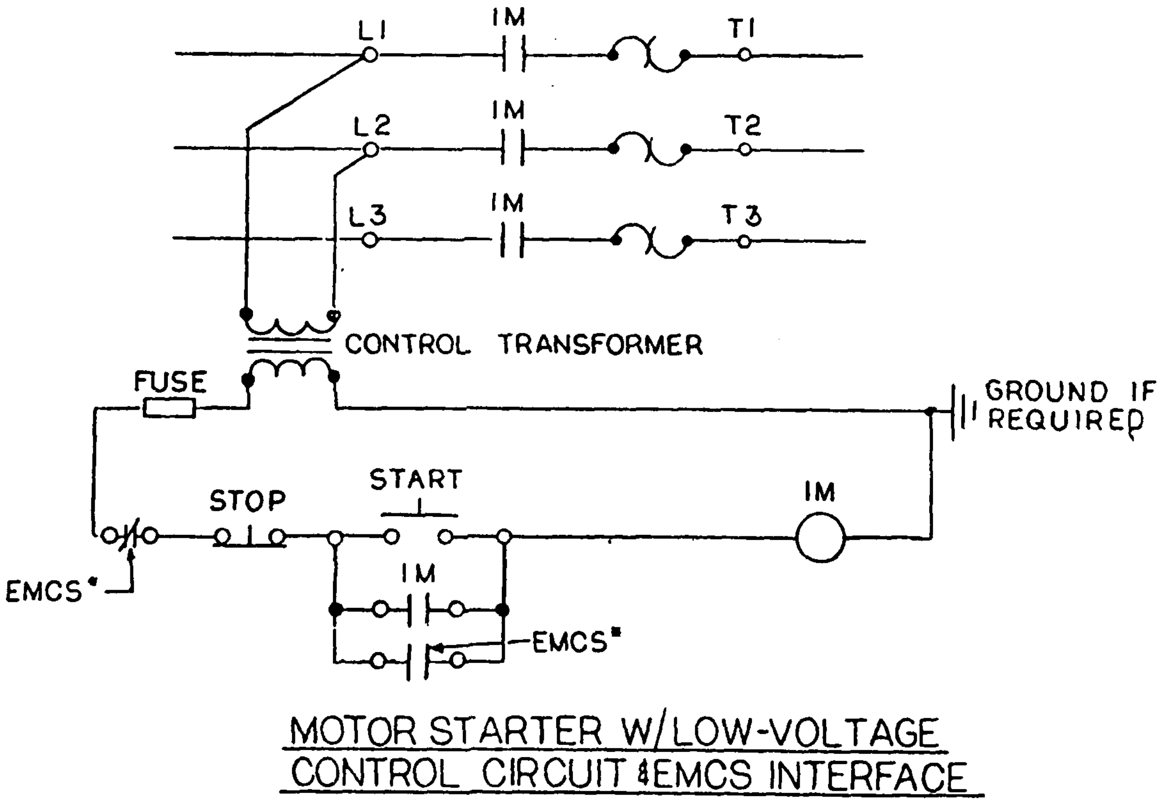
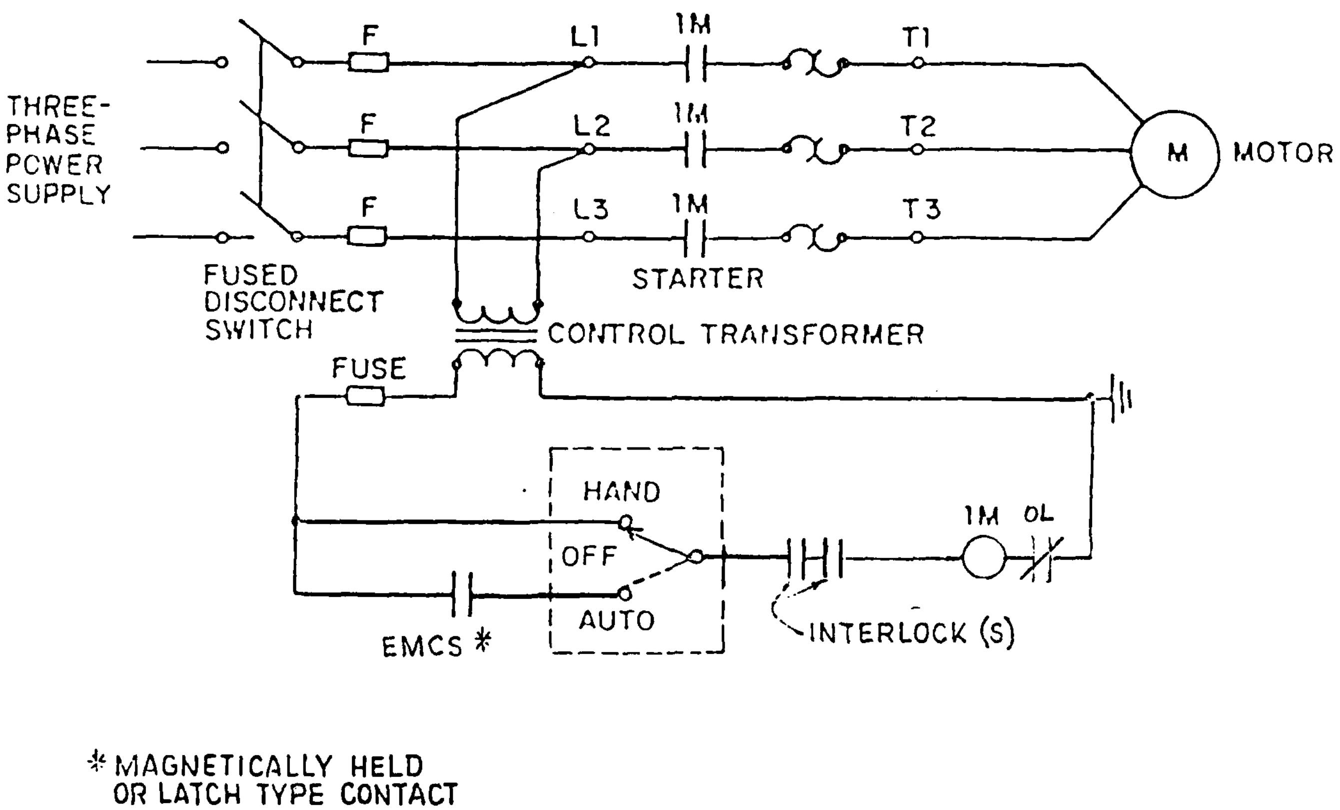

L1
1M
T1
L2
1M
T2
L3
1M
T3
CONTROL TRANSFORMER
FUSE
GROUND IF REQUIRED
START
STOP
1M
EMCS*
1M
EMCS*
MOTOR STARTER W/LOW-VOLTAGE CONTROL CIRCUIT & EMCS INTERFACE

Figure 4-7



HAND-OFF-AUTO SELECTOR

Figure 4-8

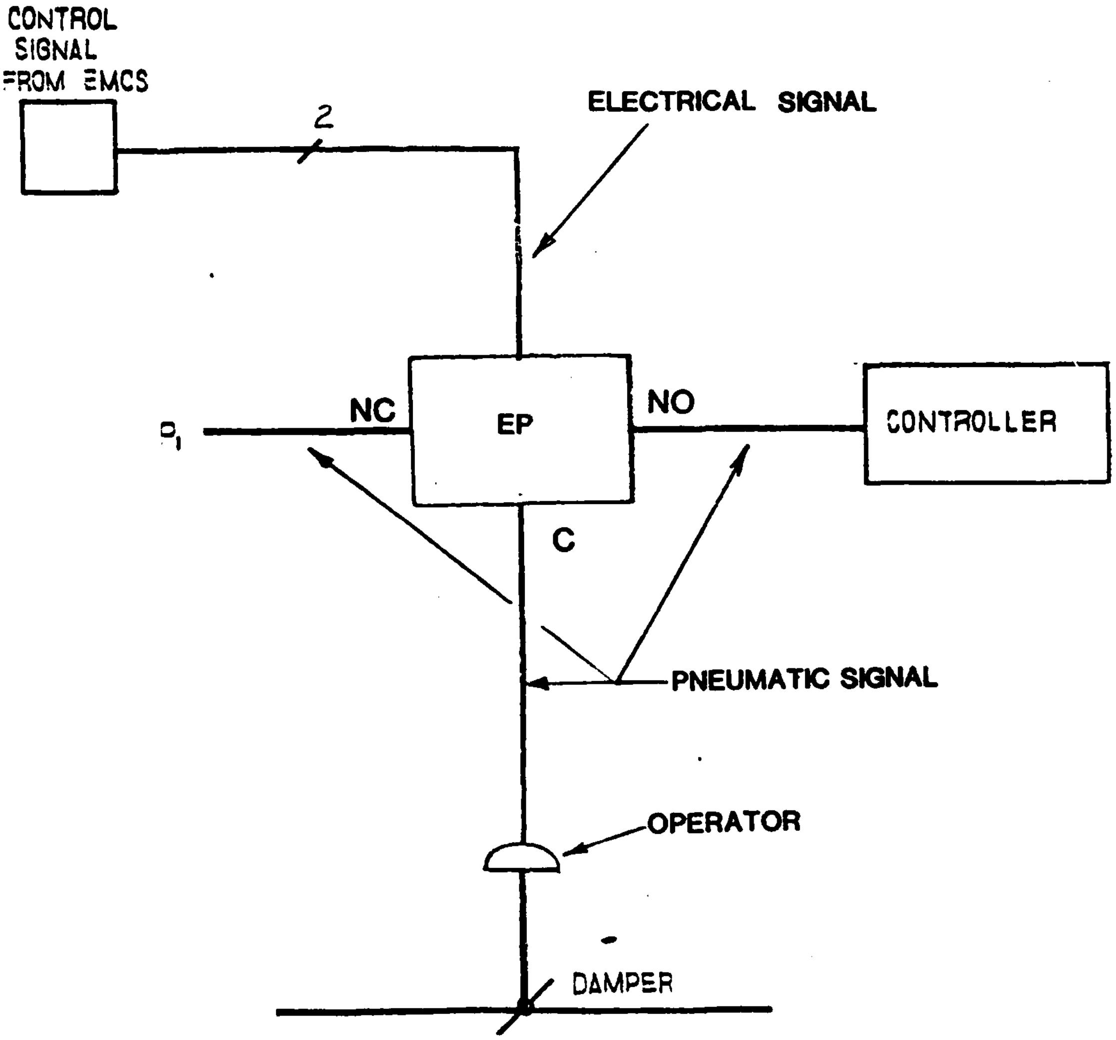

CONTROL
SIGNAL
FROM EMCS
2
ELECTRICAL SIGNAL
NC
EP
NO
CONTROLLER
C
PNEUMATIC SIGNAL
OPERATOR
DAMPER

Figure 4-9

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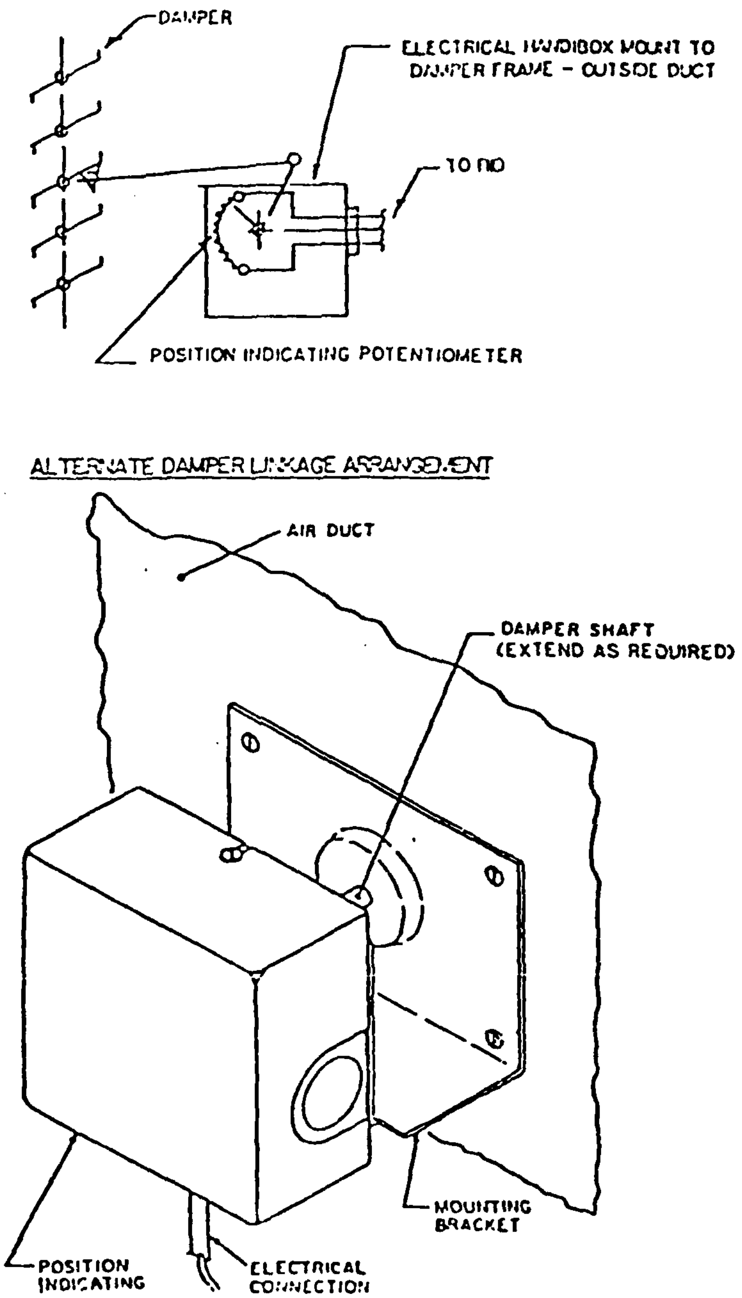

DAMPER
ELECTRICAL HANDIBOX MOUNT TO
DAMPER FRAME - OUTSIDE DUCT
POSITION INDICATING POTENTIOMETER
ALTERNATE DAMPER LINKAGE ARRANGEMENT
AIR DUCT
DAMPER SHAFT
(EXTEND AS REQUIRED)
MOUNTING
BRACKET
POSITION
INDICATING
ELECTRICAL
CONNECTION

Figure 4-10

4.4 HVAC System Review and EMCS Interface.

There are numerous types of HVAC Systems in existance which can be combined into many variations of the basic system. The following systems are typical HVAC Systems.

a. Single Zone AHU.

Single zone systems (Figure 4-1) require supply air to be heated or cooled to meet a single set of space conditioning requirements in the one zone it serves.

(1) Control Strategies Based on Outside Air Conditions.

- Economy Cycle - For this control scheme, the outside air, return and exhaust air dampers are controlled to maintain the mixed air temperature. With outside air at design winter temperature, the outside air damper and relief dampers are in minimum open positions (as determined by ventilation and exhaust requirements) and the return air damper is correspondingly in maximum open position. As outside air temperature increases, the temperature controller (TC) gradually opens the outside air dampers to maintain a constant low-limit mixed air temperature. Return and relief dampers modulate correspondingly. At some outside temperature, usually between 50° and 60°F, 100% outside air will be provided and used for cooling without mechanical refrigeration. As the outside air temperature continues to increase, at 70° to 75°F, an outdoor air high-limit thermostat is used to cut the system back to minimum outside air, thus decreasing the cooling load. This system is extensively used today.

- Enthalpy Control - Economy cycle control based on dry-bulb temperatures is not always the most effective. In very humid climates, the total heat (or enthalpy) of the outside air may be greater than that of the return air, even though the dry-bulb temperature is lower. Since the cooling coil must remove the total heat from the air to maintain the desired space conditions, it is more economical in this case to hold outside air to a minimum. To measure enthalpy, it is necessary to measure the dry bulb outside air temperature plus either wet bulb, relative humidity, or dew point.

(2) Heating.

The heating coil (hot water or steam) handles all or a large portion of the mixed air supply, at entering temperatures of 45° to 50°F or higher.

The heating coil discharge is controlled by modulating a supply valve. This supply valve is modulated by a temperature controller and regulates the flow or steam or hot water to the heating coil.

(3) Cooling.

Cooling acts in a similar manner as heating in that the chilled water supply valve is modulated by the coil discharge sensor or zone temperature controller. The cooling medium, in this case, could be chilled water or refrigerant.

b. Heating and Ventilating Units.

Heating and Ventilating units are similar in operation to the single zone AHU but do not have cooling coils.

c. Terminal Reheat System.

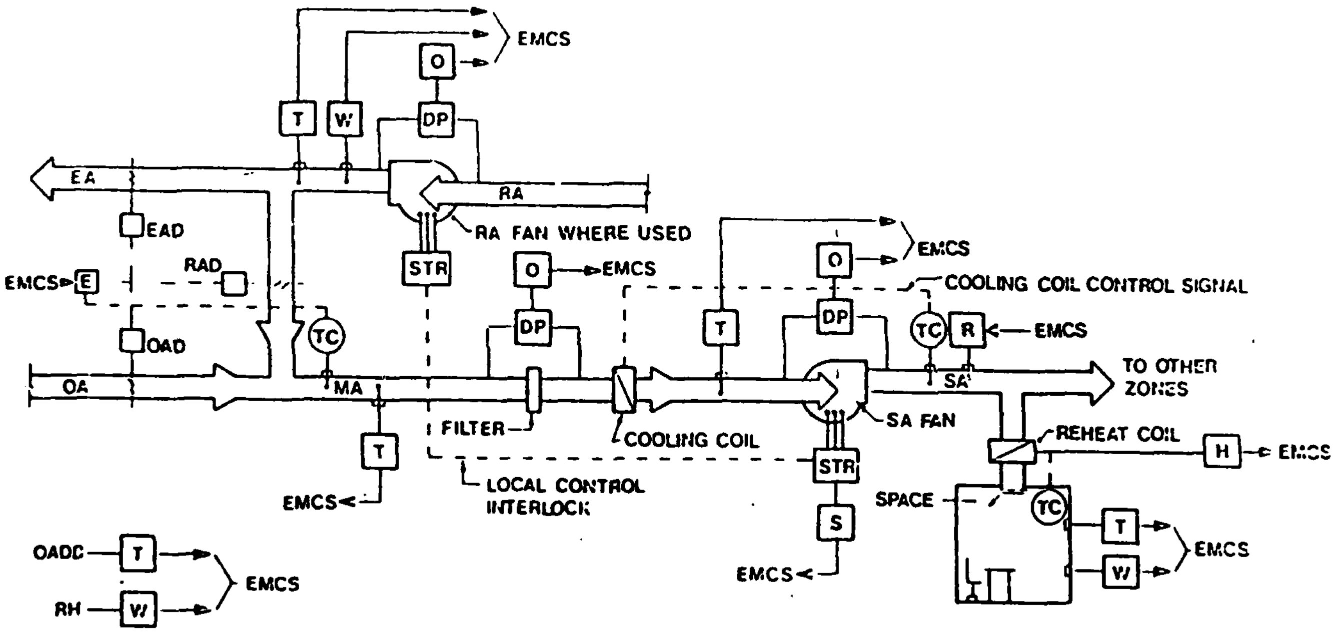
A reheat system (Figure 4-11) is a modification of the single zone system to permit zone or space control for areas with unequal thermal loading. As the word reheat implies, the application of heat is a secondary process, being applied to preconditioned air. In a reheat system, heating coils are inserted into the duct system downstream of the cooling coil. These heating coils are commonly referred to as reheat coils or terminal reheat units. The medium for reheating may be hot water, steam or electricity.

Conditioned air is supplied at a fixed cold air temperature designed to satisfy the maximum cooling load in the spaces. A control thermostat located in the spaces, calls for heat from the reheat coil as the cooling load of the space drops below maximum demand.

d. Multizone System.

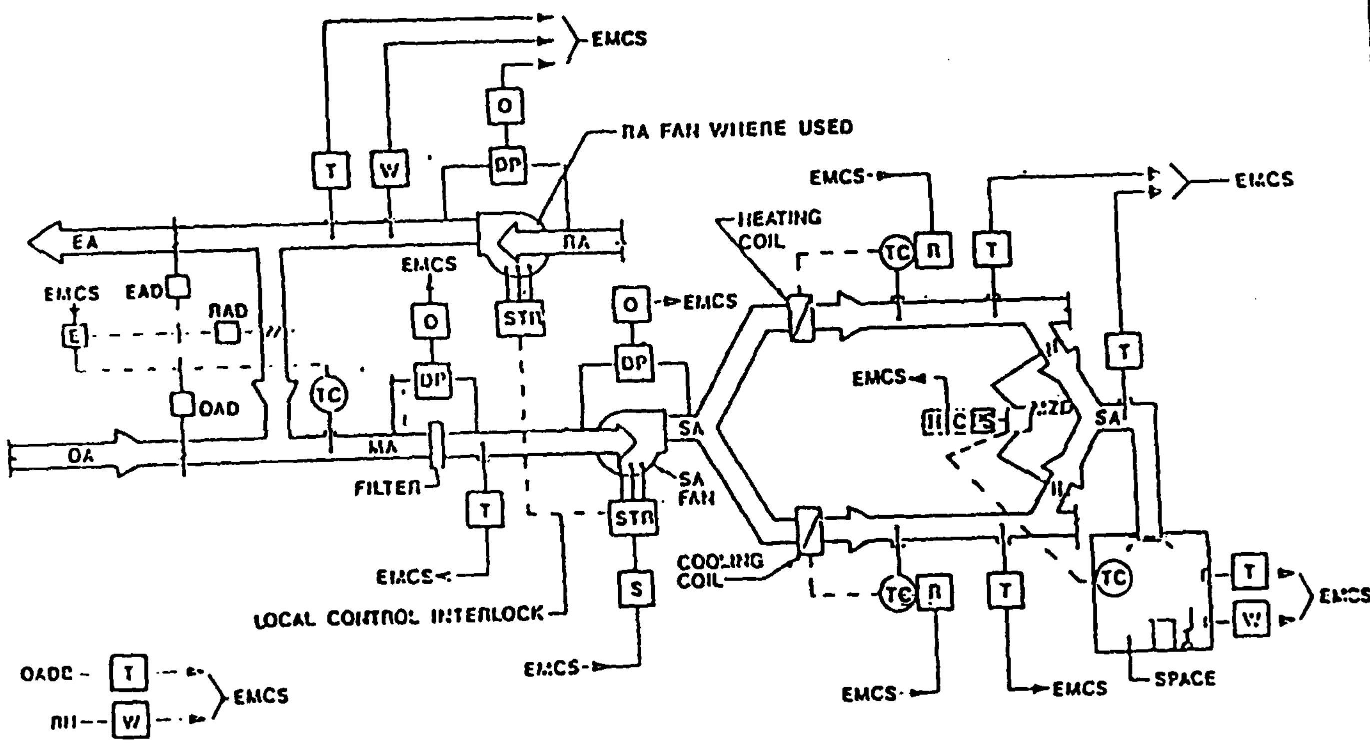
In a multizone system (Figure 4-12), supply air is conditioned in a hot deck and cold deck for each building zone. The hot and cold decks are ductwork containing a heating coil (in the hot deck) and a cooling coil (in the cold deck). Conditioned air leaving the hot and cold decks is then mixed to meet space requirements of a given zone. The proportions of hot and cold air for a zone are controlled by zone dampers controlled by zone thermostats.

The hot and cold deck temperatures are individually controlled by the duct temperature controllers to a fixed temperature discharge with the controllers reset by the EMCS to minimize the required hot-cold deck temperature differences.



Terminal reheat AHU system

Figure 4-11



Multizone AHU

Figure 4-12

e. Variable Air Volume System.

A variable air volume system (Figure 4-13) is an air system made up of a single zone air handling system and terminal units called variable air volume boxes (VAV boxes) remotely located from the central air handler. These systems are generally used for cooling only, but in some cases a VAV system may have reheat coils.

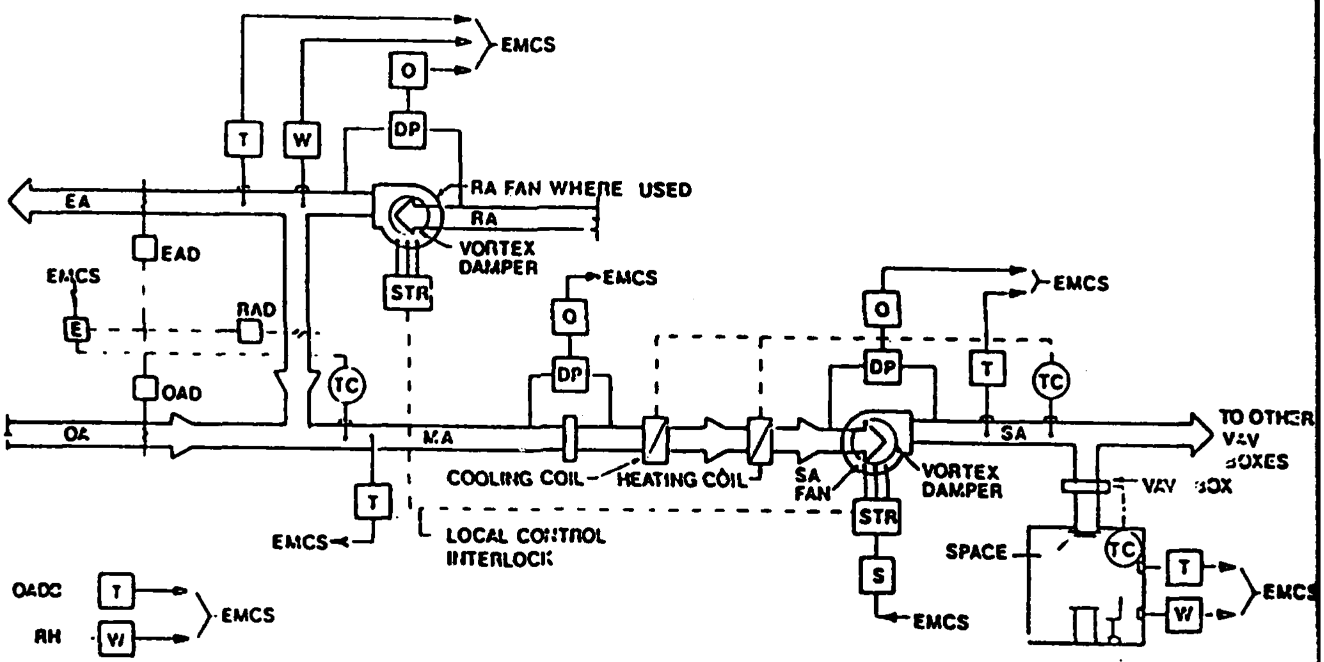
The terminal units under thermostatic control vary the position of the damper (commonly called a valve unit) in the VAV box, varying the amount of air delivered to the space.

In a variable air volume system, a means of varying the amount of air being delivered by the central air handling unit must be found. Methods of controlling the fan discharge air quantities include:

- Fan bypass or return air dumping-as the static pressure in the discharge air rises above the static pressure controller set point, the bypass damper opens and recirculates the air around into the air return system.

- Discharge static pressure controller - varies the speed of the supply fan motor.

- Inlet vane control - air inlet vanes, a part of the fan itself, are positioned by an actuator responding to a signal from the duct pressure controller. The inlet vanes are modulated to maintain the minimum static pressure required to deliver air to any one VAV box.



Variable air volume AHU

Figure 4-13

f. Refrigeration Equipment.

Refrigeration machines are designed to transfer heat from one medium to another for the purpose of cooling a medium such as water or air. Many installations will generally have a central, liquid cooling system. That is, cooling systems where a secondary liquid, such as water, that has been cooled by a refrigerant is used to condition the supply air to a space. One common type of machine used is the hermetic centrifugal liquid chiller. A typical water cooled centrifugal chiller system is shown in Figure 4-14. In centrifugal and reciprocating machines, water is chilled when heat is transferred from the water to a lower temperature refrigerant liquid. This process, which takes place in the evaporator, causes the liquid refrigerant to vaporize. The refrigerant vapor then enters the compressor which increases the temperature of the refrigerant vapor through the heat of compression. The high temperature refrigerant vapor is discharged to the condenser where heat is transferred from the refrigerant vapor to lower temperature condenser water. The condenser water flows to the cooling tower to dissipate heat to the atmosphere. The cooled and condensed refrigerant liquid flows back to the evaporator to be reused in the refrigeration process.

Instrumentation or refrigeration equipment will generally include sensors on chilled water temperature, condenser water temperature, and water flow rates. Control devices may include start/stop, chilled and condenser water temperature reset.

(1) Status Inputs (Digital).

Status signals for monitoring the chilled water and condenser water pumps are used to indicate the pump operating condition. Status signals are also used to indicate that the chiller is operating.

The pump status is determined with a differential pressure switch connected between the output and input of the pumps. The chiller status is provided by using an auxiliary contact in the chiller control circuit.

(2) Control Output (Digital).

Control of the chilled water and condenser water pump is accomplished with a digital output from the EMCS.

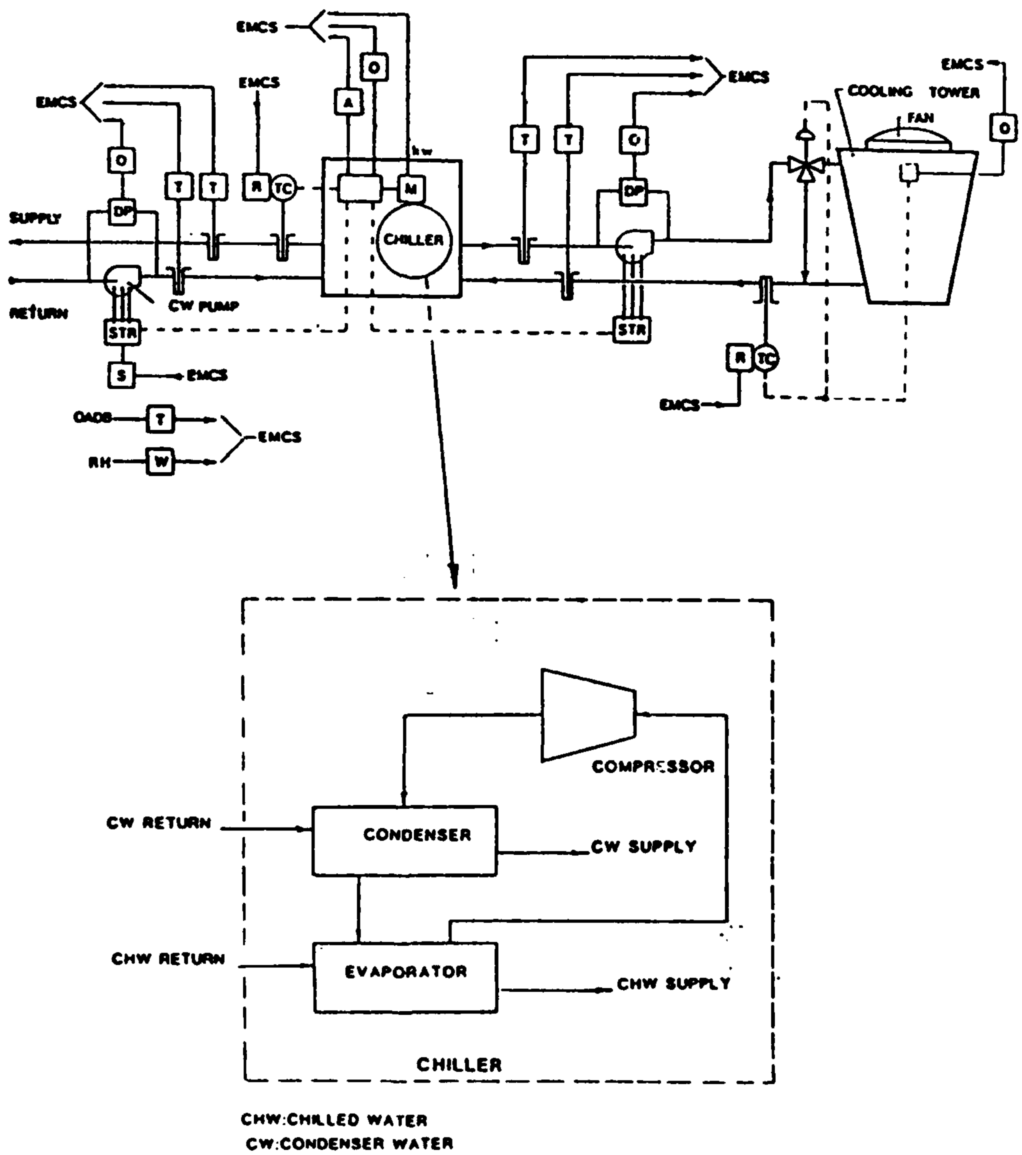

EMCS
EMCS
EMCS
EMCS
EMCS
COOLING TOWER
FAN
SUPPLY
RETURN
CW PUMP
CHILLER
STR
S
OADB
RH
COMPRESSOR
CW RETURN
CONDENSER
CW SUPPLY
CHW RETURN
EVAPORATOR
CHW SUPPLY
CHILLER
CHW:CHILLED WATER
CW:CONDENSER WATER

Figure 4-14

(3) Analog Ouput.

The EMCS may be used to change the setpoint of the condenser water and the chilled water temperature controllers.

(4) Analog Input.

The analog measurements of prime concern are:

- Chiller KW.
- Condenser Water and Chilled Water Flow.
- Condenser Water Supply and Return Temperature.
- Chilled Water supply and return temperature.

All of these measurements are used for the calculation and control of chiller efficiency. The temperature sensors are similar to those described for the air handling equipment. However, because all are measuring liquid temperatures that occur over a smaller range, the sensor must be very accurate.

Chiller electric power consumption (measured in KW) is measured directly with potential transformers (PT) and current transformers (CT). The CT and PT signals are converted to a signal compatible with the EMCS with AC current and voltage transducers.

Flow is quite often measured with an orifice plate or venturi tube. A DP flow transmitter is then used to convert the signal created across the flow meter into a signal compatible with the EMCS. In order to produce reliable measurements, the mounting of the flow meter and the piping for the transmitter must be mounted in accordance with the manufacturer's standard practices. In addition, recommended practices for flow measurements must be followed. This includes the requirements for 10 times the pipe diameter of straight pipe upstream and 5 times the pipe diameter of straight pipe downstream of the orifice plate. Figure 4-15 shows an installation for water flow measurement using a DP transmitter.

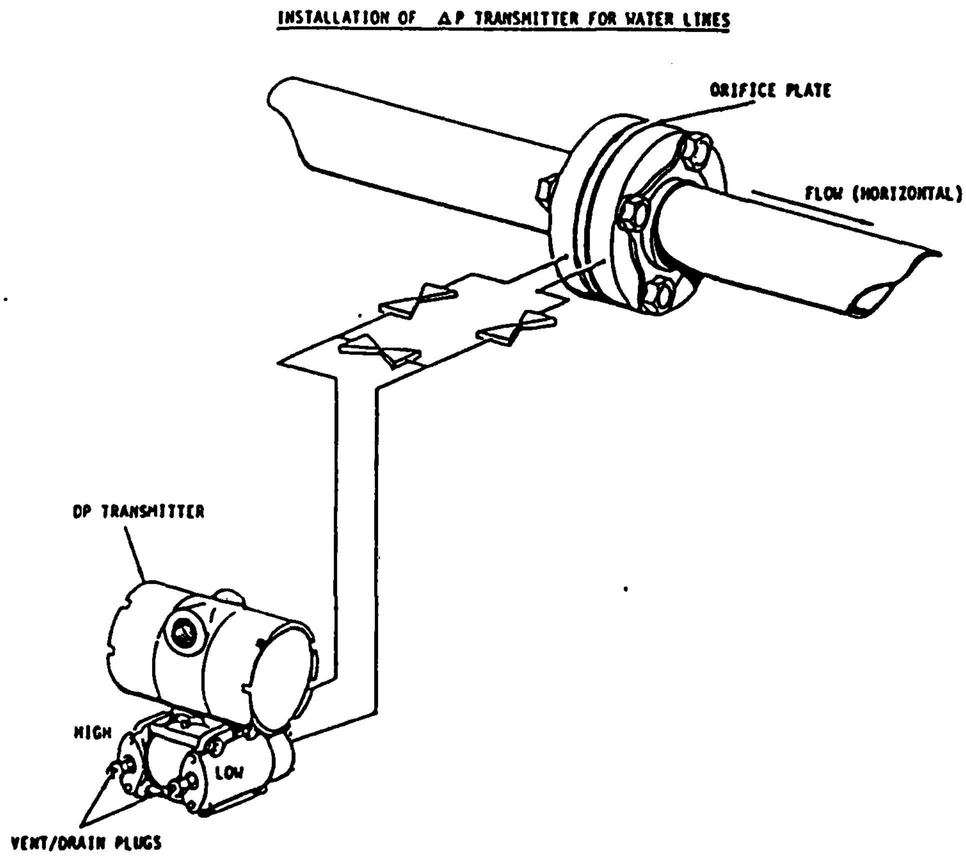

INSTALLATION OF ΔP TRANSMITTER FOR WATER LINES
ORIFICE PLATE
FLOW (HORIZONTAL)
DP TRANSMITTER
HIGH
LOW
VENT/DRAIN PLUGS

Figure 4-15

(5) Condenser Water Temperature Reset.

The energy required to operate chilled water systems that use water as the refrigerant condensing medium is directly related to the temperature of the condenser water entering the chiller. In order to optimize the performance of the refrigeration system, condenser water temperature can be reset downward when OA wet bulb temperature will produce lower condenser water temperature. (When using this function, the program must incorporate manufacturers acceptable condenser water temperature range requirements).

The condenser return water temperature is controlled with a local temperature controller that, in turn, modulates a bypass valve controlling the amount of water to be circulated through the cooling tower. The EMCS will interface with the condenser water control system and change the temperature setpoint in proportion to the change in the outside wet bulb temperature. The interface connections to the controller may be either pneumatic or electric, depending upon the type of system installed. In many cases, the control system is pneumatic, so that the EMCS must provide an electric to pneumatic interface. This is shown in Figure 4-16.

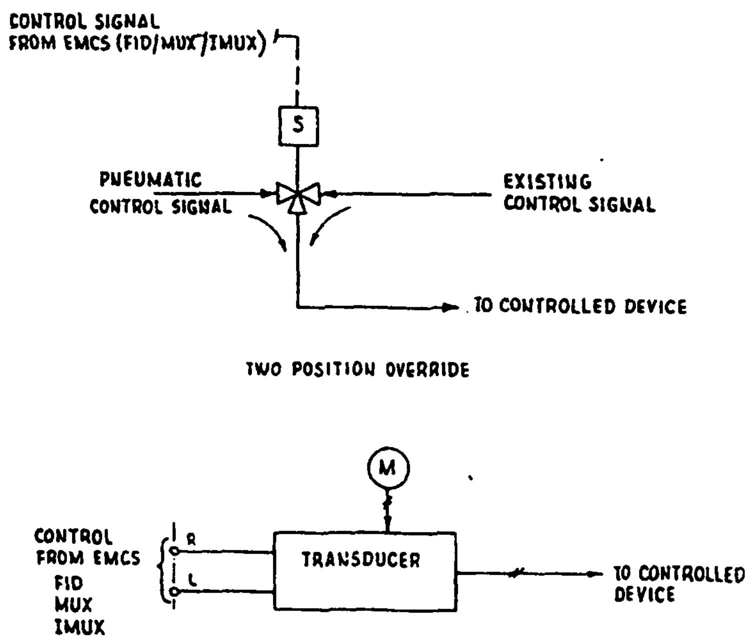
The FID°/MUX* output may be digital output signals that control an electric motor. The motor, in turn, will modulate a pneumatic regulator, thus generating a variable pneumatic signal. This signal is then used to adjust the setpoint of the temperature controller. A block diagram for this control scheme is shown in Figure 4-17.

(6) Chilled Water Temperature Reset.

The energy required to produce chilled water in a reciprocating or centrifugal machine is a function of the chilled water supply temperature. The higher the supply temperature, the lower the energy input per ton of refrigeration produced. A reduced load on the chilled water system will allow the chilled water temperature to be set to a higher value while still in most cases satisfying the cooling requirements for the system. The EMCS program resets chilled water temperature upward without exceeding space temperature and humidity requirements. This determination is made by monitoring positions of the chiller water valves on various cooling systems or by monitoring space temperatures.

The interface between the EMCS and the chilled water temperature controller functions in the same manner as the controls for condenser water control and the equipment would be the same.

°Large/Medium/Small EMCS
*Large/Medium EMCS



PNEUMATIC INTERFACE

Figure 4-16

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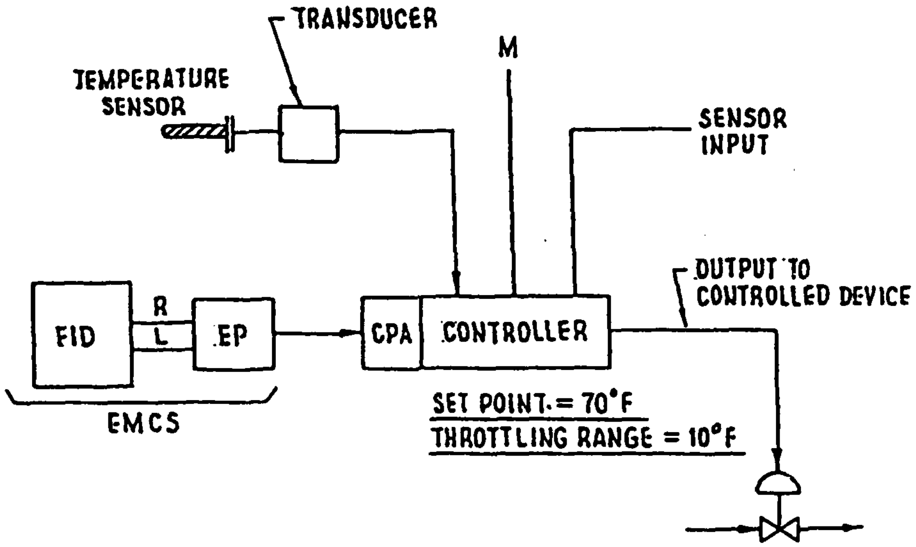

TRANSDUCER
M
TEMPERATURE SENSOR
SENSOR INPUT
OUTPUT TO CONTROLLED DEVICE
FID
R
L
EP
CPA
CONTROLLER
EMCS
SET POINT = 70°F
THROTTLING RANGE = 10°F

Figure 4-17

(g) Water Cooled DX Compressor.

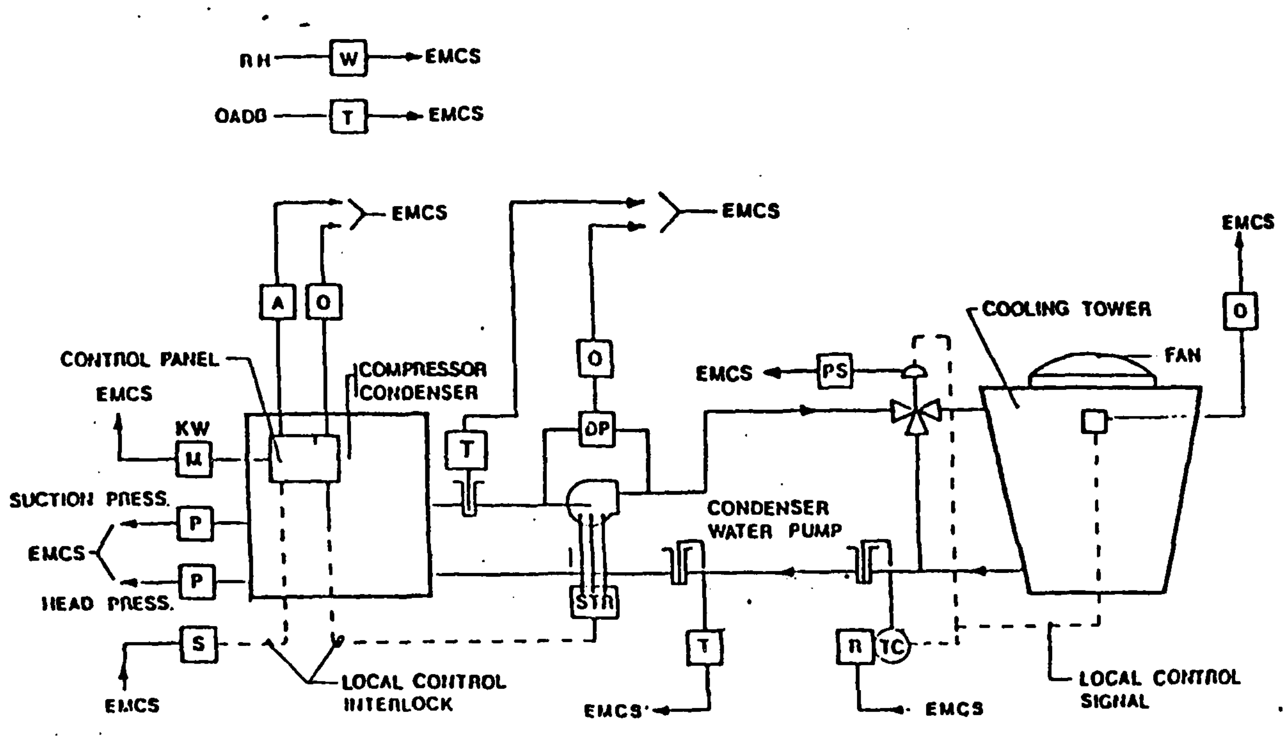
A water cooled DX Compressor operates in the same manner as a water cooled chiller with the exception that a refrigerant is used as the cooling medium. A typical system is shown in Figure 4-18. The system operates in the same manner but instead of measuring chilled water supply and return temperature, suction and supply pressures are measured.

(7) Chiller Demand Limit.

Centrifugal water chillers are normally factory equipped with an adjustable control system that limits the maximum available cooling capacity, or the power the machine can use. The method of accomplishing this function varies with the chiller manufacturer but the net result is the same; the demand limit prevents any further opening of the compressor inlet vanes.

When a chiller is selected by the EMCS for demand limiting, a single step signal is transmitted, reducing the chiller demand limit adjustment by a fixed amount. Conversely, the limit can be raised a fixed amount with a single command. Extreme caution must be exercised when applying this program, since incorrect control can cause the refrigeration machine to operate in a surge condition, potentially causing it considerable damage. The chiller manufacturer's recommended minimum cooling capacity limit must be incorporated into the program logic. This program is used in conjunction with the demand limiting program, therefore, each chiller demand control step must be assigned an equipment priority level.

In this case, the EMCS will produce a digital output signals to raise or lower the demand limit. If the chiller controls are pneumatic, then the signals must be converted to a pneumatic signal consistent with the chiller controls. If the controls are electric/electronic the interface may be nothing more than a relay.



Water cooled DX compressor

Figure 4-18

h. Heating Equipment.

Hot water and steam boilers are used to supply the hot water for heating. A boiler is a heat exchanger that uses heat generated from the burning of fuel to generate the hot water (or steam). The controls for the boilers are usually provided by the boiler manufacturers. However, with the addition of an EMCS, various parameters need to be monitored and, in some cases, controlled. A diagram of a hot water boiler is shown in Figure 4-19.

(1) Control Output (Digital).

Boiler and hot water circulating pump start/stop commands are initiated as digital outputs from the EMCS.

(2) Status Input (Digital).

The boiler status (on/off) is transmitted to the EMCS as a digital input. Supply pump status is monitored with a DP switch and is transmitted to the EMCS as a digital input. Additionally, boiler water level and flame failure safety alarm detection signals are transmitted to the EMCS as digital inputs.

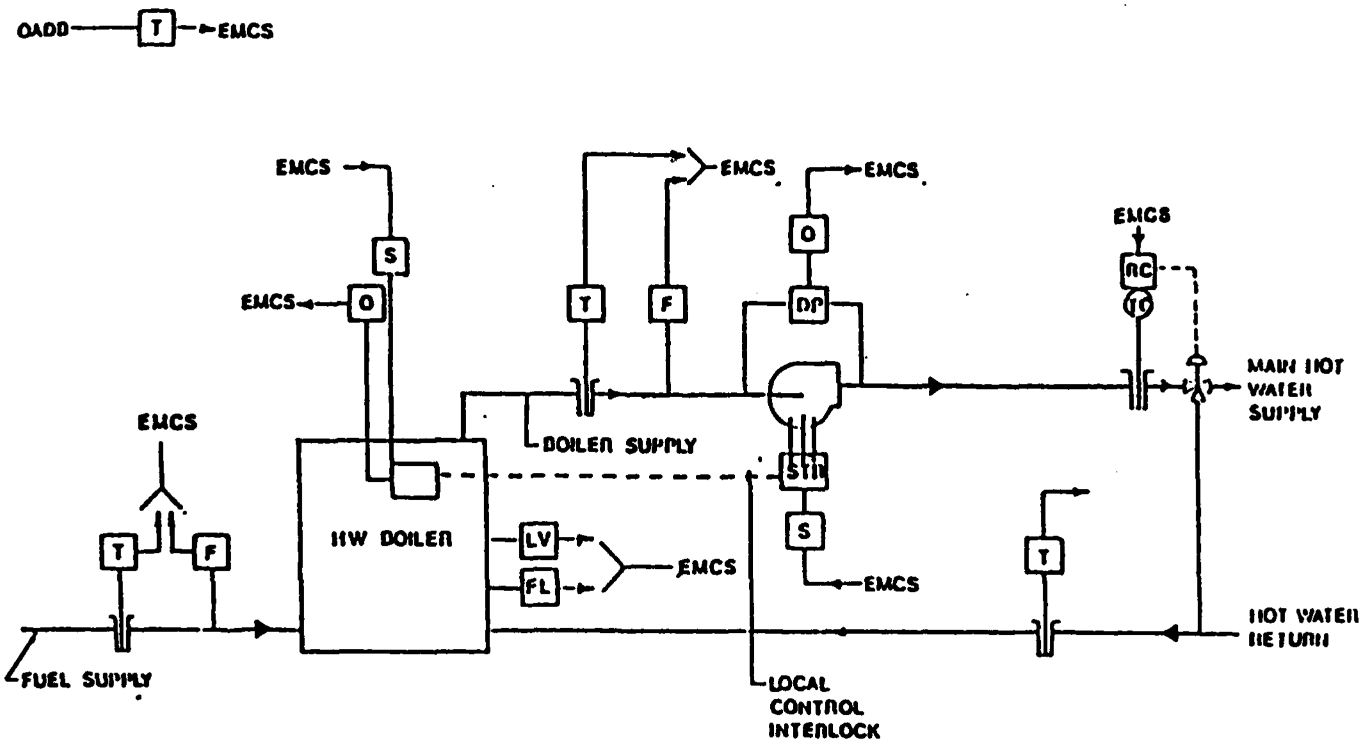

OADB
T
EMCS
EMCS
S
EMCS
O
T
F
EMCS
EMCS
O
DP
EMCS
RC
MAIN HOT WATER SUPPLY
EMCS
BOILER SUPPLY
STR
HW BOILER
LV
FL
EMCS
S
EMCS
T
F
T
HOT WATER RETURN
FUEL SUPPLY
LOCAL CONTROL INTERLOCK

Figure 4-19

(3) Analog Signals (Input).

The analog signals of concern are:

- Fuel flow.
- Hot water supply and return temperatures.
- Hot water supply flow.

(4) Analog Signals (Output).

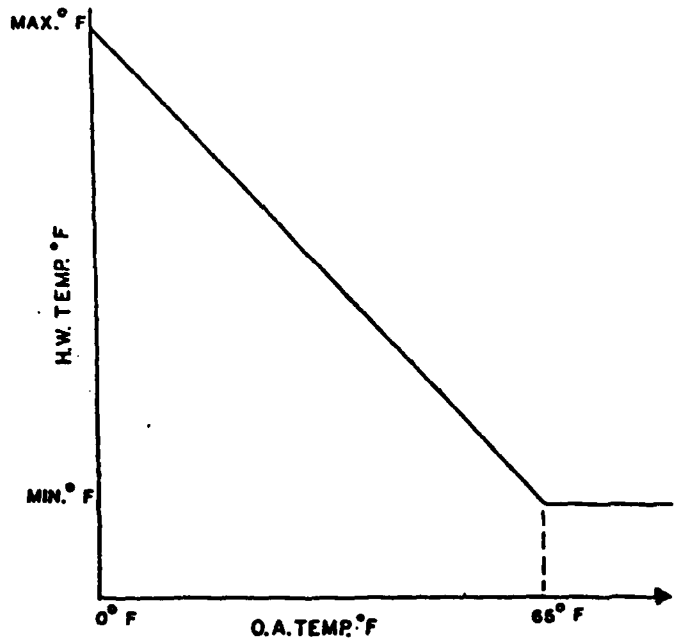
The hot water temperature may be reset to a lower setting as the outside temperature increases. Figure 4-20 shows the reset schedule for this function. Steam pressure can also be adjusted in this manner, if required.

The interface between the EMCS and the hot water temperature controller is handled in the same manner as the chilled water or condenser water reset.

i. Lighting Control.

Lighting control involves scheduled turning on and off of the lighting system in a building on a scheduled basis. The EMCS interface to a lighting panel involves the addition of an EMCS digital output to turn on or off the lights. A feedback signal from the panel is used to inform the EMCS of the status of the lighting system. This interface is shown in Figure 4-21.

OUTSIDE AIR HOT WATER RESET SCHEDULE



HOT WATER OA RESET

HOT WATER HEATING SYSTEMS AND WATER SUPPLY TEMPERATURE IS REDUCED AS THE HEATING REQUIREMENTS DECREASE BECAUSE OF INCREASED OA TEMPERATURES.

Figure 4-20

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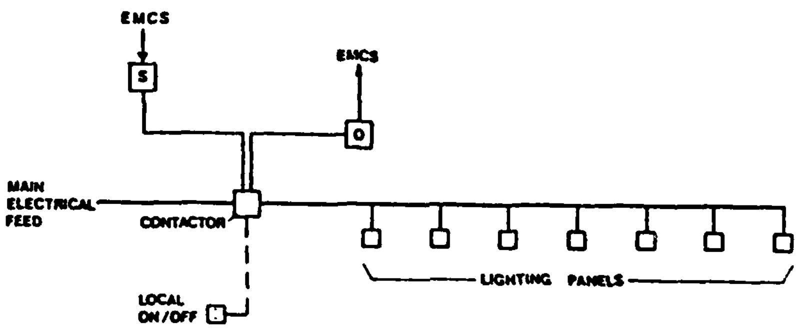
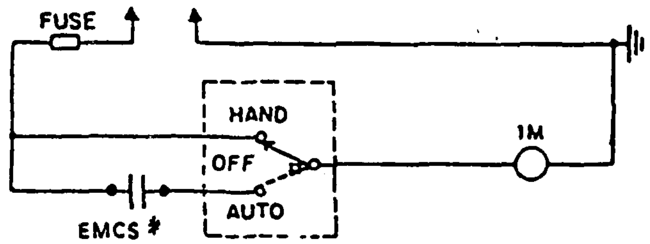




* MAGNETICALLY HELD OR LATCH TYPE CONTACT

HAND-OFF-AUTO SELECTOR

Figure 4-21

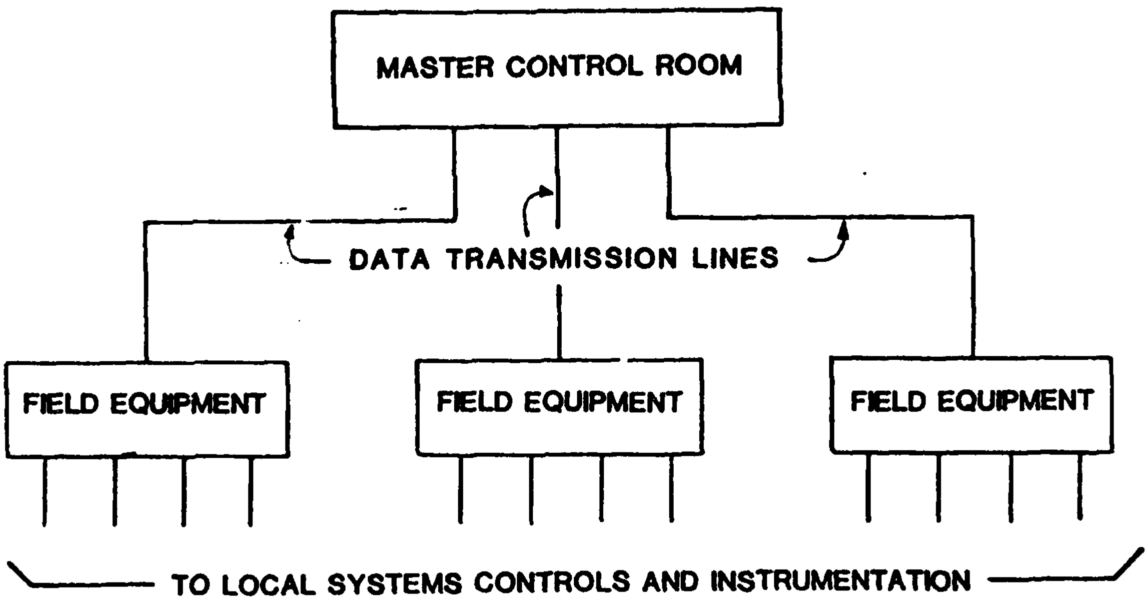
CHAPTER 5

EMCS EQUIPMENT

5.1 General.

This chapter provides a more detailed discussion of EMCS equipment and introduces terminology likely to be encountered during the EMCS inspection period. In reading this chapter, it is helpful to refer to the Tri-Services EMCS Guide Specifications. This reference identifies the physical and operational requirements for equipment and software in large, medium, small and micro EMCS configurations. Appendix "B" provides a list of references with additional background material on EMCS hardware and software.

Figure 5-1 illustrates the basic components of an EMCS that were briefly described in Chapter 2.



BASIC COMPONENTS OF AN EMCS

Figure 5-1

Figure 5-2 lists the primary EMCS equipment associated with each component and indicates whether the equipment is likely to be included in a large, medium, small or micro EMCS. This chart and the subsequent discussion in the chapter is based on the EMCS Tri-Services Specifications.

Figure 5-2: EMCS EQUIPMENT BY SIZE CLASSIFICATION

EQUIPMENT	LARGE	MEDIUM	SMALL	MICRO
FIELD EQUIPMENT:				
Field Interface Device (FID°)	x	x	optional	-
Multiplexer (MUX*)	x	x	optional	-
Intelligent Multiplexer (IMUX)	x	x	x	x
Instrumentation and Controls	x	x	x	x
FIELD SUPPORT EQUIPMENT:				
Portable Diagnostic Device	x	x	x	x
Programming and Service Panel	-	-	-	x
DATA TRANSMISION EQUIPMENT:				
Communications Link Terminations (CLT)	x	x	x	x
Data Transmission Media (DTM)	x	x	x	x
MASTER CONTROL ROOM EQUIPMENT:				
Central Control Unit (CCU)	x	x	x	x
Central Communications Controller (CCC)	x	-	-	-
Failover Controller	x	-	-	-
Operator's Console (color graphic cathode ray tube)	x	x	-	-
Operator's Console (alphanumeric cathode ray tube)	-	-	x	-
System Terminal	x	x	-	-
Real Time Clock	x	x	x	x
Alarm Printer	x	x	optional	-
Logging Printer	x	x	optional	-
Alarm/Logging Printer	-	-	x	-
Mass Storage Devices	x	x	optional	-
Bulk Loading Devices	x	x	x	-
Magnetic Tape Systems	x	x	-	-

°Large/Medium/Small EMCS
*Large/Medium EMCS

5.2 Field Equipment.

EMCS field equipment is located in the vicinity of the equipment being monitored and controlled by the EMCS. Primary components include:

- Sensors and Controls.
- Data Terminal Cabinet (DTC).
- Multiplexer (MUX*) Panels.
- Intelligent MUX (IMUX) Panels.
- Field Interface Device (FID°).
- FID Support Equipment.

a. Sensors and Controls.

Sensors and controls are the actual links between the EMCS and the equipment being monitored and controlled. Chapter 3 presents a detailed discussion of the various types of sensors and controls likely to be encountered in an EMCS installation. The Tri-Services EMCS Guide Specifications establish specific requirements for various types of sensors and controllers used for the EMCS. For example, accuracy requirements are generally specified for sensors while control devices have requirements for operating and release times.

A sensor or control is frequently referred to as a point. As indicated in the EMCS Overview, the total number of points connected to the EMCS is one factor that determines the system size configuration to be used for an EMCS (large, medium, small, or micro).

b. Data Terminal Cabinet (DTC).

The data terminal cabinet is the interface between each FID°/MUX*/IMUX and the points.

According to the Guide Specifications, the DTC must be a separate metallic enclosure and not part of the FID°, MUX* or IMUX. The DTC must have sufficient space for the I/O functions required for each FID°/MUX*/IMUX plus 25 percent expansion capability. The DTC is divided into analog and digital groups, each with separate digital and analog signal wiring raceways.

°Large/Medium/Small EMCS
*Large/Medium EMCS

c. Field Interface Device (FID).

The FID° is a microcomputer - based device which is the principle interface between the sensors/controls and the central control unit. Figure 5-3 shows the primary components of a FID°, which include:

- Microprocessor with memory
- Control panel and indicators
- Digital and analog input/output
- Real time clock
- Battery backup
- Communications interface
- Power supply
- Multiplexer (optional)

The FID° can perform the following functions:

- Collect data from sensors and generate commands to control operating devices.
- Respond to requests from the Master Control Room (MCR) for equipment operating data and status.
- Transmit alarm messages to the MCR.
- Perform calculations on information received from sensors using algorithms stored in the FID° microcomputer.

The FID° controls include:

- Main power switch.
- Control device (switch) to enable and disable communication to the CCU.
- Control device (switch) which forces the local sensors and controls into a failure mode.
- Control device (switch) for exercising FID° and communication link functions (self testing).
- Reset - to initialize CPU operation.

FID° indicators show the following:

- Power is on to the FID°.
- FID° is communicating to the CCU.
- Self test is or is not successful.
- FID° outputs are disabled.

°Large/Medium/Small EMCS

AD-A129 732 ENERGY MONITORING AND CONTROL SYSTEMS INSPECTION GUIDELINES(U) KLING-LINDQUIST INC PHILADELPHIA PA J COSIOL ET AL. DEC 82 NCEL-CR-83.001 N62474-81-C-9379

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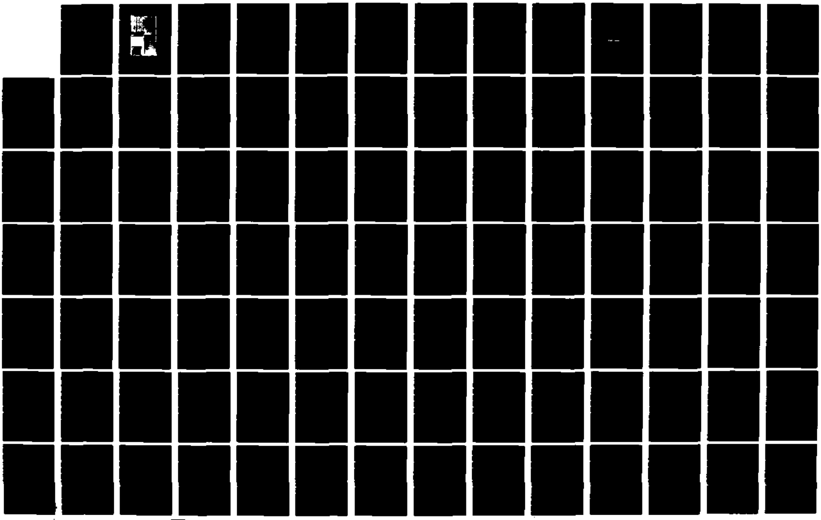
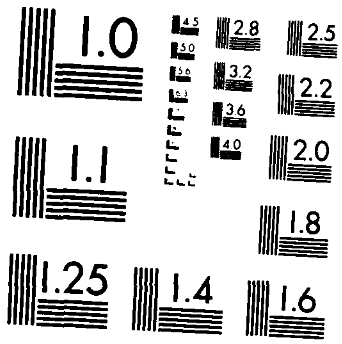
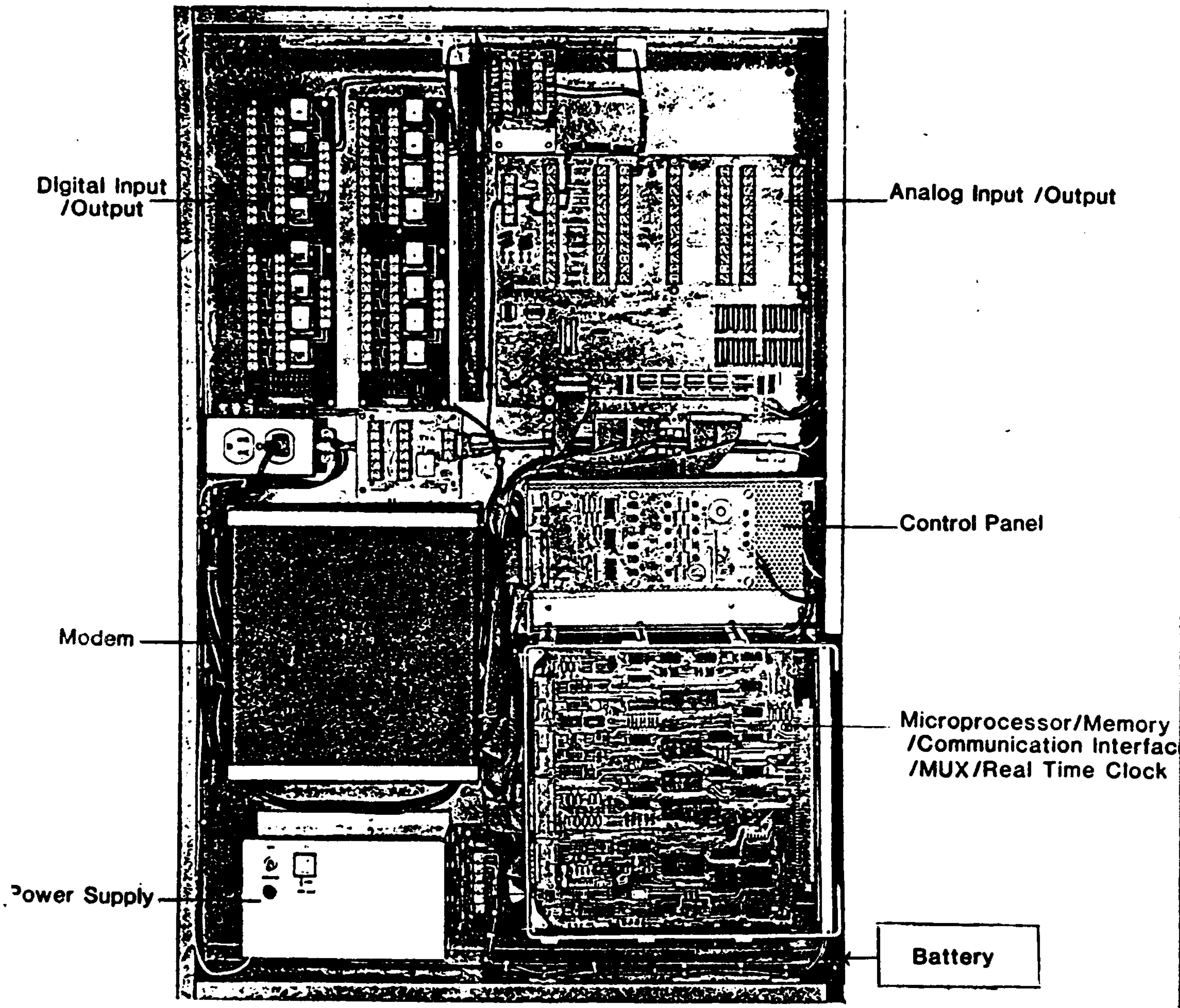




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



FIELD INTERFACE DEVICE
(FID)
Figure 5-3

Source: Oak Adec

The FID° Input/Output functions convert signals from analog and digital sensors into data that is compatible with the FID°. FID output functions convert data from the FID into signals for controls. I/O functions are either located on replaceable circuit boards or are an integral part of the MUX*/IMUX.

The Real Time Clock (RTC) maintains seconds, minutes, and hours as well as days of the week. The real time clock is used by the FID° to determine when FID resident application program events must take place.

All FID°'s are equipped with one hour battery backup for the FID° real time clock and memory (RAM). The FID° can also be equipped with battery backup for the entire FID°, enabling the FID° to continue operation during short term power shortages without degradation of performance. An alarm indication that the FID° is operating under battery back-up is displayed at the operator's console in the Master Control Room. If the FID° goes into a failure mode, the FID° outputs go into a predetermined state that corresponds to the failure modes defined in the contract documents.

The EMCS Guide Specifications require that the FID° contain sufficient spare capacity for future addition of I/O functions. The FID cabinet must conform to NEMA Standards for its indoor or outdoor location. The cabinet has a locking mechanism with the door switch wired to an intrusion alarm point. The alarm point is displayed at the Master Control Room operator's console when it is activated.

d. Multiplexer (MUX) Panels.

The MUX* enables the FID° to communicate with a specific point or group of points using a single pair of transmission media. The MUX contains the identification and addresses of connected points. Under normal operation, the MUX* "polls" each point for the current status or value and stores the information which is then transmitted and processed by the FID°.

The MUX* may be physically located within the FID°. If the MUX is remotely located, it is housed in a locking type cabinet that conforms to NEMA standards for its indoor and outdoor locations. The door switch is wired to an intrusion alarm point similar to the alarm point in the FID°. Regardless of location, the MUX* is fully supervised by the FID°.

MUX* controls include a main power switch, a control to enable and disable communication with the FID°, and a control to disable the MUX* and force the points into a failure mode. The failure mode corresponds to the I/O summary table provided by the contract requirements.

°Large/Medium/Small EMCS
*Large/Medium EMCS

The MUX* may contain a battery backup for short term power shortages with an alarm indicator that the MUX* is operating under battery power. If the MUX* goes into a failure mode, the MUX* outputs go into a predetermined state that corresponds to the failure mode defined in the contractor supplied I/O Summary Table.

e. Intelligent Multiplexer (IMUX) panels.

The intelligent multiplexer (IMUX) performs the same operation as the MUX* except the IMUX only reports data on points that have changed since the last time they were "polled". Also, the IMUX may communicate directly with the CCU if it is only performing monitoring functions.

The IMUX hardware is similar to the MUX* hardware.

f. FID° Support Equipment.

FID° support equipment includes the following:

- PROM programmer (if and where used in the EMCS).
- Portable diagnostic, programming, and bulk loading device.
- FID° Test Set.
- Data environment (DE) simulator.

The PROM programmer in the MCR can place programs into PROM chips and erase programs which can be placed in the FID° and executed. The PROM programmer operation is controlled at the CCU via the terminals located in the MCR.

The portable diagnostic, programming, and bulk loading device is designed to run hardware and software diagnostics and check out various functions of the FID°/MUX*/IMUX. Factory and Performance Verification Tests require the use of a portable diagnostic device for some of the tests on the FID°/MUX*/IMUX.

The FID° Test Set consists of a FID° and a data environment (DE) simulator. This device is used for developing and testing software in the Master Control Room. The DE simulator generates the values or status of each type of sensor and control used by the system using switches, lights, meters and potentionmeters.

°Large/Medium/Small EMCS
*Large/Medium EMCS

5.3 Data Transmission Media and Equipment.

a. Data Transmission Media.

The Data Transmission Media (DTM) allows data transmission to take place between the FID°/MUX*/IMUX and the CCU. According to the Guide Specifications, no single DTM can service more than a specified maximum percentage of the points.

Typical types of DTM include:

- Twisted pairs.
- Coaxial cable.
- Voice grade lines.
- Power line
- Radio frequency
- Fiber optics

Twisted pairs consist of two insulated conductors twisted together to minimize signal interference. In most cases, twisted pairs are permanently wired between the communicating equipment.

Voice grade lines or telephone lines are twisted pair circuits that must conform to standards established by Bell Telephone Company with characteristics similar to twisted pairs.

Coaxial cable consists of a center conductor surrounded by a shield which protects against electromagnetic interference. Some coaxial lines require signal repeaters to maintain the signal quality when transmitted over long distances. For example, repeaters are typically installed every 2,000 feet in coaxial cable systems.

Electrical power lines can be used to transmit data which is converted to a low power radio frequency (RF) signals and superimposed on the power lines. Radio frequency couplers must be installed across transformers if the RF signal must travel across transformers. Radio frequency (RF) can be used to transmit data over the air waves. The RF system requires installation of radio receivers and transmitters. Modems must also be installed at each receiver transmitter location. A modem (modulator-demodulator) changes radio frequency signals into signals that are compatible with the EMCS equipment. The use of radio frequency signals has to be coordinated with the communications officer to avoid potential interference from other existing or planned RF facilities.

°Large/Medium/Small EMCS
*Large/Medium EMCS

Fiber optics is a recent development in data transmission methods. Data is transmitted through transparent fibers using light. Fiber optics can handle high data transmission rates, and signal attenuation is significantly lower than on coaxial cable, twisted pairs, and voice grade lines. For example, fiber optics may require repeaters at 3 to 6 mile intervals, while coaxial cable may require repeaters at 2,000 foot intervals.

b. Data Transmission Equipment.

As briefly mentioned in the discussion on DTM, additional equipment is generally required for data transmission. Such equipment may include:

- Modems.
- Line drivers.
- Repeaters.
- Radio frequency terminals.
- Optical terminals.

Modems convert digital data into signals that are compatible with the data transmission media. The Guide Specifications require modems to be compatible with Bell System standards.

Line drivers provide sufficient output power to transmit digital signal over short distances using metallic circuits such as twisted pairs or coaxial lines. A typical application of a line driver would be for communication between the FID and the MUX.

A repeater restores signals to their required level and quality so that excessive signal attenuation and distortion does not occur over long distance transmission. Repeaters are typically required for coaxial cable and fiber optics.

Radio Frequency (RF) terminal units are located at the points where data is transmitted and received. These terminals convert digital data to audio signals that can be carried on a RF carrier wave. RF receiver/transmitter terminal units convert radio frequency signals back to the original data signal.

5.4 Master Control Room Equipment.

The Master Control Room (MCR) is the area containing the Central Control Unit (CCU), operator's console, system terminal, mass storage devices, printers, and other peripheral devices required for EMCS operation. A schematic of typical MCR equipment for a large EMCS. is illustrated in Figure 5-4. The MCR is generally located in a clean environment near the maintenance, service, and operations center.

Environmental conditions in the MCR are typically maintained between 60 and 85 degrees F, and between 20 and 80 percent relative humidity (noncondensing). Environmental requirements for the actual EMCS job are identified in the contract documents. The MCR must be adequately soundproofed to attenuate noise from printers, equipment fans, and other noise generating devices. Lockable space should be provided for storage of test equipment, spare parts, and other auxiliary equipment. Master control room furnishings must be provided in accordance with the contract documents. Printers and operator consoles may be segregated into separate, but adjacent, areas for noise control. Fire protection for the MCR equipment must be provided as required by using the agency's current guidelines.

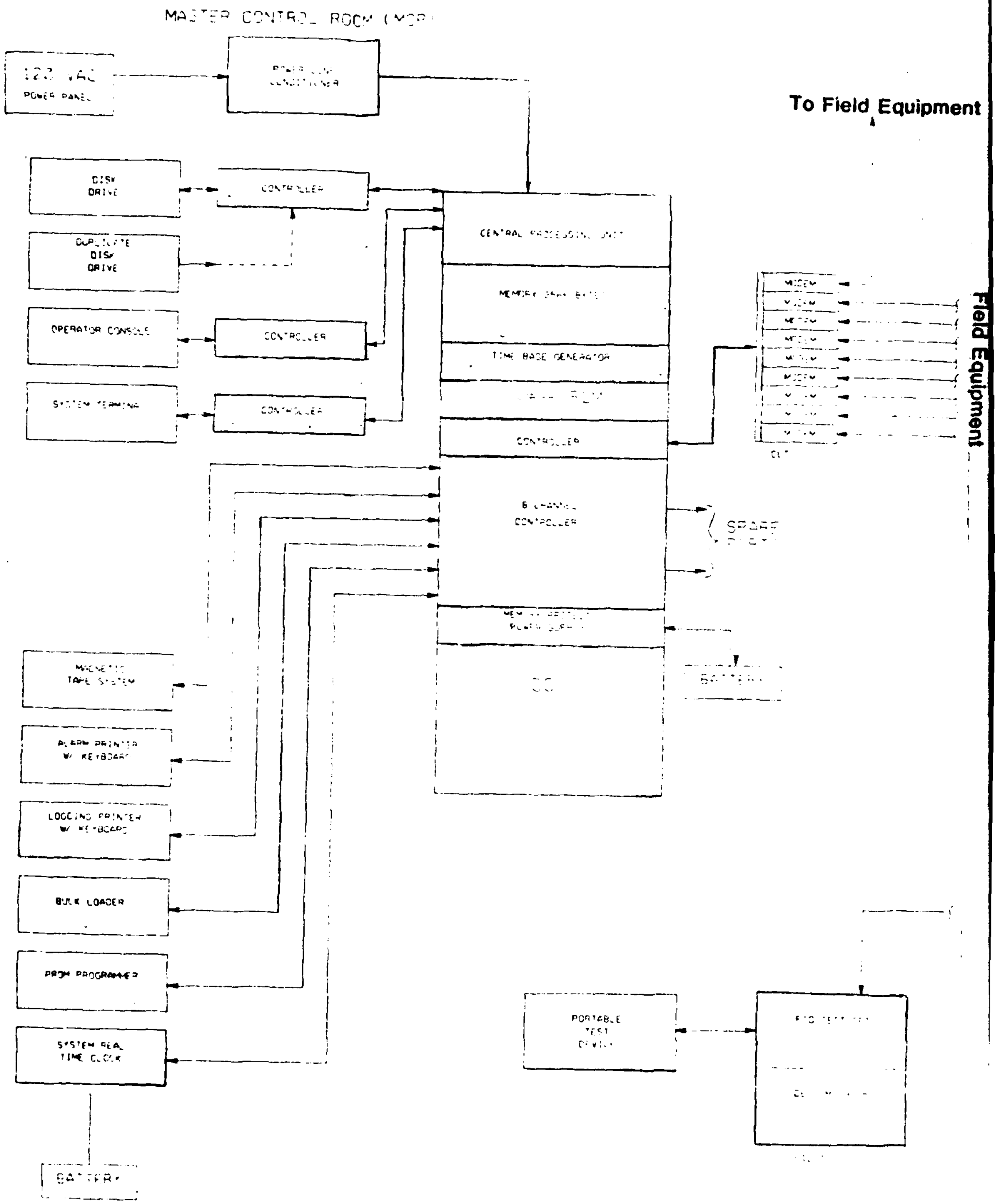
a. Central Control Unit.

The Central Control Unit (CCU) is the brains of the EMCS. It is the computer that performs the overall arithmetic and logical operations to execute the monitoring and control functions. Specific CCU functions include:

- Controlling system operation and communication.
- Controlling display and printing devices.
- Performing all automated energy management functions not resident to the FID.
- Performing arithmetic computations.
- Responding to operator commands and requests.
- Alarm reporting.
- Logging events.
- Storing information and retrieving stored data.
- Report generation.

The CCU has battery backup to protect volatile memory during short term power failures and fluctuations. Volatile memory contents would otherwise be lost during power failures requiring restart of the system. The CCU must have battery back-up for the RTC for a minimum of 72 hours.

The set of instructions that enable the CCU to perform its functions are called programs. Programs are stored in the computer's memory and mass storage devices.



SCHEMATIC OF MASTER CONTROL ROOM EQUIPMENT
FIGURE 5-4

The CCU is a single manufacturer's standard unmodified computer. It should not contain any hardware components that would prevent the computer from receiving service through a standard maintenance and service contract from the computer manufacturer.

The CCU contains sufficient memory to execute all the required programs, plus a specified amount of memory available for other EMCS related uses. The CCC, in a large system, can take over the function of the CCU when the CCU fails.

b. *Central Communications Controller (CCC).*

The CCC used in large EMCS, controls the communication between the CCU and the FID°/IMUX. The CCC reformats and buffers data between the FID°/IMUX and the CCU. The CCC is also designed to detect transmission errors and to request retransmission from the FID or IMUX. If the number of retransmission attempts exceeds an allowed maximum, the CCC will close down the communication link to the particular device.

The CCC can take over some of the functions of the CCU when the CCU fails. The CCC volatile memory has battery back-up for short term power failures. The CCC volatile memory and TBG also has battery back-up for a minimum of 30 minutes.

c. Failover Controller.

The failover controller transfers the functions of the CCU to the CCC in a large EMCS. This controller may be a hardware device, a program or a combination of both.

d. Mass Storage Devices.

The multitude of information required for EMCS operation necessitates the use of storage devices in addition to the main memory of the computer. The most common types of mass storage devices are magnetic disks and tapes.

There are two major types of magnetic disk storage systems; "hard" disks, which are high capacity magnetic disks similar in shape to a phonograph record. The "floppy" disks are smaller than hard disks with less storage capacity. Magnetic disk systems of both types are used to store applications programs, system data, and the operating system software for the computer. The operating system is used to control the basic operations of the computer. Smaller EMCS are likely to use the floppy discs, while larger systems are likely to use hard disks.

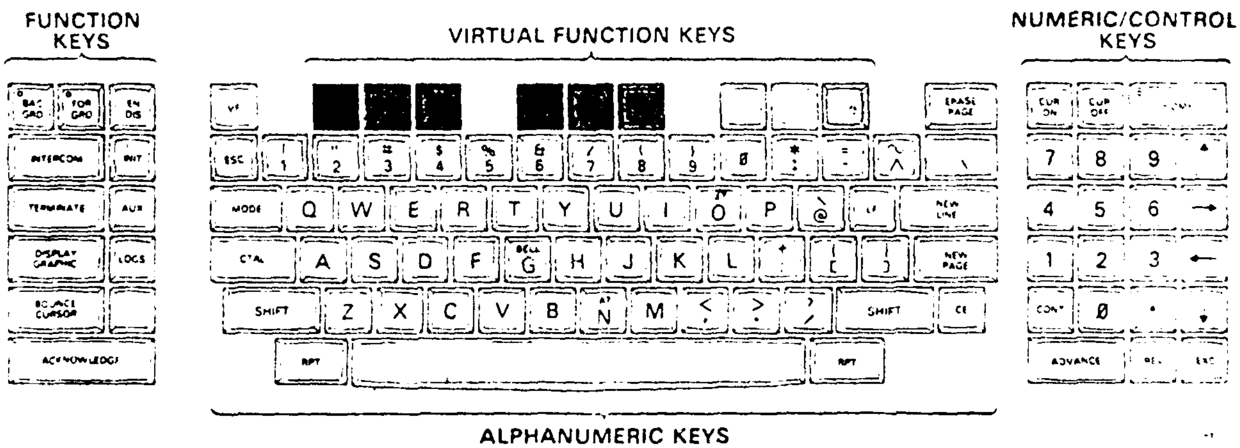
°Large/Medium/Small EMCS

d. Operator's Console.

The operator's console enables the operator to communicate with the EMCS. This equipment includes:

- Keyboard.
- Cathode-ray Tube (CRT).

The keyboard enables the operator to issue commands and request information from the computer. Typically, the keyboard resembles a standard typewriter keyboard, but it may also include special keys that accomplish specific functions. For example, there may be a "cancel" key to cancel a command, or a "help" key that requests more information about a specific command. Figure 5-5, is a schematic of a typical keyboard.



GRAPHIC OPERATOR'S TERMINAL KEYBOARD

Source: Honeywell

Figure 5-5

The CRT provides a visual display of information on the monitored and controlled equipment. This display may be alphanumeric (words and numbers), graphic, or both. Figure 5-6 shows an alphanumeric display for an alarm on a point (the supply fan in a fan system) that has changed state (from on to off). This display shows the date, time of alarm, point identification, and data on the points in the fan system (including the status of the supply fan). Figure 5-7 shows a graphic display of a [illegible] system, showing the approximate location of the points, the data associated with each point, and general information (date, time, name of the system, etc.). Large and medium EMCS use color graphic operator consoles while small EMCS use black and white CRT's.

e. Printer.

The printer provides permanent records of information on the monitored and controlled points. The Guide Specifications require separate alarm and logging printers for large and medium EMCS. Small systems use a single printer for alarm and logging information. The logging printer prints out all information that is not generated as a result of an alarm, such as equipment status reports or operator requested information on equipment.

f. System Terminal.

The system terminal is used for computer system operation and maintenance and is used to enter programs into the computer and analyze (debug) the program logic. The system terminal is an alphanumeric black and white CRT.

g. Remote Terminals.

Some EMCS installations require remote terminals, color graphic CRT's, alphanumeric CRT's, and printers. These terminals are either wired directly to the CCU or communicate to the CCU through dedicated MODEMs or line drivers over suitable DTM.

```
MONDAY          6-09-80       12:00            75F/53RH            WFD
------------------------------------------------------------------------
OFF ALARM                     12:00  CALL MAINTENANCE DEPT. EXT. 2234
          STUDENT UNION MEZZANINE FAN SYSTEM - SUPPLY FAN

STUDENT UNION MEZZANINE FAN SYSTEM

  1 NM   82 DEG:  RETURN AIR TEMPERATURE
  2 NM      SMO:  SMOKE ALARM
  3 NM   20 PCT:  OUTDOOR DAMPER ADJUST
  4 NM   75 DEG:  OUTDOOR AIR TEMPERATURE
  5 NM   80 DEG:  MIXED AIR TEMPERATURE
  6 NM      MNT:  FILTER ALARM
  7 NM      OFF:  SUPPLY FAN
  8 NM   62 DEG:  COLD DECK TEMPERATURE
  9 NM   80 DEG:  HOT DECK TEMPERATURE
```

Figure 5-6

```
MONDAY          6-09-80       12:00            75F/53RH            WFD
------------------------------------------------------------------------
OFF ALARM                     12:00  CALL MAINTENANCE DEPT. EXT. 2234
          STUDENT UNION MEZZANINE FAN SYSTEM - SUPPLY FAN
------------------------------------------------------------------------
```

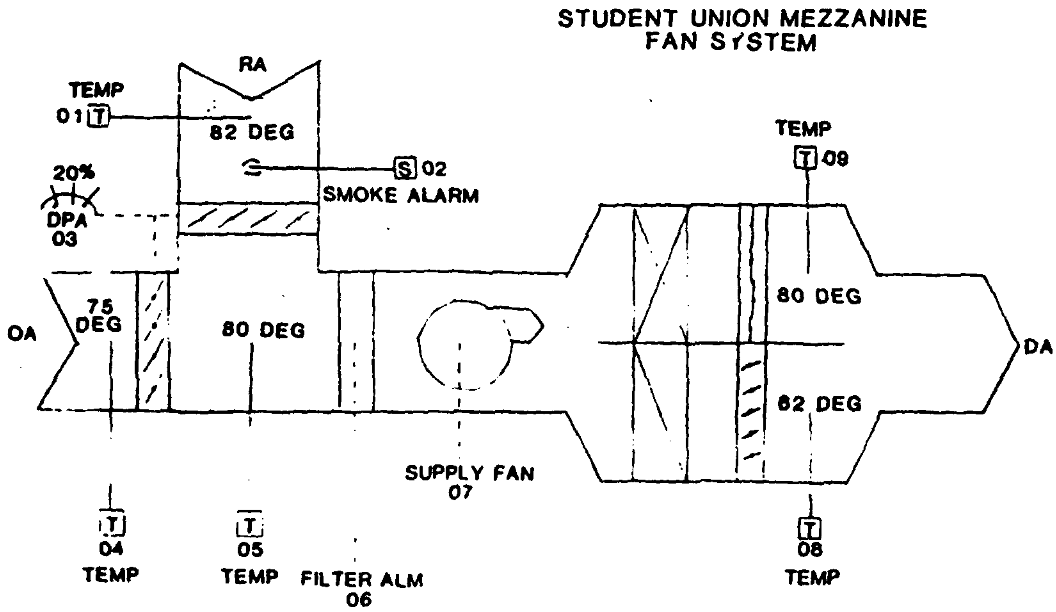


Figure 5-7

Source: Honeywell

CHAPTER 6

EMCS SOFTWARE

6.1 General.

Software is a term used to describe a collection of programs (instructions) which control the operation of the computer. Changes in software can cause the computer to perform different operations. New software is frequently added to existing software to expand or modify the capabilities of the computer.

In an EMCS, there are three basic types of software:

- System software.
- Command software.
- Application software.

6.2 System Software.

System software refers to the programs that enable the computer to perform such basic functions as system start-up, diagnostics and control of peripheral devices. This software is generally provided by the computer manufacturer. The EMCS Guide Specifications indicate that system software include the following functions:

- System start-up (or boot-strap).
- Management of peripheral devices.
- Ability to schedule tasks in accordance with priorities.
- File management.
- Ability to understand certain types of programming languages.
- Diagnostic capabilities.
- Ability to accept a new program and perform tasks in accordance with program instructions.
- Ability to control operator access to system software based on the type of operator (example - inexperienced versus experienced operator).

System start-up or boot-strap is a procedure for bringing the computer into an operational mode (bringing the computer on-line). Boot-strap procedures are provided by the computer manufacturer. After the computer has been started up, other programs are loaded from mass storage into main memory. Programs cannot be carried out (executed) unless they are loaded into the main memory.

File management procedures enable the computer to develop and locate data locations in various storage devices for data and program storage and retrieval. When stored data or programs are needed, the file management procedures enable the computer to retrieve the information for use.

Diagnostic programs enable the computer to check out a hardware device or help locate a malfunction in the device. Diagnostics are also used to check out software and locate errors (or bugs) in the programs.

System software is described in more detail in the EMCS Guide Specifications.

6.3 Command Software.

Command software refers to the programs that enable the operator to communicate (man-machine interface) with the EMCS using English language words and acronyms. The contractor also provides commands in abbreviated mode. This software is designed so that the operator does not need training in data processing or programming to issue commands to the system.

According to the EMCS Guide Specifications, the machine must prompt the operator for input. For example, the system may prompt the operator by displaying a "menu" of command options available to the operator (see Figure 6-1).

The EMCS Guide Specifications list the command software functions required for an EMCS. These functions include:

- Explanation of each command that can be used by the operator.
- Index of all available commands.
- Commands to define and modify all physical parameters and constraints assigned to any point in the field.
- Commands to start up or shut down equipment.
- Commands to request reports.
- Commands to request graphic displays of monitored and controlled equipment.
- Identification and description of alarms.
- Ability to control operator access to specified command software based on the type of operator (example - experienced versus inexperienced operator).

6.4 Application Software.

Application software programs perform all the functions described in the Input/Output Summary Tables included in the contract. These programs are designed to improve equipment operating efficiency and conserve energy.

MENU OF OPTIONS

COMMAND	COMMAND
HELP	Startup Equipment
Initiate Reports	Shutdown Equipment
Graphic Display	Enable FID/MUX
Time Scheduling	Disable FID/MUX
Display Points	Define Point
Change Analog Limits	Change password
Adjust Set Points	

ENTER COMMAND: HELP

The EMCS Guide Specifications provide a description of the following application programs:

- Command priorities.
- Analog commands.
- Alarms.
- Calculated point.
- Analog monitoring.
- Analog totalization.
- Energy totalization.
- Reports.
- Data environment restart.
- Prediction software.
- Time programs.
- Event programs.
- Scheduled start/stop.
- Optimum start/stop.
- Duty cycling.
- Demand limiting.
- Day/night setback.
- Economizer control.
- Enthalpy control.
- Ventilation and recirculation.
- Hot deck/cold deck temperature reset.
- Reheat coil reset.
- Boiler optimization.
- Hot water OA reset.
- Chiller optimization.
- Chiller water temperature reset.
- Condenser water temperature reset.
- Chiller demand limit.
- Electrical system control programs.

<u>Command Priorities.</u> Enables the operator to assign priorities to application programs so that a program of lower priority does not interfere with a higher priority program for equipment control. For example, a program to limit electric demand is generally given a higher priority than a program to start and stop equipment.

Analog Commands.	Adjusts the control point adjustment on a controller from one set point to another, or provides position adjustment to the equipment.
Alarms.	Determines whether the digital or analog point is in an alarm condition.
Calculated Point.	Computes a value from data provided by any combination of analog and digital points. The resulting value is called a calculated point and has all the properties of a real point (such as identification, parameters and alarms).
Analog Totalization.	Totalizes analog values over a time period specified by the operator.
Energy Totalization.	Calculates heat energy in BTU's for each energy source consumed by specified mechanical systems. Also totalizes the calculated BTU's over a time period specified by the operator.
Reports.	Provides standard report generation capability. Such reports may include: . Electrical power utilization summary. . Alarm summary. . Summary of disabled points (lockout summary). . Analog limit summary. . Equipment run-time. . Cooling tower profiles. . Electrical peak demand prediction. . Optimum start-stop. . Summary of points out of service. . Summary of all points.
Data Environment Restart.	Enables the computer to restart all equipment and restore all loads to the proper state after a power failure.

Prediction Software.	Programs that predict future values on the basis of historical values.
Time Programs.	Programs which are initiated on the basis of time (such as time of day and/or day of week).
Event Programs.	Programs which are initiated on the basis of an event (such as a change in outdoor air conditions).
Extended Service Programs.	Enable the operator to extend the timed schedules of equipment.
Scheduled Start/Stop.	Starting and stopping equipment based on time of day and day of week. Day of week includes weekdays, weekends, and holidays.
Optimum Start/Stop.	Automatically starts and stops the system on a sliding schedule based on the thermal inertia of the structure, the capacity of the HVAC system to either increase or reduce space temperatures, and outside air (OA) conditions.
Duty Cycling.	Shutting down mechanical/electrical equipment for predetermined periods of time during normal operating hours. Systems are generally cycled off for some fixed period of time, typically 15 minutes, out of each hour of operation. The off time period and its frequency are operator adjustable. The off time period can be automatically increased or decreased depending on space conditions.
Demand Limiting.	Stopping electrical loads to prevent demand from exceeding an electrical demand peak value (target). When the predicted demand peak approaches preset limits, predetermined scheduled electrical loads are shut off on a priority basis to reduce the connected load before the peak is exceeded.

Day/Night Setback.	Reduces the energy required for heating or cooling during unoccupied hours by lowering the heating space temperature set point or raising the cooling space temperature set point.
Economizer Control.	Utilizes outside air (OA) to reduce the building's cooling requirements when the OA dry bulb temperature is less than that of the return air from the space. This program cannot be used where humidity control is required.
Enthalpy Control.	Utilizes outside air (OA) to reduce the building's cooling requirements when the enthalpy (total heat content) of the OA is less than that of the return air from the space.
Ventilation and Recirculation.	Controls the operation of the OA dampers when the introduction of OA would impose an additional thermal load during warm-up or cool-down cycles prior to occupancy of the building.
Hot Deck/Cold Deck Temperature Reset.	Selects the zone with the greatest heating and cooling requirements, and establishes the minimum differential between the hot and cold deck temperature which will meet the space requirements.
Reheat Coil Reset.	Selects the reheat coil with the lowest discharge temperature or reheat coil valve nearest to the closed position (the zone with the least amount of reheat required) and resets the cold deck discharge temperature upward until the valve to the reheat coil with the lowest demand discharge is closed.
Boiler Optimization.	Selects the most efficient boiler(s) to satisfy the heating load.
Hot Water OA Reset.	Reduces water supply temperature as the heating requirements decrease because of increased OA temperatures.

Chiller Optimization.	Selects the chiller or chillers required to meet the load with the minimum energy consumption.
Chiller Water Temperature Reset.	Resets chilled water temperature upward without exceeding the space temperature requirements.
Condenser Water Temperature Reset.	Resets the condenser water temperature downward when OA wet bulb temperature will produce lower condenser water temperature.
Chiller Demand Limit.	Limits the amount of chiller capacity available for cooling by reducing the maximum cooling capacity in fixed increments and therefore, limiting the energy consumption.
Electrical System Control Programs.	Controls electrical systems such as lighting systems by turning on and off electrical circuits based on the time of the day and the day of the week.

6.5 Data Base.

The data base contains information on all points in the EMCS, including:

- Identification.
- Location.
- FID°/MUX*/IMUX channel address.
- Operating parameters.
- Constraints.
- Failure Mode.

This information is essential to the operation of the applications programs. Information on the points such as identification, location, operating parameters, constraints and failure mode, is provided by the Government on data entry forms submitted by the contractor. According to the EMCS Guide Specifications, the data entry forms must be returned to the contractor not later than 90 days prior to the contractor's need date.

°Large/Medium/Small EMCS
*Large/Medium EMCS

CHAPTER 7

PROJECT SCHEDULING

7.1 General.

An EMCS project consists of a number of events that must take place in a logical sequence if the project is to be successfully completed. This Chapter presents a typical sequence of events for an EMCS project and provides examples of scheduling requirements for specific events based on the Guide Specifications.

A project schedule is a very useful tool for the inspector because it enables the inspector to verify that tasks are being accomplished and submittals delivered in accordance with contract requirements.

7.2 Sequence of Events.

Figure 7-1 provides a typical sequence of the major events that take place from the time of the Contract Award to the successful completion of the Performance Verification Tests (PVT), Endurance Tests and correction of project related deficiences (punch list). Some of the events described below must take place within a specified number of days in accordance with the contract requirements. These events include:

- First review.
- Contractor submission of existing controls report.
- Second review.
- Contractor submission of Factory Test plans and procedures.
- Contractor notification of Phase I Training.
- Contractor notification of the Factory Test date.
- Contractor submission of Factory Test results.
- Contractor submission of PVT and Endurance Test Plans and Procedures and draft operations and maintenance manuals.
- Contractor notification of the Performance Verification Test date.
- Contractor submission of PVT and Endurance Test results.
- Contractor notification of Phase II Training.
- Contractor notification of Phase III Training.
- Contractor submission of Seasonal Endurance Test Plans and Procedures.
- Contractor notification of Seasonal Endurance Test date.
- Contractor submission of the Seasonal Endurance Test results.

FIGURE 7-1 - SEQUENCE OF EVENTS

ACTIVITY			
1. Contract Award (CA)	o		
2. Preconstruction Conference	->		
3. First Review	->		
4. Second Review	------->		
5. #Existing Controls Report Submission	---->		
6. #Shop Drawings Submission	------->		
7. Government Corrections to Existing Controls	---->		
8. Non-EMCS Equip. Modifications	-------------------	-------->	
9. Field Sensors & Controls Installed	-------------------	-------->	
10. #Factory Test Plans & Proc. Submission	--->		
11. Notification of Factory Tests	-->		
12. Factory Tests		o--->	
13. #Factory Test Results Submission		--->	
14. Phase I Training		--->	--->
15. Field Equipment Installation		-------->	
16. Master Control Room Installation		---->	
17. Gov't DTM & Equipment Testing	-------------------------------	--------------->	
18. Contr. DTM & Equip. Installation & Test.		-------------->	
19. #DTM Test Results Submission		--->	
20. #Data Entry Forms Submission	---------------	---->	
21. Data Entry Forms Completed by Gov't.		---------->	
22. Field Equipment & Software Checkout		----->	
23. MCR Hardware/Software Checkout		--->	
24. Contractor Field Testing		--->	
25. #Field Test Results Submission		--->	
26. #Performance Verification Test Plans and Procedures Submission		--->	
27. Notification of Performance Verification Test		-->	
28. Performance Verification Tests		-->	
29. #Performance Verification Test Results Submission			-->
30. Notification of Endurance Tests		--->	
31. Endurance Test			o-->
32. #Endurance Test Results Submission			--->
33. #O&M Manuals Submission			--->
34. Phase II Training			--->
35. Phase III Training			--->
36. Warranty (after Acceptance)			--------------->
37. Maintenance &Service(after Acceptance)			--------------->
38. #Seasonal Endurance Tests			--->
39. #Seasonal Endurance Test Results Submission			--->
Key Events:	CONTRACT AWARD	FACTORY TEST	ENDURANCE TEST

#Contractor's Submittals

Since the requirements of each project may vary, it is important that the inspector refer to the contract documents to verify that the required events and their timing have been included in an overall project schedule.

The following pages provide a brief description of each event in Figure 7-1. Some examples of scheduling requirements are also provided for selected events based on the Tri-Services Guide Specifications for large EMCS. More detailed discussions of the events and the inspector's role in these events are presented in the chapter on Inspection.

Those activities identified in Figure 7-1 by a "#" sign indicate a requirement for submittal by the contractor.

(1)	Contract Award.	Presented by the Contracting Officer to the contractor.
(2)	Preconstruction Conference	Review of contractural requirements and administrative matters.
(3)	First Review.	The Government meets with the contractor for a functional review of the contract requirements of the proposed system, to review the project schedule and to establish action items for the second review. (Example - Large EMCS: within 90 days of Contract Award.)
(4)	Second Review.	The Government meets with the contractor to review the contractor's approval in meeting the project requirements. During this meeting, action items from the first review are addressed. (Example - Large EMCS: within 150 days of Contract Award.)
(5)	Existing Controls Report.	Submitted by the contractor prior to the installation of field sensors and controls. This report identifies existing controls to be incorporated in the new system. This report also identifies nonfunctioning control devices and indicates the cost to correct the nonfunctioning items. (Example - Large EMCS: within 120 days of Contract Award.)
(6)	Corrections to Existing Controls.	Performed by the Government after receipt and verification of the existing controls report from the contractor.

(7)	Shop Drawings.	Submitted by the contractor and approved by the Government prior to the Factory Tests.
(8)	Non-EMCS Equipment Modifications.	Performed by the contractor after the shop drawings are submitted and approved for the required equipment. Non-EMCS equipment refers to all equipment specified in contract documents but not in the EMCS section of the specifications.
(9)	Field Sensors and Controls Installation.	Performed by the contractor after the shop drawings are approved for the specified devices.
(10)	Factory Test Plans and Procedures.	Submitted by the contractor to the Government for approval prior to the factory test. (Example - Large EMCS: Test plans submitted at least 150 days prior to factory test. Test procedures submitted at least 90 days prior to factory test.)
(11)	Notification of Factory Test Date.	The contractor notifies the Government of the proposed Factory Test date so that the test date can be mutually agreed upon by all parties involved. (Example - Large EMCS: At least 21 days prior to the Factory Test.)
(12)	Factory Tests.	Take place after the following activities are completed: • First and second review. • Shop drawings are approved by the Government. • Factory test plans and procedures are submitted and <u>approved</u> by the Government.
(13)	Factory Test Results.	Submitted by the contractor to the Government after the completion of the tests (successful or unsuccessful) with all equipment notations and signatures of all personnel responsible for conducting and witnessing the tests. (Example - Large EMCS: Test results are submitted to the Government within 7 days of test completion.)

(14) Phase I Training.	Some of the Phase I training is conducted at the factory or job site as required by the contract specifications. Additional Phase I Training is provided by the contractor at the job site during the Endurance Test.
(15) Field Equipment Delivery and Installation.	Performed by the contractor <u>after</u> successful completion of the Factory Tests.
(16) Master Control Room Equipment Installation.	Performed by the contractor <u>after</u> successful completion of the Factory Tests.
(17) Testing of Government furnished Data Transmission Media (DTM) and Equipment	DTM and DT equipment is made available to the contractor so that the contractor can test the Government furnished DTM and equipment after the "Notice to Proceed" and prior to the contractor's need date.
(18) Installation and Testing of Contractor Furnished DTM and Equipment.	DTM and equipment are installed and tested by the contractor prior to the contractor's need date.
(19) DTM Test Results.	Provided for Government and contractor furnished DTM and equipment and submitted by the contractor to the Government prior to the Performance Verification Test.
(20) Data Entry Forms.	Submitted by the contractor to the Government prior to the contractor's need date with sufficient time for the Government to complete the forms for the EMCS data base. (Example Large EMCS: Submitted 90 days prior to the Contractor's need date.)
(21) Completion of Data Entry Forms.	Completed by the Government prior to the contractor's need date.
(22) Field Equipment and Software Check Out.	Conducted by the contractor prior to field equipment calibration and after master control room equipment installation.

(23) Operational Check-out of MCR Hardware and Software.	Conducted by the contractor after field equipment checkout and after MCR equipment and software installation. This event includes field data entry and generation of graphics.
(24) Contractor's Field Testing.	Conducted by the contractor prior to the Performance Verification Tests. During the field testing all equipment and software operation is calibrated and checked as an integrated system. The contractor also performs grounding tests at this time in accordance with the contract requirements. The operation of the transmission media and equipment is verified along with the field equipment with the required accuracy from sensor to display at the operator's console.
(25) Contractor's Field Test Results.	Submitted by the contractor to the Government after the field tests are completed and prior to the Performance Verification Tests.
(26) Performance Verification Test Plans and Procedures. Draft Operations and Maintenance Manuals.	Submitted by the contractor to the Government after the Factory Tests and prior to the Performance Verification Tests. (Example - Large EMCS: Test plans submitted at least 150 days prior to the PVT. Test procedures submitted no later than 90 days prior to PVT.) The contractor must also provide draft Operations and Maintenance Manuals with the Test Plans and Procedures.
(27) Notification of the Performance Verification Test Dates.	Submitted by the contractor to the Government prior to the Performance Verification Test and after completing the contractor field testing. The test dates are mutually agreed upon by all parties involved. (Example - Large EMCS: Test plans are submitted at least 21 days prior to the PVT.)
(28) Performance Verification Tests.	Conducted by the contractor and witnessed by the inspector at the scheduled date.
(29) Performance Verification Test results.	Submitted by the contractor to the Government after completion (successful or unsuccessful) of the test. (Example - Large EMCS: Test results submitted within 7 days of the completed test.)

(30) Notification of the Endurance Test Date.	Submitted by the contractor to the Government prior to the Endurance Test and after completing all other Performance Verification Tests. The test date is mutually agreed upon by all parties involved. (Example - Large EMCS: Notify Government at least 21 days prior to Endurance Test.)
(31) Endurance Test.	Conducted by the contractor after the successful completion of all other Performance Verification Tests.
(32) Endurance Test Results.	Submitted by the Contractor to the Government after successful completion of the Endurance Test. (Example - Large EMCS: Submit results within 7 days of completed test.)
(33) Operations and Maintenance Manuals.	Submitted by the contractor to the Government after the successful completion of the Endurance Test.
(34) Phase II Training.	Conducted by the contractor at the job site after successful completion of the Endurance Test.
(35) Phase III Training.	Conducted by the contractor at the job site, after Phase II training is completed.
(36) Warranty Period.	Begins immediately after Government acceptance of the EMCS (after the successful completion of the Endurance Test and completion of all outstanding "punch list" items), and remains in effect for a minimum of one year.
(37) Maintenance and Service.	The EMCS Maintenance and Service is provided by the contractor after the successful completion of the Endurance Test for a period called for in the contract requirements.
(38) Notification of Seasonal Endurance Test.	Submitted by the Contractor to the Government prior to the Seasonal Endurance Test. The test dates are agreed upon by all parties involved. (Example - Large EMCS: Notify the Government at least 21 days prior to Seasonal Endurance Test.)

(39) Seasonal Endurance Tests.	Conducted by the contractor to verify system operation in the opposite climatic season to the season in which the Endurance Tests were successfully completed. For example, the contractor conducts Seasonal Endurance Tests in the summer if the Endurance Tests were successfully completed in the Winter. The Seasonal Endurance Tests are conducted during the Warranty period.
(40) Seasonal Endurance Test Results.	Submitted by the contractor to the Government after the successful completion of the tests. (Example - Large EMCS: Submit results within 7 days of completed test.)

CHAPTER 8

SUBMITTALS

8.1 General.

The contractor submittals provide a record of how the contractor intends to meet the contract requirements. These submittals correspond to certain milestones within the project schedule and/or payment schedule. According to the EMCS Tri-Service Guide Specifications, the required contractor submittals include:

- Existing Controls report.
- Shop drawings.
- Factory Test plans.
- Factory Test procedures.
- Factory Test results.
- Reports on Government and contractor furnished DTM and data transmission equipment.
- Data entry forms.
- Field test results.
- Performance Verification Test plans.
- Performance Verification Test procedures.
- Draft Operation and Maintenance Manuals.
- Performance Verification Test results.
- Training documentation.
- Operation and maintenance manuals.
- Seasonal Endurance Test Plans and Procedures.
- Seasonal Endurance Test Results.

The Government representative should refer to the contract documents to verify the number and type of submittals required of the contractor. The inspector should verify that the contractor has submitted the necessary documentation in accordance with the project requirements and schedule and that the contractor submittals have been approved by the Government before they are returned to the contractor for his use. The Government approved shop drawings are used by the contractor to order equipment and materials and proceed with the EMCS installation.

8.2 Contractor Submittals.

(1) Existing Controls Report. — Presents field test results of all existing devices and control loops to be incorporated in the EMCS. For those control devices to be interfaced to the EMCS and requiring either repair or replacement, the report identifies

cost to correct the nonfunctioning items and provides the specification sheets or written functional requirements to support the findings.

(2)	Shop Drawings.	Contain a list of equipment and materials, showing the system configuration, proposed layout and installation. Shop drawings also contain wiring, routing, and schematic diagrams.
(3)	Factory Test Plans.	Identify the factory tests required to demonstrate that the EMCS to be installed at the job site will satisfy contract requirements. EMCS Factory Test Procedures (CR83.002) have been developed to assist the Government in reviewing the Factory Test Plans submitted by the contractor.
(4)	Factory Test Procedures.	Contain the detailed sample instructions and guidelines for test setup using the equipment similar to the equipment used on the job and describe the sequence of events and expected results of each factory test identified in the test plan. The Factory Test Procedures Report (CR83.002) includes a description of initial conditions, a list of test equipment (if required), a sequence of events and expected results. These Test Procedures have been developed to assist the Government in reviewing the Factory Test Procedures submitted by the contractor.
(5)	Factory Test Results.	Document the results of the Factory Tests.
(6)	Data Transmission Media and Equipment Reports.	Provide the results of tests performed on Government and contractor furnished media and equipment that demonstrate performance with contract requirements.
(7)	Data Entry Forms.	Indicate what information is required from Government in order for the contractor to prepare the EMCS data base. The Government must complete the data entry forms prior to the contractor's need date to avoid delays in the project schedule.

(8)	Field test results.	Document the results of the functional and diagnostic tests and calibrations of all installed equipment.
(9)	Performance Verification and Endurance Test Plans.	Contain all the tests required to demonstrate that the installed EMCS satisfies the technical and operational contract requirements. EMCS Performance Verification and Endurance Test Procedures (CR83.003) have been developed to assist the Government in reviewing the Performance Verification Test Plans submitted by the contractor.
(10)	Performance Verification and Endurance Test Procedures.	Contain the detailed sample instructions and guidelines for test setup, execution, and evaluation of test results. EMCS Performance Verification and Endurance Test Procedures have been developed to assist the Government in reviewing the Performance Verification and Endurance Tests and Procedures submitted by the contractor.
(11)	Draft Operations and Maintenance Manuals.	The contractor must submit draft copies of the operations and maintenance manuals, containing the information listed under the description of Operation and Maintenance Manuals (Item 14). These manuals are submitted with the Performance Verification Test and Endurance Test Procedures.
(12)	Performance Verification and Endurance Test Results.	Document the results of the Performance Verification and Endurance Tests.
(13)	Training Documentation.	Includes the lesson plans and lists of reference materials to be used for each phase of training with samples of the Student Course handouts.
(14)	Operation and Maintenance Manuals	Submitted to the Government after EMCS acceptance. The manuals include the following: . Functional Design Manual. . Hardware Manual. . Software Manual. . Operator's Manual. . Maintenance Manual.

8.3 Contractor Proprietary Information.

Contractor proprietary information refers to the information provided by the contractor that is used exclusively for the EMCS project. This information cannot be transferred to any other person or project without prior approval of the contractor providing the original information. Contractor proprietary information includes both the software and technical data provided by the contractor to the Government in connection with the execution of the contract. The Government must include Department of Defense Form 1423 in the bid package in order to require the contractor to provide proprietary information.

Figure 8-1 is an example of DD Form 1423. This form documents and identifies the data to be furnished by the contractor to the Government under the contract. This form must be made a part of the contract. If the Government fails to include DD Form 1423 in the Bid Set, in accordance with the Defense Acquisition Regulations (DAR), the contractor can refuse to provide technical data and software documentation to the Government.

In order for the Government to release proprietary materials to third parties for work to be performed at the site where the EMCS is installed (and only at that site), it is necessary to obtain a licensing agreement either as part of the original contract in the form of a paid up license or as an option to purchase a license on or before a specified later date. Either approach will enable the Government to purchase a license to disclose all or a portion of the technical data and/or computer software for Government use at the site for activities such as system expansion or system operation by third parties. The inclusion of DD Form 1423 in the contract documents does not give the Government the right to release contractor proprietary information to a third party.

The contract documents, which indicate the classification of each submittal, generally use the following terms for the classification of the information received:

- Restricted rights.
- Limited rights.
- Unlimited rights.

These three terms are defined in the special provisions of the Defense Acquisition Regulation (DAR) 9-201, 9-601 (g,i) & 7-104.9(a through o).

(1) Restricted Rights. Applies to EMCS software. As indicated in DAR 9-601(d), software delivered with restricted rights can be used only on the computer (and a spare) for which the software is acquired.

CONTRACT DATA REQUIREMENTS LIST

ATCH NR ______ TO EXHIBIT ______

TO CONTRACT/PR N-62477-79C-0454

CATEGORY Contract Data

SYSTEM/ITEM ______

CONTRACTOR ______

1. Sequence Number	2. Title or Description of Data / 3. Subtitle	4. Authority (Data Item Number)	5. Contract Reference	6. Technical Office	9. Frequency	11. As of Date	12. Date of 1st Submission	13. Date of Subsequent Submission/Event ID	14. Distribution and Addresses	15. Total
001	Shop Drawings / All hardware & software desciptions	Sect. 13948 Par.1.3.1	Sect.13948 Par.1.3.1		As req.		See-16		Chesapeake Division Washington DC	As Req.
002	Operation & Maintenance Manuals / Functional Design Manual	Sect. 13948 Par. 1.3.4	Sect.13948 Par.1.3.4.1		1 Time	See-16			Chesapeake Division Washington DC	3/0
003	Operation & Maintenance Manuals / Hardware Manual	Sect. 13948 Par. 1.3.4	Sect.13948 Par.1.3.4.2		1 Time	See-16			Chesapeake Division Washington DC	3/0
004	Operation & Maintenance Manuals / Software Manual	Sect. 13948 Par. 1.3.4	Sect.13948 Par.1.3.4.3		1 Time	See-16			Chesapeake Division Washington DC	3/0

16. Remarks (001): Item 12 period to be designated by Contracting Officer

16. Remarks (002): Item 11 - Furnish after acceptance of equipment

16. Remarks (003): Item-11 Furnish after acceptance of equipment

16. Remarks (004): Item-11 Furnish after acceptance of equipment.

PREPARED BY: Jeff Cosiol — DATE: 2April82 — APPROVED BY: [signature] — DATE: 4-2-82

DD FORM 1423

Replaces edition of 1 Apr 66, which is obsolete.

17. Event/CEI Number — 18. DID Approval/Form Number — 19.–21. Reserved for DoD — 22. Contractor File/Document Number — 23. Estimated Number of Pages — 24. Price Group — 25. Estimated Total Price — Contract Value

DEPARTMENT OF DEFENSE FORM 1423

Figure 8-1

(2) Limited Rights. Applies to technical data describing computer software. As indicated in DAR 9-201(c), technical data delivered with limited rights can only be used by the Government at the site for which it is being provided. The data cannot be released to a third party outside the Government without previous agreement of the EMCS contractor or unless called for in the contract documents by means of a subleasing agreement.

(3) Unlimited Rights. Generally applies to EMCS software and technical data developed specifically for the project funded entirely from the Government's contract. As indicated in DAR 9-201(d), materials provided with unlimited rights have no restrictions on duplication, modification or disclosure.

Restricted rights and limited rights materials are generally stamped with the appropriate classification name. During EMCS installation and testing, it is important that the Government handle proprietary material in accordance with contract requirements.

8.4 Software Submittals.

Upon successful completion of the Endurance Test, the contractor provides computer listings of all accepted software.

- Duplicate copies of all software in each type of storage device used on the job. Duplicate copies must be stored in magnetically shielded cases.

- Complete software diagnostics on magnetic tape with a duplicate copy in a magnetically shielded case.

The contract documents may indicate additional requirements for software submittals. The Government representative should refer to the contract documents to verify completeness of contractor software submittals.

CHAPTER 9

INSPECTION

9.1 General.

Inspection begins with the contract award and ends with EMCS acceptance after the successful completion of the Performance Verification Tests and Endurance Tests. The basic phases of inspection follow the Sequence of Events presented in the Chapter on Project Schedule and are shown again in Figure 9-1.

During on-site inspection, the inspector verifies proper installation or modification of equipment to ensure that it has been installed and/or modified in accordance with the contract documents and approved contractor's submittals.

This chapter provides a more detailed explanation of the sequence of inspection likely to be encountered in the field.

9.2 Guide Specifications.

The Tri-Services Guide Specifications establish important technical and procedural requirements for the installation and testing of large, medium, small and micro EMCS.

The basic areas covered in the Tri-Services Guide Specification for EMCS include:

- System description.
- Submittals.
- Reviews.
- Testing.
- Training.
- Government furnished DTM.
- Contractor furnished DTM.
- EMCS hardware requirements.
- EMCS software requirements.
- Installation.
- Testing.
- Maintenance and service.

The Guide Specifications were developed to provide a uniform standard for the development of the contract specifications which relate to the actual EMCS job. Familiarity with the Guide Specifications can greatly facilitate the inspector's understanding of the contract specifications.

FIGURE 9-1 - SEQUENCE OF EVENTS

ACTIVITY			
1. Contract Award (CA)	o		
2. Preconstruction Conference	->		
3. First Review	->		
4. Second Review	------->		
5. #Existing Controls Report Submission	---->		
6. #Shop Drawings Submission	------>		
7. Government Corrections to Existing Controls	--->		
8. Non-EMCS Equip. Modifications	------------------	--------->	
9. Field Sensors & Controls Installed	------------------	--------->	
10. #Factory Test Plans & Proc. Submission	-->		
11. Notification of Factory Tests	-->		
12. Factory Tests		o--->	
13. #Factory Test Results Submission		--->	
14. Phase I Training		--->	--->
15. Field Equipment Installation		-------->	
16. Master Control Room Installation		---->	
17. Gov't DTM & Equipment Testing	-----------------------------------	----------------->	
18. Contr. DTM & Equip. Installation & Test.		------------->	
19. #DTM Test Results Submission		-->	
20. #Data Entry Forms Submission	-------------------	-->	
21. Data Entry Forms Completed by Gov't.		--------->	
22. Field Equipment & Software Checkout		---->	
23. MCR Hardware/Software Checkout		--->	
24. Contractor Field Testing		--->	
25. #Field Test Results Submission		--->	
26. #Performance Verification Test Plans and Procedures Submission		--->	
27. Notification of Performance Verification Test		-->	
28. Performance Verification Tests		-->	
29. #Performance Verification Test Results Submission			-->
30. Notification of Endurance Tests		--->	
31. Endurance Test			o-->
32. #Endurance Test Results Submission			--->
33. #O&M Manuals Submission			--->
34. Phase II Training			--->
35. Phase III Training			--->
36. Warranty (after Acceptance)			----------------
37. Maintenance &Service(after Acceptance)			----------------
38. #Seasonal Endurance Tests			--->
39. #Seasonal Endurance Test Results Submission			--->
Key Events:	CONTRACT AWARD	FACTORY TEST	ENDURANCE TEST

#Contractor's Submittals

9.3 Contract Documents.

Contract documents are developed by the Government to describe the type of EMCS to be installed, the layout of EMCS equipment, the controls and sensors to be interfaced to the EMCS, and the software such as the application programs required for the project. The contractor uses these documents to identify the scope of work and how the work is to be carried out.

It is important that the inspector review the EMCS project contract documents to gain a working knowledge of the project scope, contract plans and contract specifications. The project scope generally encompasses the installation of EMCS hardware and software, installation of new mechanical and electrical equipment, modifications to existing mechanical and electrical equipment, and other EMCS related work. An EMCS project may include related work, such as the insulation of new piping, reinsulation of existing piping and/or ductwork, and the reconfiguration of hot water, steam or condensate piping. EMCS contract plans indicate general interconnections and locations of EMCS equipment, and equipment layout and configuration.

9.4 Conferences and Reviews.

Conferences and reviews are held to confirm that the contractor understands the contract requirements, that the project schedule is acceptable and can be met and that any problems in project implementation are addressed and resolved. The contracting officer is responsible for setting up the review meetings. The inspector should attend these meetings to become fully aware of any changes in the project schedule or in the scope of work which could affect the project schedule and submittals.

The EMCS Guide Specifications require that at least two review sessions take place after the contract award. Additional meetings may be required by the contract documents.

9.5 Field Condition Verification.

During the time between the field survey required to prepare the contract documents and the beginning of the installation phase, existing field conditions may change, causing a possible change in project scope. For example, equipment may become damaged, modified or deleted from the project site. In some cases, equipment mounting locations may become inaccessible due to internal building modifications. It is important that the contractor verify that existing field conditions correspond to the conditions described with approved submittals prior to EMCS installation. The inspector should verify the contractor's findings. If there are discrepancies, the inspector should take appropriate action to resolve the problems prior to on-site installation of the EMCS and associated mechanical/electrical systems in order to avoid delays.

9.6 Existing Sensors and Controls.

Prior to the installation of any instrumentation and control devices, the contractor must inspect and test all existing devices that will be interfaced to the EMCS and furnish a report on the test results and on devices that require repair. The contractor is also required to submit a schedule to the Government indicating the need date for connection of the EMCS to existing devices. After the Government has approved these submittals, the inspector should become familiar with the existing controls report and the contractor's scheduled need dates to verify that the necessary repair work is accomplished according to schedule. The inspector should also verify there is a record of the date and time that the repair work is completed on each device and control loop, since the contractor will assume responsibility for the existing control loops and devices interfaced to the EMCS after repair work is completed and until the EMCS is accepted by the Government. If any local control loops or devices interfaced to the EMCS fails during construction, the contractor is responsible for repairing the device. The inspector should be aware of the failures and verify corrective measures have been taken by the contractor. The inspector should also verify that there is a record of the failure and repair with associated date(s) and time(s) for each.

The contractor must also submit written requests to disconnect any controls and to schedule equipment down time. The inspector should verify that outages are scheduled with the physical plant personnel before the events take place. The inspector should also verify there is a record of the date and time construction work is initiated on each control loop, since the contractor assumes responsibility for the control loop and the devices incorporated into the EMCS when construction begins on that loop.

9.7 Shop Drawings.

Before the Contractor performs any field work on EMCS related equipment, he must submit shop drawings of the installation to the Government for approval. Shop drawings contain a list of equipment and materials, showing the system configuration, proposed layout and installation. Shop drawings also contain wiring, routing, and schematic diagrams.

These drawings will be very helpful to the inspector during the installation phase in verifying that the EMCS is being properly installed and interfaced with electrical/ mechanical equipment. It is important that the inspector use only those drawings that have been approved by the Government.

Examples of shop drawings are shown in Figures 9-2 through 9-5. Figure 9-2 shows the wire or cable requirements for connecting an Uninterruptible Power Supply (UPS) to a FID or MUX. In addition, the diagram shows the interconnections for a Power Fail Restart Relay and a 24 VDC Power Supply. Figure 9-3 shows the connections, both mechanical and electrical, for a fan or pump differential pressure switch. Figure 9-4 illustrates the wiring changes required to add a new motor starter. Figure 9-5 is a block diagram of a CCU, including the peripheral equipment, test FID and communication lines.

9.8 Non-EMCS Equipment Installation.

A. General.

With exception to sensors, controls, data terminal cabinet, and wiring, the contractor is not allowed to deliver or install any EMCS equipment until successful completion of the factory tests. He may, however, perform modifications to equipment that is to be interfaced to the EMCS if the shop drawings for those modifications have been approved. The inspector can determine that equipment is "Non-EMCS" if it is not identified in the EMCS section of the specifications. An example of a non-EMCS modification would be the modification of ductwork to an air handling unit or the addition of a smaller boiler to an existing boiler plant.

It is the inspector's responsibility to verify that shop drawings have been approved prior to any work, and that the work is completed in accordance with the contract documents and approved shop drawings.

B. Mechanical Systems.

Depending upon the contract requirements, the contractor may modify existing mechanical equipment or install new equipment as part of the EMCS project. The contract plans and specifications will indicate what mechanical work is required, and the contractor's submittals will detail th. method of installation and/or modifications. Mechanical systems inspection can be handled in the same way as in other non-EMCS construction projects.

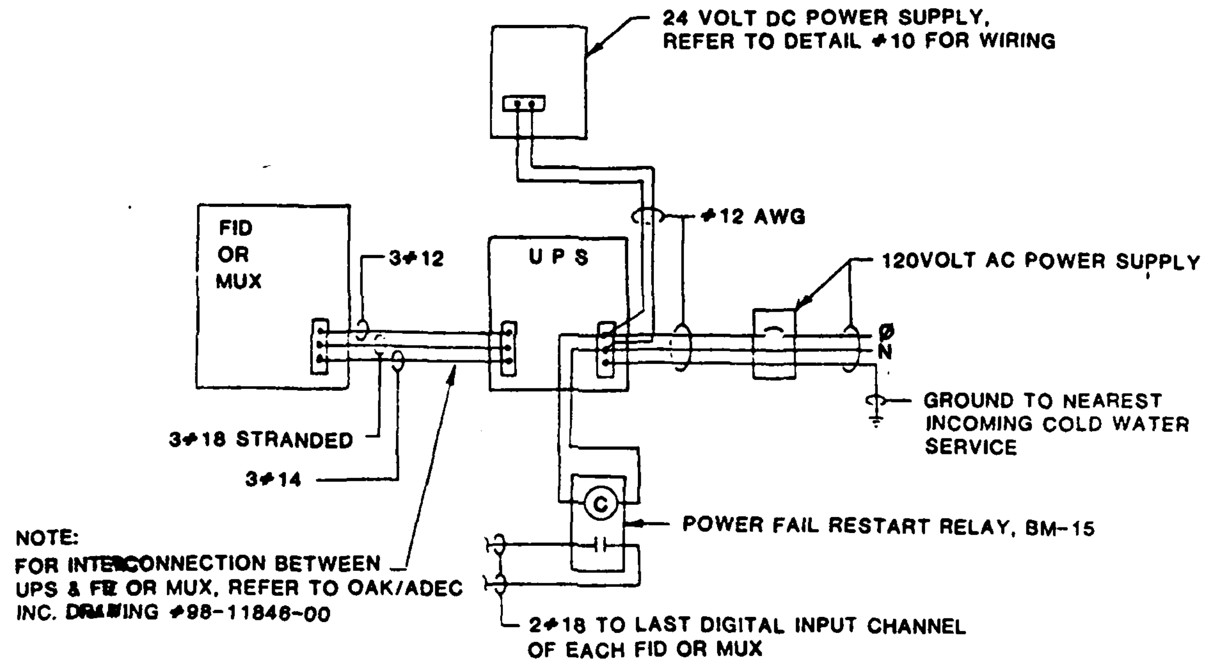

24 VOLT DC POWER SUPPLY,
REFER TO DETAIL #10 FOR WIRING
#12 AWG
FID
OR
MUX
3#12
U P S
120VOLT AC POWER SUPPLY
Ø
N
GROUND TO NEAREST
INCOMING COLD WATER
SERVICE
3#18 STRANDED
3#14
C
POWER FAIL RESTART RELAY, BM-15
NOTE:
FOR INTERCONNECTION BETWEEN
UPS & FID OR MUX, REFER TO OAK/ADEC
INC. DRAWING #98-11846-00
2#18 TO LAST DIGITAL INPUT CHANNEL
OF EACH FID OR MUX

Figure 9-2

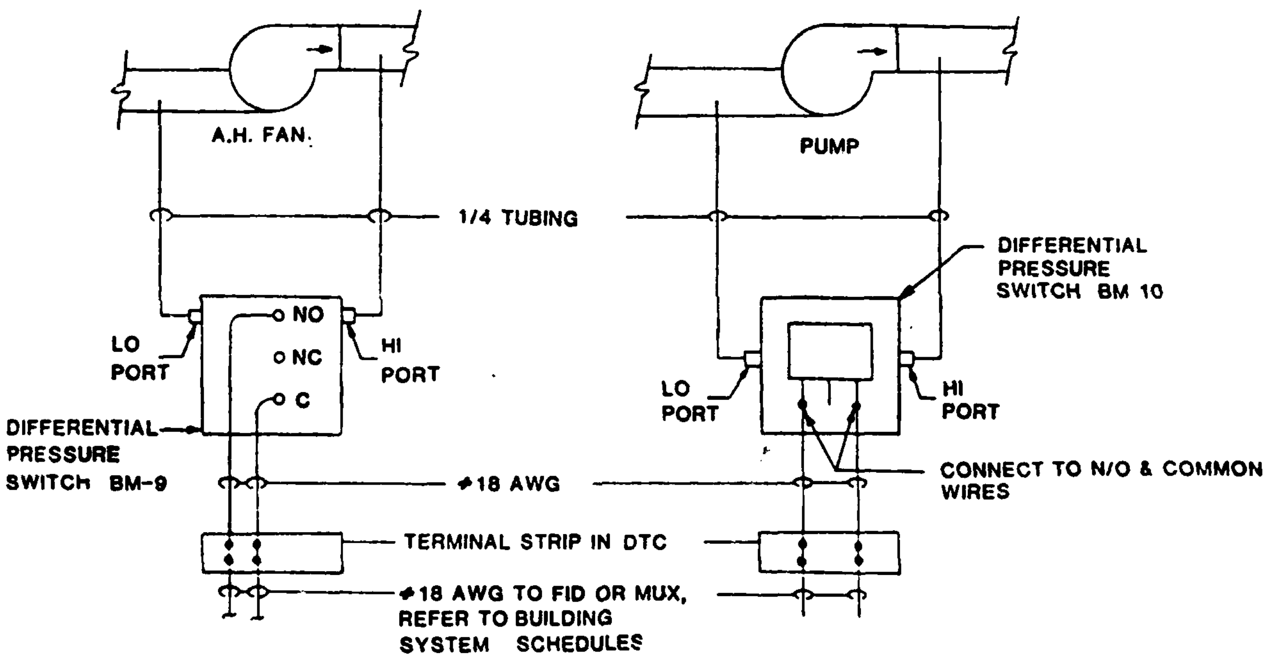

A.H. FAN
PUMP
1/4 TUBING
DIFFERENTIAL PRESSURE SWITCH BM 10
NO
NC
C
LO PORT
HI PORT
LO PORT
HI PORT
DIFFERENTIAL PRESSURE SWITCH BM-9
#18 AWG
CONNECT TO N/O & COMMON WIRES
TERMINAL STRIP IN DTC
#18 AWG TO FID OR MUX, REFER TO BUILDING SYSTEM SCHEDULES

Figure 9-3

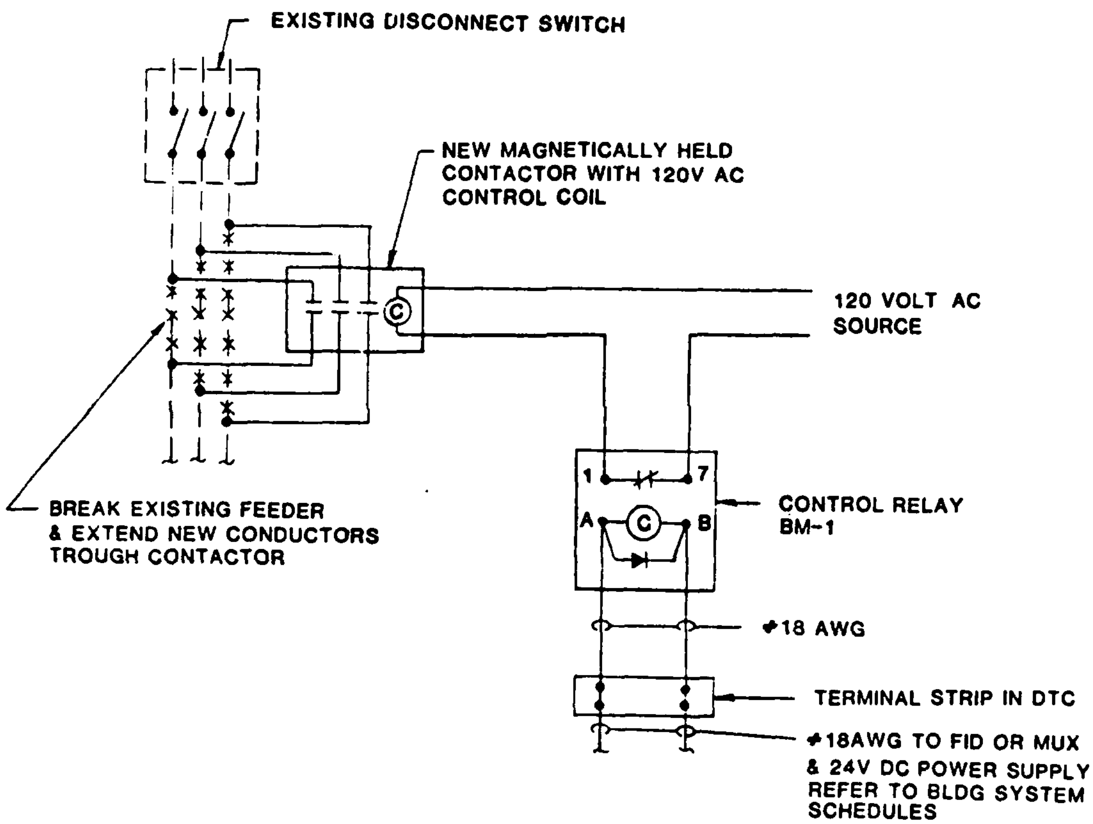

EXISTING DISCONNECT SWITCH
NEW MAGNETICALLY HELD CONTACTOR WITH 120V AC CONTROL COIL
C
120 VOLT AC SOURCE
BREAK EXISTING FEEDER & EXTEND NEW CONDUCTORS TROUGH CONTACTOR
1
7
A
C
B
CONTROL RELAY BM-1
#18 AWG
TERMINAL STRIP IN DTC
#18AWG TO FID OR MUX & 24V DC POWER SUPPLY REFER TO BLDG SYSTEM SCHEDULES

Figure 9-4

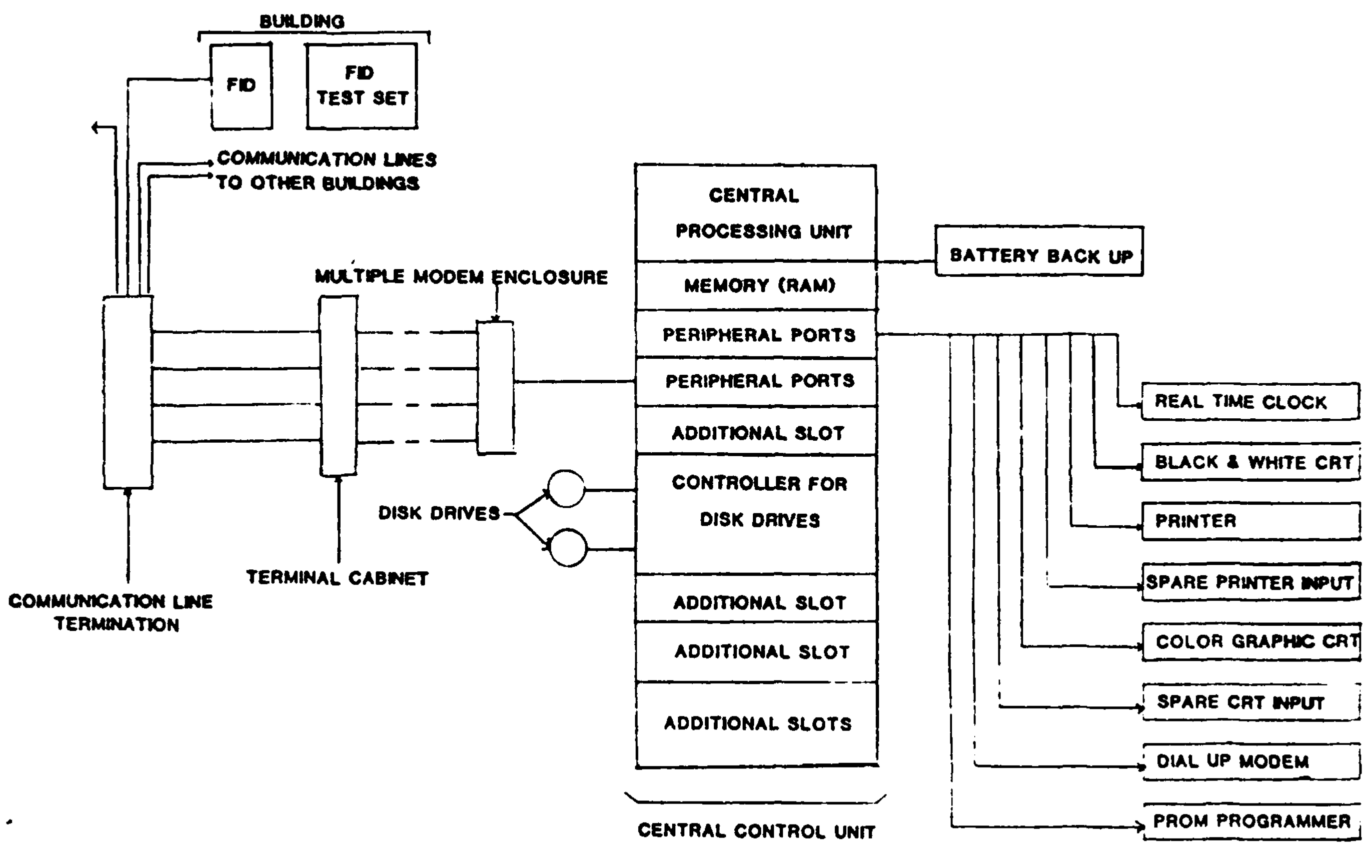

BUILDING
FID
FID TEST SET
COMMUNICATION LINES TO OTHER BUILDINGS
MULTIPLE MODEM ENCLOSURE
CENTRAL PROCESSING UNIT
MEMORY (RAM)
PERIPHERAL PORTS
PERIPHERAL PORTS
ADDITIONAL SLOT
CONTROLLER FOR DISK DRIVES
ADDITIONAL SLOT
ADDITIONAL SLOT
ADDITIONAL SLOTS
CENTRAL CONTROL UNIT
BATTERY BACK UP
REAL TIME CLOCK
BLACK & WHITE CRT
PRINTER
SPARE PRINTER INPUT
COLOR GRAPHIC CRT
SPARE CRT INPUT
DIAL UP MODEM
PROM PROGRAMMER
DISK DRIVES
TERMINAL CABINET
COMMUNICATION LINE TERMINATION

FIGURE 9-5

a. Modifications to Existing Mechanical Systems.

Existing equipment modifications may affect only a single component of an existing mechanical system such as piping or ductwork, or may affect the entire system. The following are examples of items the inspector may encounter in checking actual equipment modifications:

(1) Piping System. Check on types of materials and fittings, methods of connection for flow and system configuration, method of support, and numbers of supports. Verify pipes are reinsulated where required and pipes are retagged.

(2) Ductwork. Inspect for leaks. Verify that connections, bracing, installation of turning vanes and other specified modifications match approved submittals and contract requirements.

(3) Dampers. Inspect for proper installation as indicated in the approved submittals and contract documents. Damper operator or motor installations should be checked for proper mounting location (such as, out of air streams) and clearances with respect to linkage operation. The model number of the new operator or motor should be checked against the approved submittals. Connecting rods should be correctly installed to ensure against slippage of connecting parts, dampers should be opened, closed or modulated and damper operation should be checked for tight close-off.

b. Installation of New Mechanical Systems.

With exception of new building construction, the installation of new mechanical systems is likely to require some interface with existing systems. The inspector may, therefore, need to check the new equipment as well as the interface with existing equipment. In addition to the items listed for modifications to existing systems, the following are examples of items the inspector may encounter in checking actual equipment installation:

(1) New Equipment. Check model numbers against the numbers on the approved shop drawings. Verify equipment is properly tagged.

(2)	Piping.	Check for proper sloping and installation of traps, vents, drains and supports. Check for clearances, connections, insulation requirements and proper tagging.
(3)	Heating/Cooling Coils.	Verify proper sizing, location, and connections.
(4)	Valves.	Verify valves have identification tags. Flow arrows on valve bodies must match flow direction. Verify safety relief valves are piped to a safe location. Control valves must be checked for tight shutoff.
(5)	Sensors and Controls.	Verify proper installation in accordance with contract documents and manufacturer's requirements.
(6)	Access Doors to Equipment.	Check for proper location to enable access to equipment for repair and maintenance.
(7)	Vibration Isolation Supports.	Check for proper location of vibration isolation supports for specified air handling units, fans, pumps and other items specified in the contract documents.
(8)	Ductwork.	Verify proper connections and support in accordance with approved submittals. Verify proper insulation of ductwork and proper location of access doors.
(9)	Dampers.	Verify proper location and check for leaks.

c. <u>Electrical Systems</u>.

EMCS contract documents are developed on the basis of existing field conditions of the contract plans of the equipment to be monitored and controlled by the EMCS. The contract plans and specifications will indicate what electrical work is required. The contractor's submittals will detail the method of installation and/or modifications. The inspector should refer to the contract documents and contractor's submittals to ensure that all necessary modifications and new installations are performed in accordance with the contract documents and the approved submittals. Electrical systems inspection can be handled in the same way as in other non-EMCS construction projects.

a. Modification to Existing Electrical Systems.

The following are examples of items the inspector may encounter in checking actual equipment installation:

(1)	Use of Spare Circuits.	Verify the existing panel directories have been updated.
(2)	Conduit and Wire Sizes.	Check for percentage utilization, types of materials used, methods of grounding and proper installation of conduit in accordance with the National Electrical Code.
(3)	Pull Boxes and Junction Boxes.	Verify covers have been replaced after work is completed.
(4)	Starters.	Verify replacement starters are of proper size and type as indicated in the contract documents. Verify wiring of EMCS control wiring to starters is in accordance with starter type and required failure mode.
(5)	Rewiring to Motors.	Verify adequate flexible connections to the motors.

b. Installation of New Electrical Systems.

With exception of new building construction, the installation of new electrical systems is likely to require some interface with existing systems. The inspector may, therefore, need to check the new equipment as well as the interface with existing equipment. In addition to those items listed above for modifications to existing systems, the following are examples of items the inspector may encounter in checking actual equipment installation:

(1)	Emergency Power.	Verify proper location.
(2)	Lighting Fixtures.	Check type of fixture and lens. Verify fixtures are wired to normal or emergency circuits as indicated on the approved contract documents.
(3)	New Wiring and Conduit.	Verify installation is in accordance with the National Electrical Code (NEC).

(4)	Ground Fault Interruptors.	Verify proper installation, by witnessing trip tests on the interruptors.
(5)	Boxes and Enclosures.	Verify housing and sizing is in accordance with the National Electrical Code requirements.
(6)	Power and Control Circuits.	Verify sizing and identification or color coding is in accordance with Specifications and Codes.
(7)	Panelboards.	Verify panelboards include specified spare circuit breakers. Check panelboard directories for identification of all circuits.
(8)	Motors.	Verify motors have proper enclosures. Check for thermal overload protection and safety controls where required. Verify capacity of circuits is sufficient for new motor installation.

9.9 Instrumentation and Controls Inspection During Construction.

Prior to the installation of any instrumentation and control devices, the contractor must test and inspect all existing devices that will be interfaced to the EMCS and furnish a report on the test results and a list of devices that require repair. After the Government has reviewed these submittals, the inspector should become familiar with the existing controls report to verify the validity of the contractor's report. The inspector should also be familiar with the contractor's schedule for corrective work to verify that the necessary repair work is accomplished according to schedule. If there is any repair work on a device or control loop, the inspector should also verify there is a record of the date and time that the repair work is completed. The inspector should verify that there is a record of equipment failure and repair with associated date(s) and time(s) for each. The contractor is required to submit a schedule to the Government indicating the need date for connection of the EMCS to existing devices.

The contractor must also submit written requests to disconnect any controls and to schedule equipment down time. The inspector should verify that outages are conducted with prior approval of the physical plant personnel before the events take place. The inspector should also verify there is a record of the date and time construction work is initiated on each control loop.

During construction, the inspector should make visual inspections of EMCS instrumentation and controls to verify proper installation as indicated in the approved submittals. The inspector should be aware of situations where instrumentation may be covered by insulation or by other equipment so that the inspection can take place before the device is covered.

During construction, the inspector should verify that the model numbers of the sensor and control devices match those in the approved submittals. The inspector should also check that the interface between sensors/controls and EMCS field equipment conforms to the approved submittals. Examples of items the inspector may be checking against approved submittals during the installation of instrumentation and control devices include:

(1)	Sensors & Controls	Verify sensors and controls are properly mounted and located in accordance with approved submittal installation details. Proper installation of sensors ensures that accurate readings are taken for the given measurement. Verify wiring of controls is in accordance with failure mode requirements of each piece of equipment being controlled. Verify devices are properly tagged for identification. Verify model numbers correspond to those in the approved submittals.
(2)	Sensor & Control Wiring	Verify all equipment is protected against surges induced on sensor and control wiring installed outdoors. Verify protective devices are installed in separate metallic enclosures near equipment. (Fuses are not to be used for surge protection.)
(3)	Outdoor Sensors.	Verify outdoor sensors are enclosed in a proper environmental housing for protection from the environment.
(4)	Flow Devices.	Verify the type of device installed conforms to contract requirements and location conforms to approved submittals.
(5)	Control Devices.	Verify that the control devices are wired in accordance with the approved shop drawings and contract documents and that they operate as specified in the failure mode.

9.10 Factory Tests.

Factory tests must be successfully completed before any EMCS hardware or software (with the exception of sensor and controls) is shipped to the job site. These tests are designed to demonstrate that the EMCS intended for the job site can satisfy the technical, operational and performance requirements called for in the contract documents. A more detailed description of Factory Tests is presented in Chapter 10 (Factory Tests).

The inspector should verify the following:

- The contractor has submitted the factory test plans and procedures in accordance with the project schedule.
- The contractor's submittals of the test plans and procedures have been approved by the Government prior to factory tests.
- The contractor has notified the Government of the factory test dates in accordance with the contract requirements.
- The Government witnesses all factory tests.
- The test results have been submitted for each factory test with contractor's signature and signature of the Government or a designated representative for record purposes.

a. Factory Test Plans and Procedures.

Factory test plans identify the tests to be conducted on EMCS hardware and software at the factory. Factory test procedures describe how the test is to be carried out. Figure 9-6 is an example of a factory test procedure on data communication link overvoltage protection. This example illustrates key items of information, including:

- Test number - for easy identification.
- Page number and total pages per test - to ensure all events are completed.
- Title - brief description of the test.
- Objective.
- Reference - so that appropriate project specification paragraph can be referenced if required.
- Initial conditions - may be required for some tests.
- Test equipment - may be required for some tests.
- Event - what to do.
- Expected results.

TEST NO: Factory-6 Page 1 of 1
TITLE: Data Communication Link Overvoltage Protection
APPLIES TO: Large, Medium and Small EMCS
REFERENCE: Proj. Spec. Paragraph ___________

OBJECTIVE: To demonstrate the ability of all contractor supplied communication equipment to withstand a 480 VAC RMS 60 Hz signal superimposed on any data communication line terminal.

INITIAL CONDITIONS

1. Surge protection is installed on circuits to be tested.

TEST EQUIPMENT

1. The test equipment is a 480 VAC RMS 60 Hz single phase source.

EVENT	EXPECTED RESULTS
1. Connect the test equipment to each data communication equipment communication line terminal (one at a time) and apply the test voltage for a period of at least 1 minute while the EMCS is in operation.	1. After the application and removal of the test waveform, the communication equipment shall not exhibit any malfunctions, degradation of performance, or deviation from its normal mode of operation. Visually verify equipment operation by manually initiating changes in the DE that require the operation of the tested equipment. System displays required data.

Figure 9-6

b. Factory Test Results.

Test performance records are complete during each factory test. These records are attached to the test procedures and should include the following information:

- Test name and identification.
- Location.
- Starting date and time.
- End of test date and time.
- First test or a retest.
- Project specification paragraph.
- Personnel present (function or position).
- Observations.
- Test results.
- Retest schedule (if necessary)
- Government representative signature.
- Contractor's representative signature.

Figure 9-7 illustrates a sample format that can be used for documentation of test results.

When there is a discrepancy between the actual and expected results, the inspector should verify that the contractor has provided written observations which describe the discrepancy and indicate the reason for the discrepancy. The Government must determine what action must be taken with test procedures that fail to meet the contract requirements. The Government may require a retest at a later date, at the factory or in the field, as a separate test not related to any field test.

9.11 Data Transmission Media (DTM) and Equipment Installation.

Installation and testing of DTM and equipment takes place prior to EMCS field equipment installation. The contractor must install all DTM that is not Government furnished. The inspector should verify that all DTM not identified as "Government furnished" on the shop drawings is provided and tested by the contractor.

FIGURE 9-7

SAMPLE FORMAT FOR TEST RESULTS DOCUMENTATION

TEST NO.: ______________ START DATE, TIME: ____________
TITLE: ______________ STOP DATE, TIME: ____________
LOCATION: ______________

REFERENCE: EMCS Factory Test No. _____ PROJECT SPEC. PARAGRAPH _______
EMCS Performance
Verification Test No. _____

PERSONNEL	FUNCTION/POSITION

OBSERVATION:

TEST RESULTS: SATISFACTORY _____ UNSATISFACTORY _____

RETEST SCHEDULE: __________________

GOVERNMENT REP. SIGNATURE: ____________________________

CONTRACTOR'S REP. SIGNATURE: ____________________________

a. Data Transmission Media (DTM)

Prior to EMCS field equipment installation, the contractor must test Government furnished and contractor furnished DTM, with the required data transmission and surge and overvoltage protection in place. It is assumed that the Government furnished DTM has been previously tagged and reserved for EMCS use during the design of the EMCS. Tests on the surge protection and overvoltage protection equipment for each type of Government and contractor furnished DTM used in the project are conducted during the Factory Tests.

During on-site installation and testing, the inspector should verify the following:

- The contractor tests Government furnished DTM within the time period specified on the contract documents.
- The contractor furnishes a report on results of the DTM tests, noting deficiencies in the Government furnished DTM.
- Any deficiencies in the Government furnished DTM are corrected prior to the contractor's need date.
- The contractor provides DTM not shown as Government furnished in the approved submittals.
- All DTM installations are performed in accordance with contract requirements and approved submittals.
- The contractor furnishes a report on contractor furnished DTM that demonstrates compliance with the standards specified in the contract documents.
- The contractor provides surge protection and overvoltage protection on the DTM as specified in the contract documents and approved submittals using only the equipment successfully tested in the Factory Test.

b. Data Transmission Equipment.

Prior to EMCS field equipment installation, the contractor must have tested Government furnished and contractor furnished data transmission equipment using the tested DTM with the surge and overvoltage protection in place. The contractor may elect to test the performance of the DTM and data transmission equipment together as a system.

On-site testing of all Government and contractor furnished data communication equipment is conducted prior to the contractor's need date. During on-site installation and testing, the inspector should verify the following:

- The contractor tests Government furnished data transmission equipment within the time period specified on the contract documents.
- The contractor provides all data transmission equipment not shown as Government furnished in the contract documents.
- All data transmission equipment installation is performed in accordance with contract requirements, and approved submittals.
- The contractor provides surge and overvoltage protection on all data transmission equipment as specified in the contract documents and approved submittals, using only the equipment successfully tested in the Factory Test.

9.12 Data Entry Forms.

Data entry forms are developed by the contractor for the Government to define all the points and systems used in the EMCS data base. These forms are likely to request the following information for a point or a system:

- Identification (unique ID).
- Name.
- Type (digital or analog point).
- Location (such as system or building).
- Operating characteristics (such as start time and stop time for a digital point, or range for an analog point).
- Constraints (such as maximum on and off time for a digital point or high and low limits for an analog point).
- Units of measure (for analog sensors).
- Failure mode.

Figure 9-8 is an example of a data entry form.

According to the EMCS Guide Specifications, the contractor submits these forms to the Government no later than 90 days prior to the contractor's need date.

The inspector should verify that the contractor has submitted the forms to the Government in accordance with the contract schedule and that the forms have been completed and returned to the contractor by the contractor's need date. Some of the information on the data entry forms may require input by the contractor. Such information should be verified by the Government before the completed forms are returned to the contractor. The contractor is responsible for transferring all the data from the data entry forms to the EMCS at one time. It is important that the Government

DATA ENTRY FORM FOR DIGITAL POINT

POINT NAME : ______________________________

DEVICE OR SENSOR TYPE
(EX - SENSOR, CONTROL, MOTOR): ______________________________

BUILDING ID : ______________________________

FID LOCATION : ______________________________

CHANNEL ADDRESS IN FID : ______________________________

MUX/IMUX LOCATION : ______________________________

STATUS : ______________________________

ALARM CLASS : ______________________________

ALARM MESSAGE : ______________________________

FAILURE MODE : ______________________________

MAXIMUM STARTS : ______________________________

MINIMUM OFF TIME : ______________________________

MINIMUM ON TIME : ______________________________

MAXIMUM OFF TIME : ______________________________

START/STOP SCHEDULE

	WEEKDAYS	WEEKENDS	HOLIDAYS
START HOURS:			
STOP HOURS :			

SAMPLE DATA ENTRY FORM
Figure 9-8

completed forms contain point identifications and parameters that are correct for each facility. Complete and correct data entry forms, avoid the problem of having the Government redo the contractor's work at a later date because data on operating parameters such as start/stop times and alarm points was incomplete or incorrect.

9.13 EMCS Field Equipment Delivery and Installation.

The contractor can deliver to the job site and proceed to install the sensors, controls, and the data terminal cabinets after their respective shop drawings are approved by the Government.

After successful completion of the balance of the Factory Tests, the contractor can begin delivery and installation of EMCS field equipment. This equipment includes:

- Field interface device (FID°) and peripherals.
- Multiplexer (MUX*) devices.
- Intelligent Multiplexer (IMUX) devices.

The contractor is responsible for delivering and installing equipment in accordance with the project schedule. The inspector has the following responsibilities:

- Verifies that all factory tests have been successfully completed before EMCS equipment is shipped to the site.
- Verifies that the model numbers of installed equipment match the model numbers in the approved contract submittals and in the successfully completed Factory Tests.
- Checks delivery and installation dates against project schedule.

a. FID°/MUX*/IMUX Inspection.

During FID°/MUX*/IMUX installation, the inspector should check for the following:

- Equipment model numbers match those in the approved submittals and used on the Factory Tests.
- Equipment is installed in conformance with the manufacturer's requirements and the National Electrical Code.
- Equipment contains all controls and indicators identified in the contract documents.
- There is sufficient clearance in the front and side for repair and maintenance.
- There is adequate grounding.

°Large/Medium/Small EMCS
*Large/Medium EMCS

- Equipment has expansion capability as required in the contract documents.
- The FID contains a real time clock with required time indicators (such as seconds, minutes, hours and day of week).
- Sealed battery backup is provided where required.
- A 120 VAC, 15A, 60Hz. duplex outlet is provided either in the equipment enclosure or within six (6) feet.
- Cabinets for the FID°/MUX*/IMUX can be locked, and an intrusion alarm wired to the door switch is provided.
- There is adequate waterproofing where required.
- Lightning and surge protection is provided as required in the contract documents.
- Required spare I/O is installed in the FID°/MUX*/IMUX.
- Wiring between the FID°/MUX*/IMUX and the DTC is numerically identified at the terminal strips at both ends.
- Low voltage and line voltage wiring is installed separately.

The inspector should also verify that the FID°/MUX*/IMUX hardware and software tests are conducted in accordance with equipment checkout procedures.

b. Data Terminal Cabinet (DTC).

Data terminal cabinets provide the interface between the FID°/MUX*/IMUX and sensors and control devices. During field installation, the inspector should inspect each DTC for the following:

- Installation in accordance with the National Electrical Code.
- Installation of separate sensor and control signal wiring raceways.
- Installation of separate analog and digital terminal strips.
- Separate grouping of analog and digital functions.
- Identification of each terminal strip with a listing of terminals with connected devices and operating characteristics.
- All instrumentation or controls are located outside the DTC, FID°/MUX*/IMUX.
- All items connected to the DTC are terminated at a double side screw terminal.
- Each DTC has expansion capability for each type of I/O function provided as specified in the contract documents.

°Large/Medium/Small EMCS
*Large/Medium EMCS

c. Support Equipment.

The inspector should verify that the contractor has provided the following equipment:

- PROM programmer - for FID's and other equipment that utilize PROM for applications programs.
- Portable diagnostic, programming and bulk loading device.
- FID test set.

9.14 Master Control Room Installation.

Inspection of the EMCS Master Control Room (MCR) construction with its associated mechanical/electrical systems can be handled in the same manner as any other general construction project for the modification of an existing structure or the construction of a new structure. During MCR installation, the inspector should verify the following:

- The MCR has a raised floor or other raceway means for the electrical wiring of the EMCS equipment as required by the contract documents.
- The electrical power service to the MCR for the EMCS equipment is grounded to avoid signal noise problems and safety hazards to operating personnel, in the event of lightning surges induced in the data transmission media.
- All metal enclosures including conduits are grounded to a low impedance ground as required by the National Electrical Code.
- Raised floors and wire troughs are grounded.
- Grounding is installed and tested in accordance with the National Electrical Code.
- The MCR environmental conditioning system is installed in accordance with the approved submittals and that the environmental conditioning system provides the required conditions specified in the contract requirements.

During installation of EMCS equipment in the Master Control Room, the inspector should verify the following:

- The EMCS equipment installed by the contractor matches the equipment model numbers and types specified in the approved submittals and used in the Factory Tests.
- The MCR furnishings are provided in accordance with the contract requirements.
- Each EMCS equipment component is installed by the contractor in accordance with the original equipment manufacturer's recommendations.

- The CCU does not include any hardware which would prevent the purchase of a standard maintenance and service contract.
- There are sufficient clearances around the equipment for maintenance and service.
- There is adequate grounding of all transmission equipment and MCR equipment.
- Lightning and surge protection for all MCR equipment is provided in accordance with the contract requirements, approved submittals and tested in the Factory Test.
- All contractor furnished wiring between the MCR EMCS equipment and the EMCS field equipment is properly grounded in accordance with the equipment manufacturer's requirements and is secured in place.
- All wiring is labeled at the MCR and in the field hardware with the nomenclature used in the contractor furnished operation and maintenance manuals.
- Sealed batteries and automatic charging equipment are provided for the CCU and CCC.
- The communications link termination is conditioned for bridging, padding, impedance matching and amplifying to maintain signal integrity.
- The contractor has provided all disk storage systems and magnetic tape storage called for in the contract documents.
- The contractor has provided the required printers (large and medium EMCS generally require separate alarm and logging printers).
- The contractor has provided CRT systems where required. The EMCS Guide Specifications for large and medium EMCS specify an operator's console with color graphic CRT and alphanumeric keyboard.
- A telephone modem is provided with a selectable 300 to 1,200 baud rate and answer-automatic originate capability

The inspector must ensure that tests on all hardware and software are conducted in accordance with approved Factory and Performance Verification Test plans and procedures.

9.15 Contractor Field Testing.

Prior to the Performance Verification Tests, the contractor conducts field testing and calibration of all EMCS equipment and software.

The inspector should verify the following:

- All tests are witnessed by the Government.
- Ground rod tests are conducted in accordance with contract requirements before any wire is connected to a ground rod.

- The contractor performs a cross check of each sensor within the EMCS to verify end-to-end accuracy (the difference between the readings at the sensor and at the CRT display in the Master Control Room are within an accuracy level specified in the contract documents).
- The contractor performs a cross check of each control point within the EMCS to verify end-to-end accuracy (control command issued in the MCR and the subsequent control response are within an accuracy level specified in the contract documents).
- Tests are conducted to verify all systems are operable in the failure mode as a result of an EMCS failure or loss of power.
- Tests are conducted to verify all systems return to EMCS control automatically upon resumption of EMCS operation or return of power.
- The contractor submits the results of functional and diagnostic tests, and calibrations to the Government.

9.16 Performance Verification Tests (PVT's)

Performance Verification Tests (PVT's) must be successfully completed before the EMCS undergoes the Endurance Test. The PVT's are designed to demonstrate that the EMCS installed at the job site can satisfy the technical, operational and performance requirements called for in the contract documents. A more detailed description of Performance Verification Tests is presented in Chapter 11 (Site Tests).

The inspector should verify the following:

- The contractor has submitted to the Government written certification that all materials and equipment have been installed, calibrated, and tested and are in conformance with the technical provisions of the contract.
- The contractor has submitted the PVT plans and procedures in accordance with the project schedule.
- The contractor has notified the Government of the PVT dates in accordance with the project schedule.
- The contractor submittals of the test plans and procedures have been approved by the Government prior to the PVT's.
- The Government witnesses all PVT's.
- The test results have been submitted by the contractor for each PVT with the contractor's signature and the signature of the Government or designated representative.

a. Performance Verification Test Plans and Procedures.

Performance Verification Test plans identify the tests to be conducted on EMCS hardware and software at the job site. Performance Verification Test procedures describe how the test is to be carried out. The basic format and contents of a Performance Verification Test procedure is the same as a Factory Test procedure (see figure 9-6). Key elements of the procedure include:

- Test number - for easy identification.
- Page number and total pages per test - to ensure all events are completed.
- Title - brief description of the test.
- Objective.
- Reference - so that appropriate project specification paragraph can be referenced if required.
- Initial conditions - may be required for some tests.
- Test equipment - may be required for some tests.
- Event - what to do.
- Expected results.

b. Performance Verification Test Results.

Test performance records are complete during each Performance Verification Test. These records are attached to the test procedures and should include the following information:

- Test name and identification.
- Location.
- Starting date and time.
- End of test date and time.
- First test or a retest.
- Project specification paragraph.
- Personnel present (function or position).
- Observations.
- Test results.
- Retest schedule (if necessary).
- Government representative signature.
- Contractor's representative signature.

Figure 9-7, which illustrates a sample format for Factory Test results, can apply to the documentation of Peformance Verification Test results.

When there is a discrepancy between the actual and expected results, the inspector should verify that the contractor has provided written observations which describe the discrepancy and indicate the reason for the discrepancy. The Government must determine what action must be taken with those test results that fail to meet the contract requirements. The Government may require a retest at a later date.

9.17 Endurance Test.

All Performance Verification Tests must be successfully completed before the contractor can perform the Endurance Test. The Endurance Test is designed to demonstrate that the installed and operational EMCS can continuously and reliably meet all contract requirements for a predetermined test period. The Endurance Test is described in more detail in Chapter 11 (Site Tests).

The inspector should verify that:

- All PVT's have been successfully completed by the contractor and that all outstanding deficiencies have been corrected.
- The contractor provides operators in addition to any available personnel to operate the EMCS a minimum of eight hours per day including weekends, for the duration of the Endurance Test.
- The contractor provides on-the-job training as required in the contract.
- The contractor maintains a written log of EMCS availability as defined in the contract requirements to demonstrate successful completion of the Endurance test.

9.18 Contractor's Submittals after EMCS Acceptance.

Upon EMCS acceptance and prior to the job close-out, the inspector should verify that the contractor has submitted all documentation identified in the contract requirements. In the EMCS Guide Specifications, the contractor must submit the following documentation after EMCS acceptance:

- Operation and Maintenance Manuals.

  - Functional Design Manual.
  - Hardware Manual.
  - Software Manual.
  - Operator's Manual.
  - Maintenance Manual.

- Software - in source code (a programming language such as FORTRAN) and object code (a code translated from source code so that it can be executed by the computer). Typically, the EMCS source code contains numerous pages of documentation and may contain contractor proprietary information that must be safeguarded from public release as required by the Defense Acquisition Regulations.

CHAPTER 10

FACTORY TESTS

10.1 General.

Factory acceptance test procedures for Energy Monitoring and Control Systems (EMCS) are designed to demonstrate that the technical, operational, and performance requirements called for in the contract are tested and definitive results from the test procedures are documented. EMCS Factory Test Procedures Manual CR83.002 presents generic tests which establish the minimum requirements for factory test acceptance of each generic EMCS size configuration (large, medium, and small). Micro systems are generally not tested in the factory. Actual test procedures for a particular EMCS project must be provided by the contractor and must address all hardware and software requirements specified in the contract documents. The inspector should verify that the contractor has successfully completed all approved Factory Tests before any EMCS equipment is installed in the field.

10.2 Contractor's Requirements.

Prior to the initiation of the tests, the contractor provides the Factory Test plans and procedures, plus sufficient documentation on the following to conduct the Factory Tests:

- EMCS hardware description.
- EMCS software description.
- Operator's commands.
- I/O summary tables with failure modes for test points.
- Required passwords for each operator access level.
- Description of each type of digital I/O and analog I/O in the data environment emulator (DEE).
- List of test equipment.

For each application program shown in the I/O summary table, the contractor provides:

- Inputs required for each program (I/O point values and status) and corresponding expected results for each set of input values.

- Default values for the program inputs in the application programs to be tested.

- Failure modes for each I/O function required in the project.

10.3 Test Equipment and Setup.

All test equipment must be traceable to NBS Standards or verified against a primary standard. The accuracy of the test equipment and overall test method must be at least twice the maximum accuracy required for the test. For example, if the temperature sensor has an accuracy of ± 1°F over the expected range, the test instrument used should have an accuracy of at least ± 0.5°F. All test equipment is provided by the contractor unless otherwise noted in the contract documents.

10.4 Overview of Factory Tests on EMCS Hardware.

Prior to shipment of any equipment, excluding sensors, controls and DTC's, specific software and hardware components of large, medium and small EMCS are tested in accordance with the approved factory test plan and approved test procedures. The contractor must provide the model numbers of the assembled factory test EMCS to establish that the tested equipment matches the model numbers of the equipment to be delivered to the Government installation.

The factory tests on EMCS hardware generally include the following:

- CCU
- All mass storage systems
- CCC**
- Failover controller**
- Operator's console
- System terminal
- System RTC
- Alarm and logging printers
- Data environment emulator (contractor owned)
- Two FIDS
- FID test set
- Sufficient MUX* or IMUX panels to demonstrate I/O capability to be provided.
- I/O functions required in the I/O summary forms.
- Communications links of every type to be used during the actual installation and other data transmission equipment including MODEMS.
- Surge protection equipment for power lines, data communication links, and function card signal lines as specified. (Fuses are not to be used for surge protection.)

Factory Test procedures for EMCS hardware and software are described in more detail in the EMCS Factory Test Procedures Manual CR83.002.

* Large/Medium EMCS
**Large EMCS

10.5 Overview of Factory Tests on EMCS Software.

a. System Operating Modes.

Factory tests on EMCS software are generally conducted under the following system operating modes:

- Normal mode
- Normal heavy load
- Abnormal conditions
- Failure mode
- Power failure

(1) Normal Mode

Unless otherwise noted, all EMCS software tests are conducted under normal mode operation, in which EMCS equipment is operating and performing all of its assigned tasks.

(2) Normal Heavy Load Conditions.

Normal heavy load conditions are specified in the contract documents. For a typical large generic EMCS, the following occurrences take place during successive one second intervals:

- Three status changes
- Three digital alarms
- Three analog high or low limit alarms
- Three analog quantity changes within the high and low limits.

Factory tests on system response under normal heavy load conditions include the following:

- System reaction to alarms
- System reaction to commands
- CCU data base update

(3) Abnormal Conditions.

Abnormal conditions occur when there are at least 10 times the occurrences specified under normal heavy load conditions. The system update rate is proportionately longer than the required response rate during normal heavy load conditions. Factory tests on EMCS response during abnormal conditions include the following:

- System response to commands
- System response to alarms

(4) Failure Mode. An EMCS component is in the failure mode if it is not operating and performing its assigned tasks. An EMCS component failure can cause a change in the operation of other EMCS components in response to the failure. Factory tests include EMCS response to the component failure modes for the following:

- CCU
- CCC**
- Disk Storage
- Printer and CRT
- CLT and DTM
- FID/MUX*/IMUX

(5) Power Failures. Power failures cause an orderly shutdown of the CCU and peripherals without loss of contents of memory, registers, or machine status. Upon restoration of power, the EMCS initiates automatic restart of system in accordance with the specifications. Factory tests on EMCS response to power failure and automatic restart include the following components:

- CCU
- CCC**
- FID/MUX*/IMUX

b. Software Tests.

Factory tests on CCU software include all system software, command software and applications programs. Contractor furnished test software for CCU, CCC** and peripherals must demonstrate all system functions required in the contract documents.

Factory tests on FID resident applications programs are performed in normal and stand-alone modes. The contractor furnished test software must demonstrate all local software functions required in the contract documents.

Factory test procedures for generic EMCS software are described in more detail in the EMCS Factory Test Procedures Manual CR83-002.

* Large/Medium EMCS
**Large EMCS

CHAPTER 11

SITE TESTS

11.1 General.

Site tests are conducted after the installation of EMCS components. Site tests include:

- Ground Rod Test
- Contractor's Field Tests
- Performance Verification Tests
- Endurance Test
- Seasonal Endurance Tests

11.2 Grounding and Ground Rod Tests.

a. General.

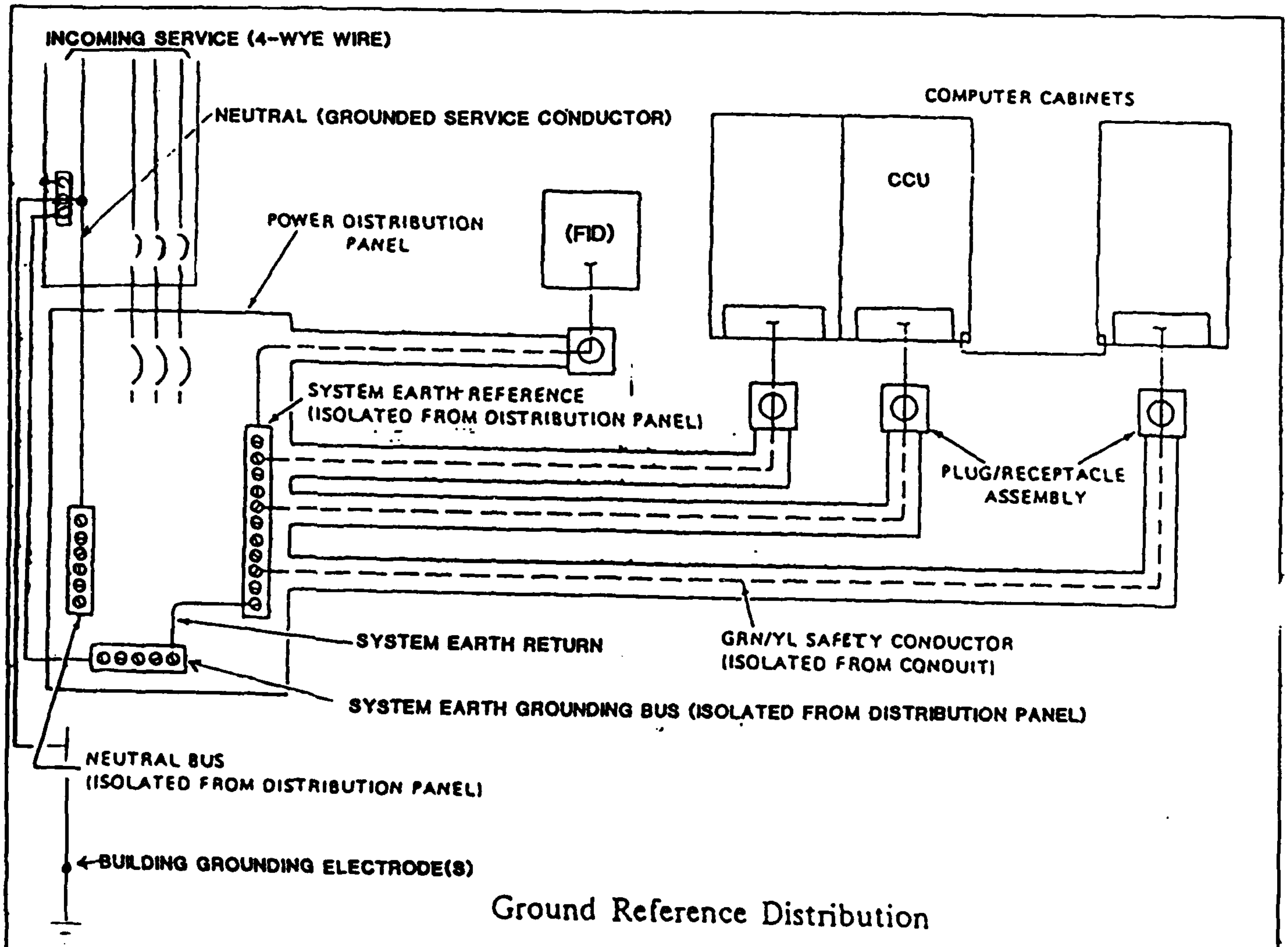
Grounding for a computer system will include grounding for both safety and electromagnetic interference reduction.

The requirements for grounding of a specific system are specified by the computer manufacturer and are shown or referenced in the manufacturer's technical manuals. These requirements should also be reflected in the contractor's shop drawings.

Figure 11-1 is a representative drawing of a ground reference distribution showing:

- A 5-wire wye computer power feeder. The 4th and 5th wires are used for a separate neutral conductor and a ground conductor.
- A common system earth reference.
- Separate ground returns for the individual computer components in the system.
- For clarity, the AC power distribution is not shown.

Analog signal wiring is considered low level wiring and is shielded in order to protect the analog signals from electrostatic interference. A shield for low level wiring must be connected to a ground reference in order to effectively protect the analog signals.



Ground Reference Distribution

Figure 11-1

The RTD sensor in Figure 11-2 is connected to the EMCS System with a shielded wire. The shield, in turn, is connected to a common point in the FID or IMUX cabinet and the common point connected to the ground distribution network.

b. Grounding.

The grounding tests are conducted by the contractor. The inspector verifies that the tests have been successfully completed and documented.

An important part of site preparation is to ensure that both the power and earth reference distribution comply with the National Electrical Code for safety and with the computer manufacturer's requirements. The successful installation of a computer system requires careful attention to the details of ground distribution.

Grounding means "a connection to the earth for conducting electrical current to and from the earth". There are two purposes for establishing an earth connection to equipment and systems:

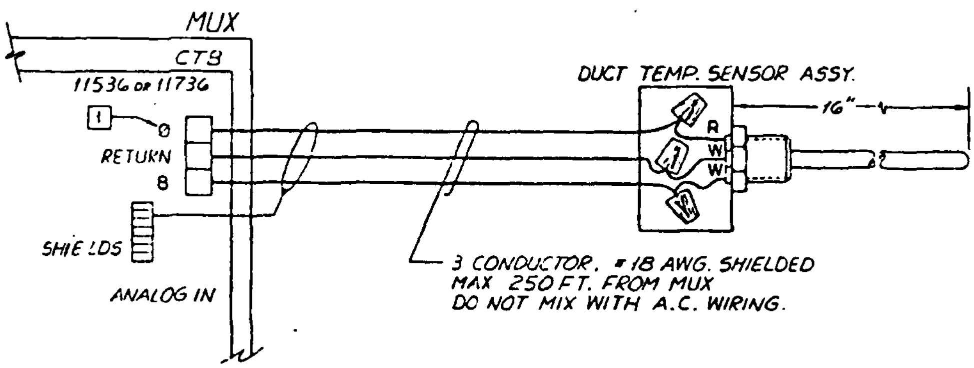
- Safety - To prevent a shock hazard in the event that an equipment chassis frame or housing develops a hazardous voltage due to lightning or an accidental breakdown of wiring or components.
- Electromagnetic Capability - To reduce susceptibility interference, equipment chassis are earth referenced at one common point.

The requirements for ground and bonding of electrical installations are specified in the National Electrical Code. This is detailed in Article 250 of the NEC.

In order to meet the grounding requirements, as outlined in the NEC, particular attention must be paid to bonding, grounding conductors and electrodes, and the size of the grounding conductors.

The equipment grounding conductors must be no smaller than 14 AWG and the grounding electrode conductor no smaller than 8 AWG. The sizing of the conductors is outlined in Article 250 of the NEC.

Surge protection of equipment, power and communication lines are required and specified in the EMCS specifications. This specification requires the protection to be mounted near the equipment to be protected, in a separate metallic enclosure at ground potential.



DETAIL 14 -- RTD DUCT TEMPERATURE SENSOR

Figure 11-2

c. Earth Ground Resistance Test.

The "three terminal" or "fall of potential" method is used to determine earth resistance. The NEC requires this to be 25 ohms or less.

Instruments for earth-resistance tests include:

- A voltage source.
- An ohmmeter to measure resistance directly.
- Switches to change the instrument's resistance range. Extension wires connect four terminals (P_1, C_1, P_2, C_2) on the instrument to the earth and reference electrodes, as shown in Figure 11-3.

This test is described in greater detail in the James G. Biddle Co. Publication "Getting Down to Earth".

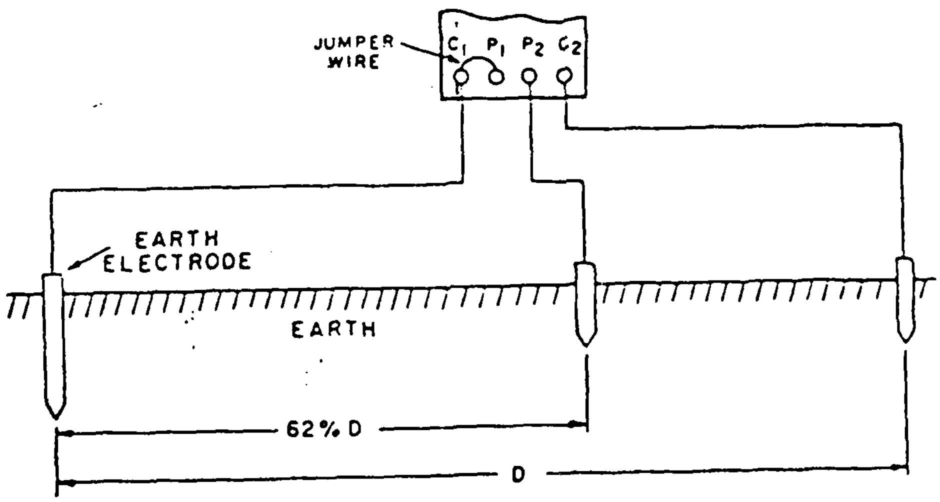
11.3 Contractor's Field Tests.

a. General.

Field tests are conducted by the contractor to demonstrate that the EMCS equipment is fully operational in accordance with the contract requirements. These tests are conducted prior to the Performance Verification Tests. All field tests must be successfully completed and results submitted to the Government before the Performance Verification Tests begins. Field tests are conducted at each level of control and monitoring, starting at the sensors and controls, progressing to the FID°/MUX*/IMUX and terminating at the MCR. At the end of the field tests, the contractor submits EMCS field test results, which include the following:

- Field equipment operation and calibration including testing of all sensors and controls including failure mode operation FID°/MUX*/IMUX using a diagnostic portable device.
- Data transmission media and equipment operation and tests.
- Total EMCS operation tests using the approved Performance Verification Test Plans and Procedures as a guideline for the field tests.
- Certification that all field tests have been completed and that the system is ready for the Performance Verification Tests.

°Large/Medium/Small EMCS
*Large/Medium EMCS



"FALL-OF-POTENTIAL" OR "THREE-TERMINAL
EARTH-RESISTANCE TEST

Figure 11-3

b. Field equipment operation and calibration.

Field equipment includes the FID°/MUX*/IMUX, the data terminal cabinet, sensors, and controls. Calibration tests on field equipment are conducted during normal mode operation using standards traceable to the National Bureau of Standards or primary standards. Diagnostic tests on the FID°/MUX*/IMUX are performed using a portable diagnostic device. Data transmission between the FID° and MUX*/IMUX is also tested.

The inspector should verify that the contractor has submitted the results of the functional and diagnostic tests and calibrations on all field equipment to the Government prior to the Performance Verification Tests.

c. Data transmission media (DTM).

After sensor and control operation is verified, the data transmission media is tested to verify end-to-end data transmission accuracy between the FID°/MUX*/IMUX and MCR. The inspector should verify the contractor has successfully completed the DTM and equipment tests for the performance of EMCS monitoring and control functions and submitted the results of DTM and equipment tests under normal mode and heavy load conditions.

11.4 Performance Verification Tests and Endurance Test.

a. General.

Performance Verification Tests are designed to demonstrate compliance of the completed EMCS with the contract requirements. EMCS Performance Verification and Endurance Test Procedures CR83.003 presents generic tests which establish the minimum requirements for Performance Verification Test acceptance of each generic EMCS size configuration (large, medium, small and micro). Actual test procedures for a particular EMCS project must be provided by the contractor and must address all hardware and software requirements specified in the contract documents. Performance Verification Tests are conducted on the EMCS during various system operating modes, including normal mode, normal heavy load, abnormal conditions, failure mode, and system power failure.

°Large/Medium/Small EMCS
*Large/Medium EMCS

b. Contractor's Requirements.

Prior to the initiation of the tests, the contractor provides the Performance Verification Test plans and procedures, plus sufficient documentation on the following to conduct the Performance Verification Tests:

- EMCS hardware description.
- EMCS software description.
- Draft Operations and Maintenance Manuals.
- I/O summary tables with failure modes.
- Required passwords for each operator access levels.
- Description of each type of digital I/O and analog I/O to be used in the test.
- List of test equipment.

For each application program shown in the I/O summary table, the contractor provides:

- Inputs required for each program (I/O point values and status) and corresponding expected results for each set of input values.
- Default values for the program inputs in the application programs to be tested.
- Failure modes for each I/O function required in the project.

c. Test Equipment and Setup.

All test equipment must be traceable to NBS Standards or verified against a primary standard. The accuracy of the test equipment and overall test method must be at least twice the maximum accuracy required for the test. For example, if the temperature sensor has an accuracy of $\pm$ 1°F over the expected range, the test instrument used should have an accuracy of at least $\pm$ 0.5°F. All test equipment is provided by the contractor unless otherwise noted in the contract documents.

11.5 Endurance Test.

The Endurance Test is conducted after successful completion of the Performance Verification Tests. According to the EMCS Guide Specifications for a large EMCS, the Endurance Test requires the EMCS to perform its functions in accordance with contract requirements for 30 consecutive days, 24 hours per day. During this period, the EMCS must maintain a level of availability that is defined in the contract documents.

The following definition is a typical example of a definition for availability:

$$\text{Availability} = \frac{\text{TP - Summation of Outages}}{\text{TP}}$$

Where: TP = The test period in hours

Summation of Outages = Total number of points out of service divided by the total number of points in the system times the length of outage in hours. The summation is totalized and updated each hour of the test period.

Some types of outages may not be included in the determination of EMCS availability. For example:

- Power failure in excess of the specified backup source requirements.
- Communication link failures on equipment not furnished by the contractor.
- Existing equipment failure.
- Equipment failure from sensor or controller failure (assuming no more than one percent of the sensors and controls are out of service at any time. Failures in excess of the percent are included in the determination of availability).
- System hardware that fails and is restored to service within 72 hours of failure.

The contractor must keep a record of the time and cause of each outage that takes place during the test period. The contractor must also provide the operators to man the system for at least eight hours per day for the duration of the Endurance Test. In all cases, the system must continue to operate in accordance with the operational requirements (normal and failure modes) established in the contract documents.

If the EMCS availability level falls below the minimum requirement during the test period, the Endurance Test is extended on a day-by-day basis until the availability requirements are maintained for 30 consecutive days. If the availability consistently falls below the minimum requirements, the Contracting Officer can recommend termination and rescheduling of the Endurance Test. The Endurance Test results are submitted to the Government after the test is successfully completed. EMCS acceptance is dependent upon the Government receipt of the test results and upon the contractor correcting all outstanding deficiencies. The Endurance Test is described in more detail in the EMCS Performance Verification Tests CR83.003.

11.6 Seasonal Endurance Test.

During the warranty period but no later than six months from the completion of the Endurance Tests, the contractor performs a Seasonal Endurance Test. This test is designed to demonstrate that the EMCS operates according to contract requirements during the heating or cooling season that is opposite the heating or cooling season when the Performance Verification and Endurance Tests were successfully performed. Heating or cooling equipment that was not in operation during the Performance Verification Tests can therefore be tested in the Seasonal Endurance Test.

The contractor also provides the operators to man the system at least eight hours a day during the entire test. The EMCS must maintain an availability level specified in the contract documents for the duration of the test. Upon completion of the Seasonal Endurance Test, the contractor submits the results of the tests for Government approval. Failure to maintain the required availability for the duration of the test will necessitate extension of the test until the total time requirement with the required availability is achieved.

CHAPTER 12

TRAINING

The contractor° provides training on the operation, maintenance, and programming of the actual EMCS configuration installed on the site. Generalized types of instruction (canned lessons) are not acceptable. The contractor must provide instructors that are familiar with the subject matter, provide training manuals for each trainee, and provide equipment and materials required for presentation. The training program can consist of three phases or as specified in the contract documents.

a. Phase I training is provided to operating personnel prior to the Performance Verification Test (either at the factory or on-site or as required by contract) and during the Endurance Test for the time periods specified in the contract documents. Phase I training includes the following:

- General EMCS architecture
- Operation of computer and peripherals equipment
- System initialization procedures
- Operator commands
- Operator diagnostics
- Color graphics generation
- Failure-recovery procedures
- Report formats
- Alarm formats

b. Phase II on-site training is provided to operators, equipment maintenance personnel and programmers after the Performance Verification Tests for a time period specified in the contract documents. Operators receive a refresher course on the Phase I training plus additional detailed information. Equipment maintenance personnel are trained on the following:

- General equipment layout
- Troubleshooting and diagnostics
- Repair instruction
- Preventive maintenance and calibration of field equipment

° Large/Medium/Small EMCS
* Large/Medium EMCS
**Large EMCS

Programmers are trained on the following:

- Software architecture
- Command software
- CCU-CCC** applications programs
- FID° applications programs

c. Phase III on-site training is provided to operators and programmers after the completion of Phase II training for the time period specified in the contract documents. Operators are trained on advanced operations materials and programmers are trained on advanced materials such as:

- Operator command
- Interrupt logic
- Interfaces
- Diagnostics
- Communications software
- Applications programs manipulation and design
- File management
- FID° programming

° Large/Medium/Small EMCS
* Large/Medium EMCS
**Large EMCS

CHAPTER 13

WARRANTY

The warranty period starts after EMCS acceptance and is provided by the contractor for one year or longer if required by the contract documents. Warranty requirements are detailed in the contractural provisions of the contract documents. In general, warranty covers any repair of equipment and software that fails during the warranty period.

CHAPTER 14

MAINTENANCE AND SERVICE

EMCS maintenance and service can either be performed by the Government or the contractor if required by the contract documents. If the maintenance and service is provided by the contractor, the contractor must provide all services, materials, and equipment necessary to maintain in operation the entire EMCS for the period called for in the contract documents, after the system is accepted by the Government. All EMCS hardware/software is included under the maintenance and service requirements of the contract, including:

- All MCR computer equipment.
- Software updates of the system software.
- Command software.
- Application software.
- Contractor furnished data transmission media and equipment.
- FID°/MUX*/IMUX panels.
- Sensors and control devices installed as part of the EMCS contract.

The contractor's responsibility is limited to the EMCS equipment, the actual interface devices between the existing local loop control system and the EMCS, and all other equipment furnished as a part of the contract. After EMCS acceptance, the local loops existing prior to EMCS installation become the responsibility of the Government and are not included in the maintenance and service contract unless specifically called for in the contract documents. The contractor is also required to schedule quarterly inspections in accordance with the contract requirements. Minor inspections, scheduled at six month intervals or less, include the following tasks:

- Visual checks of EMCS hardware.
- Mechanical adjustments on peripherals.
- Fan checks and filter changes.

Major inspections, scheduled between minor inspections at six month intervals, include all minor inspection work plus the following:

- Cleaning EMCS hardware.
- Signal voltage and system isolation checks.
- Field device check and calibration.

° Large/Medium/Small EMCS
* Large/Medium EMCS
**Small EMCS

- System software diagnostics and correction.
- Resolution of outstanding problems.

Scheduled maintenance is performed during regular working days and hours. The contractor must notify the Government of scheduled maintenance work at least seven days in advance. Emergency service requests from the Government must be provided by the contractor within 24 hours of the service call or as called for in contract. The contractor is required to keep records and logs of scheduled maintenance work on all devices on a building-by-building basis. Records of work requests and corrective action taken are also required from the contractor.

° Large/Medium/Small EMCS
* Large/Medium EMCS
**Large EMCS

APPENDIX A

DEFINITIONS

Algorithm:	A set of well defined rules or procedures for solving a problem or providing an output from a specific set of inputs.
Analog:	A continuously varying signal value temperature, current pressure, etc.)
Analog to Digital Converter:	A circuit or device whose input is information in analog form and whose output is the same information in digital form.
Architecture:	The general organization and structure of hardware and software.
ASCII:	American Standard Code for Information Interchange. An 8-bit coded character set to be used for the general interchange of data among information processing systems, communications systems, process control systems, and associated equipment. Various character/graphic subsets are discussed in FIPS PUB 15.
Assembler:	Utility program which translates assembly language source code into the machine-executable object code.
Assembly language:	A low-level computer language used to program and manage the operations of a computer.
Asynchronous Computer:	An automatic digital computer in which each operation starts as a result of a signal generated by the completion of the previous event or operat'.n, or by the availability of the parts of the computer required by the next event or operation.
Asynchronous	Data transmission in which each character contains its own start and stop bits.

Automatic Temperature — A local loop network of pneumatic or electric/electronic devices which are interconnected to control temperature.

Background Programming: A feature of computer hardware to provide a means of writing, testing, and debugging a software program on the computer at the same time the computer is performing other "Real Time" programs.

BASIC: An acronym for Beginners All-Purpose Symbolic Instruction Code, a highlevel, English-like programming language used for general applications.

Baud: A unit of signalling speed equal to the number of discrete conditions, or signal events, per second.

Bit: An acronym for binary digit. The smallest unit of information which can be represented. A bit may be in one of two states, represented by the binary digits 0 and 1.

BCD: Binary Coded Decimal.

Bit Error Rate: The number of incorrect or erroneous bits divided by the total number (correct plus incorrect) over some stipulated period of time.

Bootstrap: A technique or device designed to bring a computer into a desired state by means of its own action.

Break Point: A point in a program where an instruction or other condition enables a programmer to interrupt the running of a program by external intervention or a monitor routine. Used in debugging.

Buffer: A temporary data storage device used to compensate for a difference in data flow rate or event times, when transmitting data from one device to another.

Bus:	A circuit path (or parallel paths) over which data instructions are transferred to all points in the computer system. Computers have several separate busses: the data, address, and control busses are those of greatest importance.
Byte:	Eight bits.
Call:	A term used to designate the software procedure by which software control is transferred to a callable subroutine.
Callable:	A subroutine module to which software control can be transferred.
Cathode Ray Tube (CRT):	An electron beam tube in which the beam is focused to a small cross section on a luminescent screen and varied in position and intensity to produce a visible pattern.
Central Memory:	Core or semiconductor memory which communicates directly with a CPU.
Central Communication Controller (CCC):	A computer that performs data gathering and dissemination from and to the FIDs, as well as providing limited backup to the CCU.
Central Processing Unit (CPU):	The portion of a computer that performs the interpretation and execution of instructions. It does not include memory or I/O.
Central Control Unit (CCU):	A process control digital computer that includes a CPU, central memory, and I/O bus.
Character:	One of a set of elementary symbols which normally include both alpha and numeric codes plus punctuation marks and any other symbol which may be read, stored, or written.
Communications Link Terminations (CLT):	An independent peice of hardware that provides an interface point between the CCC and/or CCU and the Data Transmission Links.

<u>Clock</u>: A device or a part of a device that generates all the timing pulses for the coordination of a digital system. System clocks usually generate two or more clock phases. Each phase is a separate, square wave pulse train output.

<u>Command Line Mnemonic (CLM)</u>: A computer language consisting of a set of fixed, simplified English commands designed to assist operators unfamiliar with computer technology in operating the EMCS.

<u>Command Line Mnemonic Interpreter (CLMI)</u>: Software used to implement the CLM language.

<u>Compiler</u>: A language translator which converts source statements written in a high level language into multiple machine instructions. A compiler translates the entire program before it is executed.

<u>Controls</u>: Devices which govern the performance of a system.

<u>Control Point Adjustment (CPA)</u>: The procedure of changing the operating point of a local loop controller from a remote location.

<u>Control Sequence</u>: Equipment operating order established upon a correlated set of data environment conditions.

<u>Core Resident</u>: Core resident specifies a program which currently resides in central memory (and may thus be considered active) as opposed to programs residing on the disk which must be loaded into central central memory for execution.

<u>Crowbar</u>: An electronic circuit which can rapidly sense an over voltage condition and provide a solidstate low impedance path to eliminate this transient condition.

<u>Cycle Time</u>: In microseconds/word for central memory is the minimum time interval that must elapse between the starts of two successive accesses to any one storage location.

Data Communications Equipment:	A device for transmitting digital information to and from any other system.
Data Environment (DE):	The sensors and control devices connected to a single FID/MUX/IMUX (IMUX only in small and micro systems) from the equipment and systems sampled or controlled.
Data Terminal Cabinet (DTC):	An independent metallic enclosure that provides an interface point between the FID/MUX/IMUX Field Wiring Terminals and the Data Environment.
dbm:	A measure of absolute power values. Zero dbm equals one milliwatt.
Data Transmission Media (DTM):	Transmission equipment including cables and interface modules (excluding MODEMs) permitting transmission of digital and analog information.
Debug:	The procedure of running a program to detect and correct errors in a program.
Decibel (db):	The standard unit for expressing transmission gain or loss utilizing logrithmic power and voltage ratios.
Deck:	In HVAC terminology, the air discharge of the hot or cold coil in a duct serving a conditioned space.
Demand:	The term used to describe the maximum rate of use of electrical energy averaged over a specific interval of time and usually expressed in kilowatts.
Demultiplexer:	A device used to separate two or more signals previously combined by compatible multiplexer for transmission over a single circuit.
Diagnostic Program:	Machine-executable instructions used to detect and isolate malfunctions.
Digital Signals:	A discontinuous signal, the various states of which are descrete intervals apart. In radix 2 the signal is either on or off (zero or one) and is referred to as binary.

<u>Direct Digital Control (DDC)</u>: Sensing and control of processes directly with digital control electronics.

<u>Digital to Analog (D/A) Converter</u>: A hardware device which converts a digital signal into a voltage or current proportional to the digital input.

<u>Direct Memory Access (DMA)</u>: Provision for transfer of data blocks directly between central memory and an external device interface.

<u>Disk Storage</u>: A bulk storage, random access device for storing digital information. Usually constructed of a thin rotating circular plate having a magnetizable coating, a read/write head and associated control equipment.

<u>Distributed Processing System</u>: A system of multiple processors each performing its own task, yet working together as a complete system under the supervision of a central computer, to perform multiple associated tasks.

<u>Download</u>: The transfer of digital data or programs from a host computer to another data processing system such as central computer to microcomputer.

<u>Driver/Handler</u>: Software which manages input/output to and from a given peripheral device.

<u>Duplex</u>: A method of operation of a communications line in which each terminal can simultaneously transmit and receive.

<u>EMCS</u>: Energy Monitoring and Control System.

<u>Executive Program</u>: The main system program designed to establish priorities and to process and control other programs.

<u>Failover Controller</u>: A hardware device or software to transfer the communications function from CCU to CCC in the event of CCU failure, or the communications functions from CCC to CCU in the event of CCC failure.

Fall-Back Mode: The pre-selected operating mode of a FID when communications cease with the MCR or the operating sequence of each local control loop when the FID to which it is connected ceases to function.

Field Interface Device (FID: A small, intelligent hardware device containing software which implements the distributed processing aspects of operation with the central computer as well as maintaining effective control of field control loops in the absence of higher level influence. Operating constants are changed by down-line loading from the CCC as well as from within the FID.

Firmware: A procedure for accomplishing arithmetic operations where the instruction set is resident in ROM or PROM.

FORTRAN: An acronym for FORmula TRANslation. A highlevel, English-like programming language used for technical applications.

Function Keys: Keys which, when depressed, send more than one character and are interpreted by the computer as a specific command.

Half duplex: A method of operation of a communications line in which each terminal can transmit and receive, but not simultaneously.

Hardware: Equipment such as a CPU, memory, peripherals, sensors, and relays.

Hardware Vectored Interrupts: Hardware feature which allows the CPU to directly determine the identity of an interrupting device and to automatically transfer control to a program which will service the interrupt.

Initialization: (of the System) The process of loading the operating system with the computer. Initialization is required to start normal operation of the computer after the computer has been out of service.

Intelligent Multiplexer (IMUX):	A device that combines data from a number of points in the DE and communicates on a single channel in the "report by exception" mode.
Input/Output Bus:	The connection through which data is transmitted and received from peripheral devices interacting with the processor.
Input/Output (I/O) Device:	Digital hardware that transmits or receives data.
Interactive:	Functions performed by an operator with the machine prompting or otherwise assisting these endeavors, while continuing to perform all other tasks as scheduled.
Interpreter:	A language translator which converts individual source statements into machine instructions by translating and executing each statement as it is encountered.
Interrupt:	An external or internal signal requesting that current operations be suspended to perform more important tasks.
Large Scale Integration (LSI):	The technology of manufacturing integrated circuits capable of performing complex functions. Devices of this class contain 100 or more logic gates of a single chip.
Line Conditioning:	Electronic modification of the characteristic response of a line to meet certain standards. The characteristics include frequency response, signal levels, noise suppression impedance, and time delay.
Line Driver:	A hardware element which enables signals to be directly transmitted over circuits to other devices some distance away.
Loader:	A program used to prepare the computer and store other programs into memory locations in preparation for machine execution.

Local Loop Control: The controls for any system or subsystem which existed prior to the installation of an EMCS and which will continue to function when the EMCS is non-operative.

Macro: A single programming symbolic instruction that generates multiple assembly language instructions.

Machine Language: The binary code corresponding to the instruction set of the CPU.

Master Control Room (MCR): The central Facility containing the operator console, CCU, CCC, and related equipment for control and supervision of the complete EMCS.

Medium Scale Integration (MSI): As in LSI but to a lesser degree.

Memory: Any device that can store logic 1 and logic 0 bits in such a manner that a single bit or group of bits can be accessed and retrieved.

Memory Address: A binary number that specifies the precise memory location of a stored word.

Memory Modules: Increments of memory, usually 4K, 8K, 16K, etc. words in length.

Microcomputer: A computer system based on a microprocessor and containing all the memory and interface hardware necessary to perform calculations and specified transformations.

Microprocessor: A central processing unit fabricated as one integrated circuit.

Mnemonic: A symbolic representation or abbreviation to help operators remember and understand.

MODEM: An acronym for MOdulator/DEModulater. A hardware device used for changing digital information to and from an analog form to allow transmission over voice grade circuits.

Multiplexer MUX: A device which combines multiple signals on one transmission media.

Multi-Tasking: The procedure allowing a computer to perform a number of programs simultaneously under the management of the operating system.

Non-Volatile Memory: Memory which retains information in the absence of applied power (i.e.; magnetic core, ROM, and PROM).

Normal Mode Operation: Equipment operating and performing its assigned tasks.

Object Code: A term used to describe machine language.

Operating System: A complex software system which manages the computer and its components and allows for human interaction.

Optical Isolation: Electrical isolation of a portion of an electronic circuit by using optical semiconductors and modulated light to carry the signal.

Parameter: A variable that is given a constant value for a specific purpose or process.

Parity: A checking code within a binary word used to help identify errors.

PASCAL: A "structured programming" high level computer language.

Peripheral Equipment: Equipment used for man-machine communications and further support of a processor.

Point: Individual connected monitor or control devices (i.e., relay, temperature sensor).

Predictor/Corrector Program: Applications software which allows continuous prediction of a future value and subsequent correction based on actual measurements.

Process Automation: Process control without human intervention.

Process Control:	The collective functions performed by the equipment which is to control a variable.
Program:	A sequence of instructions causing the computer to perform a specified function.
Prompt/Response Sequence:	Man-Machine dialogue by which the computer asks questions and requests responses from the operator.
Protocol:	A formal set of conventions governing the format and relative timing of message exchange between two terminals.
Random Access Memory (RAM):	Volatile semiconductor data storage device in device in which data may be stored or retrieved. Access time is effectively independent of data location.
ROM, PROM, EPROM, EEPROM:	Read-Only-Memory, Programmable ROM, Erasable PROM, Electronically Erasable PROM. All are non-volatile semiconductor memory.
Real Time:	A situation in which a computer monitors, evaluates, reaches decisions, and effects controls within the response time of the fastest phenomenon.
Real Time Clock (RTC):	A device which indicates actual time of day. The RTC may be updated by hardware or software.
Register:	A digital device capable of retaining information.
Reinitialization:	Refer to initialization.
Resistance Temperature Detector (RTD):	A device where resistance changes linear as a function of temperature.
RTDOS/E:	Real-Time Disk Operating System/Executive.
Selective Generation:	Where the management of input/output is restricted to selected peripherals.

Sensors:	Devices used to detect or measure physical phenomena.
Single Stepping:	Procedure by which the next statement in a core resident program is executed by depressing a switch.
Snapshot:	Picture of the instantaneous status and state of a system.
Software:	A term used to describe all programs whether in machine, assembly, or high-level language.
Source code:	A term used to describe assembler and high level programmer developed code.
Stand-Alone:	A term used to designate a device or system which can perform its function totally independent of any other device or system.
Supervisory Control:	Separate (and usually remote) control and monitoring of local control loops. (See Direct Digital Control.)
System Normal Heavy Load Conditions:	System normal heavy load conditions are defined as the occurrence throughout the system of a total of three status changes, three digital alarms, three analog high or low limit alarms, and three analog quantity changes within the high and low limits during a single one second interval. This number of similar occurrences shall repeat on a continuous basis during successive 1 second intervals for up to 30 seconds. The system normal heavy load conditions shall have 50 percent of the changes and alarms, including no less than one of each type, occurring at a single FID, MUX, or IMUX with the remaining changes and alarms distributed among the remaining FID/MUX/IMUXs. No DTM link shall be more than 65 percent loaded during this normal heavy load condition and the alarm printer shall continue to print out all occurrences.
Throughput:	The total capability of equipment to process or transmit data during a specified time period.

Time Base Generator (TBG):	See Clock
Time Tag:	Date and time of occurrence of an event.
True digital:	A representation of any value by symetric digits, used to form fixed length words.
Volatile Memory:	A semiconductor device in which the stored digital data is lost when power is removed.
Word:	A set of binary bits handled by the computer as the primary unit of information.
Zone:	An area composed of a building, a portion of a building, or a group of buildings affected by a single device or piece of equipment.

ABBREVIATIONS

AA	Analog alarm
ac	Alternating current
A/D	Analog to digital
AHU	Air handling unit
AI	Analog input
AO	Analog output
ASCII	American Standard Code For Information Interchange
ATC	Automatic temperature control
B/C	Benefit to cost ratio
bps	Bits per second
Btu	British thermal unit
CCC	Central communications controller
CCU	Central control unit
CHW	Chilled water
CLM	Command line mnemonic
CLMI	Command line mnemonic interpreter
CLT	Communications link termination
CPA	Control point adjustment
cps	Characters per second
CPU	Central processing unit
CRT	Cathode ray tube

CT	Current transformer
D/A	Digital to analog
dB	Decibel
dc	Direct current
DDC	Direct digital control
DE	Data environment
DI	Digital input
DMA	Direct memory access
DO	Digital output
DPS	Differential pressure switch
DTC	Data terminal cabinet
DTM	Data transmission media
DX	Direct expansion
E/C	Energy to cost ratio
EMCS	Energy monitoring and control systems
EMI	Electromagnetic interference
EEPROM	Electronically erasable PROM
EPROM	Erasable PROM
FCB	Failover control board
FID	Field interface device
FS	Flow switch
FSK	Frequency shift keying
H/C	Hot/cold

HOA	Hand-off-automatic
HVAC	Heating, ventilating, and air conditioning
HW	Hot water
IC	Integrated circuit
I/O	Input/output
kHz	Kilohertz
kW	Kilowatt
kWh	Kilowatt-hour
lpm	Lines per minute
LSI	Large scale integration
mA	Milliamp
Mb	Megabyte
MBtu	Btu (millions)
MCR	Master control room
MHz	Megahertz
MODEM	Modulator/demodulator
MUX	Multiplexer
OA	Outside air
PROM	Programmable ROM
PS	Pressure switch
psi	Pounds per square inch
psia	Pounds per square inch, absolute
psid	Pounds per square inch, differential

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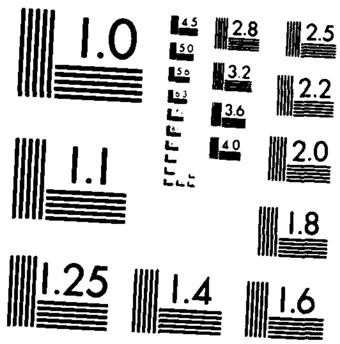

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

psig	Pounds per square inch, gauge
PT	Potential transformer
RAM	Random access memory
RF	Radio frequency
RFI	Radio frequency interference
RH	Relative humidity
RHT	Reheat
ROM	Read only memory
RT	Run time
RTC	Real time clock
RTD	Resistance temperature detector
SCR	Silicon controlled rectifier
S/I	Simple savings to investment ratio
SIR	Discounted savings to investment ratio
S/N	Signal to noise ratio
S/S	Start/stop
TTL	Transistor-transistor logic

APPENDIX B

APPLICABLE PUBLICATIONS

1. American National Standards Institute (ANSI) Publications:

C2-81	National Electrical Safety Code
C12-1978	Electricity Metering, Code for
C57.13-1978	Requirements for Instrument Transformers
MC96.1-1975	Temperature Measurement Thermocouples
X3.64-1979	National Standard Code for Information Interchange (ASCII)
X3.9-1978	Programming Language, FORTRAN
X4.14-1977	American National Standard Keyboard Arrangements Accommodating the Character Sets of ASCII and ASCSOCR

2. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Publication:

1981	Handbook of Fundamentals

3. American Society of Mechanical Engineers (ASME):

6th. ed., 1971	Fluid Meters, their Theory and Application

4. American Telephone and Telegraph Company:

BSP 41004-1973	Bell System Technical Reference Data Communications Using Voiceband Private Line Channels.

5. American Society for Testing and Materials (ASTM):

   B117-73 Salt Spray (Fog) Testing

6. Automatic Process Control

   Donald P. Eckman

   John Wiley & Sons, Inc.

7. Biddle Instruments, Blue Bell, Pa.

   (April 1981)

8. Carrier Corporation:

   The ABC's of Air Conditioning (1975)

9. Control Systems for Heating, Ventilating and Air Conditioning,

   Second edition

   Roger W. Haines

   Van Nostrand Reinhold Company

10. Electronic Industries Association (EIA) Publications:

RS-232-C-69	Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange
RS-422-A-78	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
RS-423-A-78	Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits

11. Federal Specification:

ZZ-R-765	Rubber, Silicone; Low and High Temperature and Tear Resistant

12. Fischer and Porter, Warminister, Pa.:

Guide to Flow Measurement

13. Honeywell Corporation:

Energy Conservation with Comfort (1979)

Software Dictionary (1980)

14. The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Publications:

IEEE Std.472-1974	IEEE Guide for Surge Withstand Capability (SWC) Tests.

15. Instrument Engineers Handbook, Volume I

"Process Measurement"

Bela G. Liptak, Editor

Chilton Book Company, Radnor, Pa.

16. McGuinness and Stein

Mechanical and Electrical Equipment for Buildings,

Wiley Publications, N.Y., 1971

17. Military Standards:

MIL-Std-461	Electronic Interference Characteristics Requirements for Equipment

18. National Electrical Contractors Association, Washington, D.C.

Microprocessor Based Energy Controls (1979)

19. National Electrical Manufacturers Association (NEMA) Publication:

WC41-1975	Coaxial Communication Cable (CATV)
ICS-1978	Industrial Controls and Sensors
MG1-1978	Motors and Generators
250-1979	Enclosures for Electrical Equipment (1,000 Volts Maximum)

20. National Fire Protection Association (NFPA) Publications:

NFPA 70-81	National Electrical Code

21. National Weather Service (NWS) Specifications:

A105-SP001	Pyrometers

22. Naval Civil Engineering Laboratory, Port Hueneme, Ca., Energy Monitoring and Control Systems:

- Factory Test Procedures (CR83.002) August 1982
- Performance Verification and Endurance Test Procedures (CR83.003) August 1982

23. Rural Electrication Administration (REA) Publications:

Form 511a	Specifications and Drawings for Construction of Pole Lines, Aerial Cables and Wires, Buried Cables and Wires, and Station Installation
PE20	Plastic Insulated - Plastic Jacketed Station Wire
PE22	Aerial and Underground Telephone Cable
PE23	Direct Burial Telephone Cable

24. University of California, San Diego (UCSD) Publications:

UCSD Pascal

25. U.S. Army Corps of Engineers, Huntsville, Alabama

Energy Monitoring and Control Systems (Technical Manual 5-815-2; Air Force: 88-36; Navy DM-4.9) Sept. 1, 1981

APPENDIX "C"

PARTIAL LIST OF EMCS INSPECTION ITEMS

<u>General</u>.

1. Contractor loads all software and operational data required for a fully operational system, including all graphic software fully integrated with live data.

2. Operating Manuals, Maintenance Manuals and Training Manuals are delivered by the contractor in regular print form. All documentation is provided in hard copy and not in reduced/alternate means such as MICROFICHE.

3. All documentation must be job specific and not of the generic type.

4. All field equipment must be labeled. Labels on all equipment must be the same as the names used in the data displays in Master Control Rooms and record drawings.

5. Installed equipment is the same as in the approved submittals and type successfully tested in factory tests, i.e., surge protection and overvoltage protection equipment.

6. Factory tests and field tests performed in accordance with approved procedures.

7. Grounding for all equipment must be in accordance with applicable Codes.

8. Contractor can not ship EMCS equipment to the job site prior to successful completion of the Factory Tests.

9. Contractor performs field tests including calibration of sensors and controls for his own benefit prior to the Performance Verification Tests.

10. Contractor provides the required manpower to operate system during Endurance Tests.

11. Training documentation and material including audio visual aids delivered to the job site.

12. Training is conducted by competent instructors using audio visual training materials.

13. Control diagrams must be posted in Mechanical Rooms.

14. Training program with time assignments for each phase must be submitted for approval.

Field Equipment.

15. FID/MUX/IMUX spare I/O functions are provided.

16. Battery backup for the entire FID/MUX/IMUX is provided for those FID/MUX/IMUX so designated on the contract drawings.

17. Battery backup for all FID real time clocks and RAM memory is provided.

18. FID support equipment and diagnostics for field equipment is provided.

19. FID/MUX/IMUX operational alarm functions are provided.

20. FID/MUX/IMUX control panel switches and indicators are provided.

21. Installed sensors meet accuracy requirements.

22. Data terminal cabinets provided with separate low voltage, line voltage raceways, and spare terminals.

Field Equipment Master Control Room.

23. Surge and overvoltage protection on input/output functions, power supplies, and communication equipment is provided.

24. Point loading for each DTM is below the maximum percentage stated in the specifications.

25. Lightning protection equipment is mounted in separate enclosures from the equipment that it is intended to protect.

26. All MODEMS are Bell System compatible.

Master Control Room.

27. Master Control Room electrical service wiring provided in accordance with the CCU/CCC manufacturer. Usually a five wire system is required.

28. FID support equipment including FID test set, data environment emulator, PROM programmer is interfaced with the CCU.

29. CCC is installed and operational as specified (large EMCS only).

30. Battery backup for CCU/CCC system real time clock is provided.

31. Number of disk controllers and disk drives are provided as specified and disk drive capacity is provided in accordance with approved disk sizing submittals.

32. Function keys on the color graphic operator's terminal are provided as specified.

33. Failover controller is operational as specified (large EMCS only).

34. Auto-answer-auto originate MODEM is operational and interfaced to CCU.

35. Software diagnostics for MCR equipment are furnished as specified.

36. Standard graphic symbol library is provided as specified.

37. Access to command line mnemonics is interfaced with user password access.

38. CLM commands are available under EMCS operating mode.

39. Standard reports are provided and implemented as specified.

40. FID software development capabilities are provided as specified.

41. CCU software development capabilities are provided as specified.

42. Command line mnemonics for the CCC while operating in the CCU backup mode, are similar to, or consistent with those provided with the CCU (large EMCS only).

43. RTC has 10 digit visual display.

44. Spare CRT and printer ports are provided in CCU as specified.

DISTRIBUTION LIST

AF HQ LEEEU (Aimone), Wash., DC

AFB AFCS/DEO (Corbett), Scott AFB, IL; AFSC DEE, Andrews AFB, Wash, DC; HQ AFLC DEE (EMCS Mgr), Wright-Patterson AFB, OH; HQ ATC/DEM (Lang), Randolph AFB, TX; HQ PACAF DEE (EMCS Mgr), Hickam AFB, HI; HQ SAC/DEE (Butters), Offutt AFB, NE; HQ SAC/DEER, Offutt AFB, NE; HQ SAC/DEM (Tonsi), Offutt AFB, NE; HQ SPACECOM DE (Movtinia), Peterson AFB, CO; HQ TAC/DEE (Seerey), Langley AFB, VA; HQ TAC/DEM (White), Langley AFB, VA; MAC/DEE (West), Scott AFB, IL; MAC/DEM (Kosch), Scott AFB, IL

AFESC DEB (Stother), Tyndall AFB, FL

USAF-AAC DEE, Elmendorf AFB, AK

ARMY CORPS OF ENGINEERS DAEN-MPC-C (Wharry), Wash., DC; DAEN-MPE-E (Brake), Wash., DC; DAEN-MPE-E (McCarthy), Wash., DC; DAEN-MPO-U (Walton), Wash., DC

ARMY ENG DIV EUDED-TM (O Malley),; HNDED-ME (Carlen), Huntsville, AL; HNDED-ME (DeShazo), Huntsville, AL; HNDED-ME (Herden), Hunstville, AL; HNDED-ME (Holland), Huntsville, AL; HNDED-ME (Wilcox), Huntsville, AL; HNDED-PM (Brown), Huntsville, AL; HNDED-PM (Ganus), Huntsville, AL; MRDED-TM (Beranck), Omaha, NE; MRDED-TM (Jones), Omaha, NE; NADCO-CM (Eng), New York, NY; NADEN-TM (Stuart), New York, NY; NPDEN-TE (Wottlin), Portland, OR; ORDED-T, (Norman), Cincinnati, OH; PODED-T (Nakasone), Ft. Shafter, HI; SADCO-CC (Mindel), Atlanta, GA; SADEN-TE (Smith), Atlanta, GA; SPDED-TG (Kishaba) San Francisco, CA; SWDED-M (Powell), Dallas, TX

ARMY ENGR DIST. CO, Tulsa, OK; MRKED-DM (Rabuse), Kansas City, MO; MRKED-M (McCollum), Kansas City, MO; MROCD-SM (Hall), Omaha, NE; MROCD-SM (O Brien), Omaha, NE; MROED-DC (Sawick), Omaha, NE; NABCO-S (Meisel), Baltimore, MD; NABEN-D (Kelly), Baltimore, MD; NANCO-C (Spector), New York, NY; NANEN-DM (Kessenides), New York, NY; NAOEN-MA (Daughety), Norfolk, VA; NAOOP-C (Herndon), Norfolk, VA; NPSEN-DB (Eason), Seattle, WA; ORLED-D (Pfeifer), Louisville, KY; SAMCO-SI (Rawls) Mobile, AL; SAMEN-C (Anderson), Mobile, AL; SAMEN-CI (Tunnell), Mobile, AL; SASEN-DF (Plunkett), Savannah, GA; SASEN-MA (Grimes), Savannah, GA; SCD-SB (Stone), Savannah, GA; SPKCO-C (Del Porto), Sacramento, CA; SPKCO-C (Evans), Sacramento, CA; SPKED-M (Lowell), Sacramento, CA; SPKED-M (Stoner), Sacramento, CA; SPLCO-CS (Molina), Los Angeles, CA; SWFCD-ST (Ready), Ft. Worth, TX; SWFCD-ST (Wood), Ft. Worth, TX; SWFED-DM (Story), Ft. Worth, TX; SWFED-DM (Wike), Ft. Worth, TX

NAVFACENGCOM Code 03 Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code 04 Alexandria VA; Code 04T2 (Knapp), Alexandria, VA; Code 04T2B (McGrath), Alexandria, VA; Code 04T7B (Stickley), Alexandria, VA; Code 05D1 (Bersson), Alexandria, VA; Code 09M54, Tech Lib, Alexandria, VA; Code 111 (Mitchum), Alexandria, VA; Code 1112E (Tayler), Alexandria, VA; Code 111B (Hanneman), Alexandria, VA

NAVFACENGCOM - CHES DIV, CO, Washington DC

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