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LoanSTAR Monitoring and Analysis Program

MONITORING EQUIPMENT INSTALLATION MANUAL

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Preface

The Texas LoanSTAR (Loans to Save Taxes and Resources) Program is a $98.6 million revolving loan fund to finance energy conservation retrofits in Texas government buildings. The loans are repaid through energy cost savings resulting from the retrofits. These energy cost savings are verified through an extensive metering and monitoring program conducted by the Texas A&M University Energy Systems Laboratory (ESL). The National Center for Appropriate Technology (NCAT) and its for-profit subsidiary, the NCAT Development Corporation, have been the principal monitoring instrumentation subcontractors to ESL throughout the Program's life.

This manual has been prepared by the NCAT Development Corporation to document the monitoring equipment installation techniques and approaches used by NCAT and ESL in the LoanSTAR program and is based on actual in-field experiences. It is more than simply an installation manual, however. It is really a **process** handbook. For example, copies of all forms and documentation used in the installation process are included and instructions for their use are provided. Essentially, this manual is designed to be used as a guidebook by future monitoring subcontractors in the LoanSTAR Program to ensure both continuity of methodology and instrumentation technology. Each step in the monitoring equipment installation process is described and extensive "how-to" information is provided. Illustrations accompany the text throughout the manual.

The manual is targeted at the practitioner. Little emphasis is placed on providing detailed instrumentation theory; however, references are provided for the interested reader (see Appendix G.) Furthermore, a Professional Engineer's license is not necessary to use this manual. The target audience includes instrumentation technicians, site construction managers (field engineers), and project managers. Little "hands-on" energy monitoring experience is assumed.

The authors wish to express their thanks to the Texas A&M Energy Systems Laboratory for providing the opportunity for the NCAT Development Corporation to support the LoanSTAR Program and to develop this manual. We especially acknowledge the longstanding and productive working relationship that has been maintained with Dr. Dan Turner, the director of ESL, Professors Dr. Dennis O'Neal, Dr. David Claridge, and Dr. Jeff Haberl, and ESL Staff Curtis Boecker, John Bryant, and Debbie Greer. Without their guidance and technical expertise, the instrumentation accomplishments of the LoanSTAR Program would not have been possible.

We further wish to thank ESL for granting permission to use its *Building Energy Monitoring Workbook*. Chapter 1 of this text was based in large part on this manual. We also wish to thank Synergistic Control Systems for granting permission to use illustrations and other information from their data acquisition system Installation Manual.

Funding for this manual has been provided by the Texas State Energy Conservation Office (SECO), under the direction of Ms. Patrice Parsons. The SECO Program Administrator for the LoanSTAR Program is Mr. Mike Wiley. The NCAT Development Corporation gratefully acknowledges the program and administrative support to the LoanSTAR Program by these two individuals.

Introduction: Data Acquisition System Subcontractor Role

The purpose of the Monitoring and Analysis task of the Texas LoanSTAR Program is to accurately measure energy cost savings resulting from Energy Conservation Retrofit Measures (ECRMs). The process involves both the Energy Systems Lab (ESL) and the Data Acquisition System Subcontractor (DASS), who is under a task order subcontract agreement with ESL.

The basic monitoring procedure, which is similar for each site, is as follows: First, ESL identifies the ECRMs to be installed and provides a list of proposed monitoring points to the DASS. Based on this information, the DASS develops a preliminary Monitoring and Analysis Plan (PreMAP) and cost estimate. When ESL approves the PreMAP and cost estimate, a contract amendment is negotiated with the DASS to fund the installation of the energy monitoring equipment included in the PreMAP. At this point, the PreMAP becomes a Site Monitoring and Analysis Plan (SiteMAP). The DASS then proceeds to install energy monitoring equipment based on the established monitoring plan.

In order to successfully install energy monitoring equipment, the DASS must understand all of the individual components of the installation process, including:

- the ECRMs;
- building electrical and mechanical systems;
- monitoring system design and cost estimation;
- monitoring techniques and equipment;
- installation coordination and oversight;
- verification of equipment operation; and
- installation documentation.

This manual will serve as a guide to these components and is based on methods that have been successfully used in the LoanSTAR Program.

1-0 Monitoring Equipment

The Texas LoanSTAR Monitoring and Analysis Program at the Energy Systems Laboratory began installing and maintaining energy monitoring equipment in 1989. Since that time, many brands and models of equipment have been used to address the variety of monitoring needs that have arisen. Most of the equipment has been durable, accurate, and reasonably priced. Naturally, however, some equipment did not satisfy these criteria, and some suppliers have been changed over the years.

In a project of this size, it is essential to achieve a level of standardization of equipment selection. Doing so is important both to help contain costs and to reduce the potential for human error in system design, installation, maintenance, and calibration. The result is a more efficient installation and more accurate data.

The standard equipment used in this program includes data acquisition systems and components to monitor electrical energy, thermal energy, fluid flow, temperature, and weather conditions. Additionally, signal-conditioning equipment is commonly used. Table 1-1 provides an overview of standard equipment functions, manufacturers, and component model numbers typically used in LoanSTAR monitoring. Detailed specifications of standard energy monitoring system components are included in Appendix C, "Equipment Specifications."

Since monitoring needs do vary from facility to facility, it is occasionally necessary to identify new energy monitoring system components. When a new component is required, it must undergo testing and calibration by the ESL Calibration Facility. ESL will then approve or reject the component for use in the field.

Table 1-1. LoanSTAR Standard Energy Monitoring Equipment.

Device	Use	Manufacturer	Model Numbers	Selection Criteria
Data Acquisition System	Receive, totalize, record, and transmit monitoring data	Synergistic Control Systems, Inc. 504-885-8180	B-80, C120E, C140E, C180E, and variations of each model	Type of channels and total number of channels needed at site
Modem	Telephone line communication to receive and transmit	Synergistic Control Systems, Inc.	MDM-2400	DAS to be head end unit or satellite unit
Potential Transducer	Provide reference voltage to DAS for primary voltages	Synergistic Control Systems, Inc.	PT-1	Total number of electrical feeds to be referenced
Current Transducers	Monitor current in primary conductors	Sentran Corp. 503-682-9083	4LS2, 4LS3, 4LN2	Primary rating, window size and accuracy needed
Watt-Hour Transducers	Monitor electrical energy usage	Ohio Semitronics, Inc. 800-537-6732	WL-3968	Used when only digital channels are available
BTU Meters and Temperature Sensors	Totalize CHW and HW BTUs and flow; measure temp	DK Enterprises, Inc. 800-451-2012	System 90 BTU Meter and 10" MRA with wiring head	CHW, HW, or Glycol Solution and Temperature Range
Insertion Flow Meters	Monitor CHW and HW flow rate	Data Industrial Corp. 800-338-0312	225B (option S-71470-12R)	Flow rate, pressure, and temp range of operation.
Condensate Flow Meters	Monitor Condensate or Boiler Feed Water flow rates	ISTA Energy Systems Corp. 908-241-8880	10/G, 20/G, 30/G, 50/G, 80/G	Flow rate, pressure, and temp range of operation.
Signal Conditioners	Conversion of analog signals, usually to digital	Ohio Semitronics, Inc.	VFC-050, 060, 070, 080	Signal type to be conditioned and transmitted
Isolation Relays	Split and isolate digital signals, usually utilities	Solid State Instruments, Inc. 303-452-2604	PIR-2,RPR-2, RPR-2P	Signal type to be isolated and split
Signal Isolation and Conditioning	Isolation or conditioning of analog signals	Kele & Associates 901-382-4300	DT13 and Model Nos. 500, 550, 600, 650	Signal type to be conditioned, isolated and transmitted
Humidity and Temperature	Monitor humidity and temperature conditions inside and outside	Vaisala Sensors Rotronic Inst. Co. HY-CAL Eng. General Eastern Synergistic Control Systems	HMD 20UB/YB F2, F22, T2 CT-xxx, and 1000_ TT-xxx, RH-xxx LM34	Desired accuracy, temp and RH range, location and cost
Solar Sensors	Monitor solar radiation	LI-COR 402-467-3576	LI-200SZ	Only typical sensor used
Signal Cable	Carry signal from transducer to DAS	Multi-Cable Corp. 203-589-9035 Network Prod.Inc. 800-886-0069	Plenum-rated multi-pair cable	Plenum rated, twisted pairs, stranded,shielded, with drain
Fuses	Protect and isolate equipment	Bussman-Newark Kele Radio Shack	HLR and GLR28F 6W30 and fuses 1 Amp FA w/hld	Voltage and current encountered
Cable Connectors	Terminations of cable to sensors; cable splices	WAGO 800-444-5029	WA-260-301 and 260-331	Low resistance and easy to use

1-1 Measurement Techniques

This section provides a basic review of measurement techniques, including a review of electrical monitoring for Alternating Current (AC) systems, flow and BTU monitoring, utility meter pulse output monitoring, temperature monitoring, and humidity monitoring. Only those measurement techniques that are most commonly used in the LoanSTAR program will be reviewed here. For further information, refer to equipment specifications and installation instructions for each type of equipment or see Appendix C.

1-1.1 Electrical Monitoring

Measuring the energy use of a building or a device requires a meter that measures and records the amount of power used over a period of time. Utility revenue meters, watt transducers, and multi-channel, integrated, solid-state watt-hour meters are all used to measure electrical energy consumption in the LoanSTAR Program.

The primary advantages of a multi-channel, integrated, solid state watt/watt-hour meter (such as contained in the Synergistic Control Systems C Series data acquisition systems) are that only Potential Transducers (PTs) and Current Transformers (CTs) are required to monitor electrical consumption, and multiple loads can be monitored at once. This eliminates the need for a separate meter or watt-hour transducer (WHT) for each load being monitored, and since this type of meter is combined with a microprocessor that records data, it can be easily reconfigured when monitoring requirements change.

Electric power measurements are computed in the data logger or WHT as the product of voltage and current. **It is necessary to maintain the correct phase relationship between the current and the referenced voltage in all electric metering.** In other words, the conductor on which any CT is installed must be traceable to the same phase that is referenced for voltage at the PT or WHT. Furthermore, the data logger must be programmed to identify the correct phase of the associated PT.

Electrical monitoring in the LoanSTAR Program usually means energy (kilowatt-hour) monitoring. The same equipment and techniques are used to monitor demand, or instantaneous power. To summarize, electrical monitoring has been accomplished in three principal ways in the LoanSTAR Program:

1) Use of CTs connected to a Synergistic Data Acquisition System (DAS) for current measurements, and use of PTs connected to the Synergistic DAS for reference voltage measurements. Current and voltage are multiplied in real time to produce electric power and energy consumption measurements;

2) Use of WHTs connected to a Synergistic DAS for electric energy consumption measurements; and

3) Use of Pulse-Initiating utility revenue meters connected to a Synergistic DAS for electric energy consumption measurements.

All three of these methods provide accurate and dependable electrical energy monitoring data. Each type of equipment is constructed so that the product of voltage, current, and phase angle produces a measurement of the real power in an AC circuit. The choice of which type to use depends on the individual site, the availability of utility revenue metering, and the budget for the site.

- Utility metering is normally used whenever available and feasible;
- CT and PT metering is used at sites where multiple electrical loads are to be monitored because of the lower cost associated with their use; and
- WHTs are typically used at small sites with one to three electrical loads, or where there are more electrical loads to be monitored than available PT and CT inputs into the DAS.

Decisions regarding the best electrical monitoring method are always made during the PreMAP cost estimation process and are based upon achieving the maximum amount of monitoring at the site for the least cost.

Regardless of which equipment is used to measure AC power consumption, the basic laws of electricity apply. In a single-phase electrical system, when the current and voltage are exactly in phase, power in watts is measured and calculated as:

$$P = I * V$$

Where
P = instantaneous power in watts
I = instantaneous current
V = instantaneous line voltage

If the current and voltage are not exactly in phase, the phase angle (power factor) enters the calculation. Power factor is the factor by which the apparent power (amperes times volts) must be adjusted to obtain real power. Power in any single-phase or 3-phase-4-wire (3Φ-$W) system is equal to the sum of the power in the individual phases. The formula below is used to calculate power:

$$P = \Sigma (I * V * PF)$$

Where
P = instantaneous power in watts
I = instantaneous line current
V = instantaneous line voltage referenced to neutral
PF = power factor

Total real power in any balanced 3-phase system may be calculated as shown in the formula:

$$P = \sqrt{3} * V * I * PF$$

Where P = instantaneous power in watts
I = instantaneous line current
V = instantaneous line to line voltage
PF = power factor

Electrical Monitoring Using CTs and PTs

This approach requires CTs, PTs, and any of the C Series of DASs (see Table 1-3 for list of C Series DAS). The CTs are installed on the current-carrying conductors of the loads to be monitored, and the primary sides of the PTs are phased and installed on the same voltage source used by the load being monitored. The secondary sides of the CTs and PTs are terminated at their associated inputs of the DAS. The DAS must be programmed to reflect the primary rating of the CTs and the associated phase of each referenced voltage.

CTs may be terminated directly to the DAS, in parallel to the DAS or in parallel through summing modules to the DAS. The use of parallel connections or summing modules greatly increases the capability of the DAS to monitor multiple electrical loads.

The types of electrical measurements (Real Time Data) shown in Table 1-2 can be recorded as a Time Series Record (TSR) in the DAS with the use of CTs and PTs. Frequently, the only TSR to be recorded will be the kW record with a one-hour integration period. In that case, average kW per hour equals kilowatt-hour consumption. (See Section 4-4, "DAS Programming and Installation" for further details.) It should be noted that real time data for voltage, current, and kilowatts are used extensively for verification of each CT and PT that is installed.

Table 1-2. Measurement types using the DAS CT and PT inputs.

Measurement Type and Description	**Abbreviation**
Voltage; average line voltage	V
Current; average line current	Amp
Kilowatts; average real power	kW
Kilowatt-hours; average real power consumption	kWH
Kilovoltamperes; average apparent power	kVA
Kilovoltampere-hours; average apparent consumption	kVAH

Electrical Monitoring Using WHTs

This approach requires WHTs, CTs, and any C Series or B80 DAS. The CTs are installed on the current-carrying conductors of the loads to be monitored. The same source voltage is phased and supplied to the WHT as reference voltage and instrument power. The secondary side of each CT is terminated at the appropriate inputs of the WHT. The pulse output of the WHT is terminated at the associated digital input of the DAS. The DAS must be programmed to reflect the kWH value of each pulse.

Only kWH consumption can be recorded as a TSR in the DAS with the use of a WHT. There are other transducers available that can measure kW and other electrical quantities. **However, with a few rare exceptions, only the WHT is used in the LoanSTAR program.** The TSR recorded is the total kWH consumption for each one-hour integration period, which equals the average kW per hour.

Electrical Monitoring Using Utility Pulse-Initiating Electric Meter

This approach requires a utility pulse-initiating meter, and any C Series or B80 DAS. The utility already has CTs and PTs installed on the service being metered, but it may be necessary for a utility to install a pulse initiator. The pulse output of the utility meter is terminated at the associated digital input of the DAS. The utility will provide the value of each pulse from its meter.

The DAS must be programmed to reflect the kilowatt-hour value of each pulse.
The TSR recorded is the total kWH consumption for each one-hour integration period. The kWH consumption equals the average kW per hour.

There are numerous utility meters available that can measure kW and other electrical quantities. **However, with a few rare exceptions, only the kilowatt-hour meter is used in the LoanSTAR Program.**

1-1.2 Temperature Monitoring

The following devices are all used to measure temperature:

- thermoelectric sensors (thermocouples);
- resistance temperature detectors (RTDs);
- semiconductor-type resistance thermometers (thermistors); and
- junction semiconductor devices, which are also called integrated circuit (IC) temperature sensors.

This section provides a brief introduction to RTDs and thermistors, which are most commonly used in the LoanSTAR program. For further information, see Benedict (1984) and Doeblin (1990). Also see Hurley (1985) and Wise (1976), referenced in Appendix G.

Temperature Monitoring Using RTDs

Electrical resistance in many materials changes with temperature. In some materials, this change is very reproducible and therefore can be used as an accurate measure of temperature.

Monitoring temperature independently from BTU metering is typically accomplished in the LoanSTAR Program using RTDs. The RTDs used in the LoanSTAR Program have been 1000Ω platinum immersion temperature probes installed in chilled water, hot water, glycol, condenser water, boiler feedwater, or condensate return piping and in supply air or return air ducts for air temperature measurement. A few 100Ω Platinum RTDs have been used in weather stations as ambient air temperature sensors.

The RTDs have a single pair of leads from the sensor that is terminated into a single analog channel in the DAS. The DAS, which is internally programmed to directly accept the RTD output, reads the resistance which increases linearly with temperature, and calculates the temperature. For installations with long sensor lead lengths, the resistance of signal wire should be determined, and the DAS input channel must be offset to compensate for that resistance. Alternatively, RTDs may be terminated into a transmitter that will measure the resistance and supply an analog output (4 to 20 mA or 0 to 5 VDC) proportional to the temperature. If no analog channels exist in the DAS, the RTD must be terminated into a transmitter that will measure the resistance and supply digital pulse output proportional to temperature. This signal terminates at a digital channel.

Temperature Monitoring for BTU Metering Using Thermistors

Thermistors are semiconductor temperature sensors with a resistance output that decreases non-linearly with temperature and hence requires a corrective algorithm to produce an accurate measurement. They are used in all chilled water, hot water, and condenser water BTU monitoring equipment installed in the LoanSTAR program. The stated accuracy of the thermistors used in these systems is ±0.1°C. The thermistors are located across a load or heat source as in a heat-recovery system and the two wire leads of each thermistor are terminated at the appropriate inputs of the BTU/flow totalizer.

1-1.3 Flow Monitoring

In many situations, measurements of natural gas, chilled water, hot water, condensate return, and boiler feedwater are needed to measure the energy consumption of a building or group of buildings. Most often this requires accurate measurements of fluid flow, usually at the service entrance to the building.

To choose a flow meter for a particular application, you must know what type of fluid is being measured, how dirty or clean that fluid is, the lowest and highest expected flow velocities for that fluid, and the available budget. This section discusses the common liquid flow measurement devices that are used alone or in conjunction with temperature measurements to determine the thermal energy in a fluid flow. For further details, refer to the papers by Doeblin (1990) and Baker and Hurley (1984), cited in Appendix G.

Condensate and Boiler Feedwater Flow Monitoring

Turbine meters measure fluid flow by counting the rotations of a rotor placed in a flow stream. Turbine meters can be an axial-type or insertion-type. **Although both types of turbine flow meters have been used in the LoanSTAR Program, only the axial-type is currently specified.** The insertion-type are expensive and difficult to maintain.

Selection of an in-line flow meter is standardized for all condensate and boiler feedwater services. These flowmeters are specified considering fluid pressure, temperature, pipe size, and flow rate. The output from the flow meter head is a pulse signal that represents a specified number of gallons. The two signal leads of the pulse head are terminated into a digital input channel of a data logger and the data logger is programmed to apply the correct conversion factor to the accumulated pulses. The value stored in the TSRs are gallons per hour.

BTU Meter Flow Monitoring

Insertion-type tangential paddlewheel meters are used in all chilled water, hot water, condenser water, and heat-recovery BTU monitoring in the LoanSTAR program. They are installed with a wet tap directly into a pipe without draining the system. Flow is measured by counting the rotations of a tangential rotor in a flow stream. Selection of flow meter is standardized for this type of monitoring independent of pipe size within a specified rating for fluid temperature and pressure. The flow sensor may be mounted in either the supply or return line. An outage is not required for installation because the tap for installation of the meter is accomplished while the pipe is pressurized (i.e., wet tap).

The output from the flow meter is a frequency carried on a shielded signal cable and terminated at the appropriate inputs of a BTU/flow totalizer.

Natural Gas Flow Monitoring

This approach requires a utility pulse-initiating meter and a data logger digital input channel. Typically, the utility already has a pressure-compensated meter installed at the monitoring point, but it may need to be retrofitted with a pulse initiator. The 2-wire pulse output of the utility meter pulse initiator is terminated at the associated digital input of the DAS. The DAS must be programmed to convert the pulse data into cubic feet of natural gas and store the data in a TSR.

1-1.4 BTU Monitoring for Hot Water and Chilled Water (or Glycol)

Determining the thermal energy used in a building's heating or cooling system often requires monitoring heat transfer. A BTU meter measures both flow and a temperature difference continuously to solve the following relation:

$$BTU = C \int M (T_1 - T_2)\, dt$$

where
- C = the specific heat of the fluid
- M = the mass flow of the fluid during time increment
- T_1, T_2 = the supply and return temperatures
- dt = time increment

In many situations in the LoanSTAR Program, heat transfer measurements are needed for a building or group of buildings. Most often this requires accurate measurements of liquid flow and temperature in a hot or chilled water pipe, usually at the service entrance to each monitored building. The monitoring approach consists of installing two thermistor temperature sensors, a tangential paddlewheel flow meter, a BTU/flow totalizer, and a data logger with digital input capability.

In a typical installation, the two thermistors are located across a load or heat source, as in a heat-recovery system, and the two wire leads of each thermistor are terminated at the appropriate inputs of the BTU/flow totalizer. The output signal from the flow meter is also terminated at the appropriate inputs of the BTU/flow totalizer. The totalizer is factory-programmed to function accurately over a given temperature range and for a given specific heat. The totalizer is field-programmed to adjust for pipe diameter since the same flow meter can be used in different sized pipes. The totalizer can also be field-programmed to adjust the pulse output value in gallons and BTUs per contact closure. The pulse output signals from the totalizer are terminated into two digital input channels of the logger. The data logger must be programmed to apply the correct multiplier to the accumulated pulses to convert the output directly into BTUs and gallons.

1-1.5 Weather Station and Building Interior Temperature and Humidity Monitoring

Weather stations are rarely installed in the LoanSTAR program. Therefore, monitoring techniques will not be covered in this manual. If weather stations are required in the future, ESL will participate in designing the system and directing the DASS. (The same is true for indoor relative humidity or air-temperature monitoring for HVAC applications.) Refer to Table 1-1 for a list of typical equipment used to monitor weather, indoor relative humidity and indoor temperature. The LM34 integrated circuit temperature sensor is particularly suited for use with the Synergistic C Series DAS.

1-2 Data Acquisition System Use

This section is an introduction to the data loggers manufactured by Synergistic Control Systems Inc., the primary data loggers used in the LoanSTAR Program. Refer to the manufacturer's Installation Manual and Section 4 of this manual for additional details.

1-2.1 Data Acquisition System Overview

It is important to read the Synergistic Installation Manual thoroughly and use it as a reference as necessary. In most circumstances, selecting the necessary DAS will be easy, but at times there will be more than one option. (See Section 2-4, "Selecting Monitoring Points and Equipment.") This section addresses the capabilities of the data loggers and proper use of each type of capability. Table 1-3 below summarizes the model numbers, total number of available channels, and types of channels available.

Table 1-3. C180 series and B80 data logger model numbers and number of available channels.

Model No.	CT Inputs	PT Inputs	Digital Inputs	Analog Inputs	Communication Options
C180E	16	2	16	15, optional	MDM, DC loop
C140E	8	2	8	8, optional	MDM, DC loop
C120E	4	1	4	4, optional	MDM, DC loop
B80	0	0	8	0	MDM, DC loop

The data loggers have different input capabilities and options. In order to select a particular model for a specific application, you must understand exactly what capabilities and options are required. CT inputs, PT inputs, digital inputs, and analog inputs are among the capabilities and options available. Each of these, along with the communications capabilities and options, will be briefly reviewed in this section.

1-2.2 Configuration of the Data Logger Input Channels

Figure 1-1 shows the C180E series of data loggers by Component Arrangement. Figures 1-2 and 1-3 show the basic termination boards for the C180E-A data logger with CT, PT, digital, and analog channel capabilities.

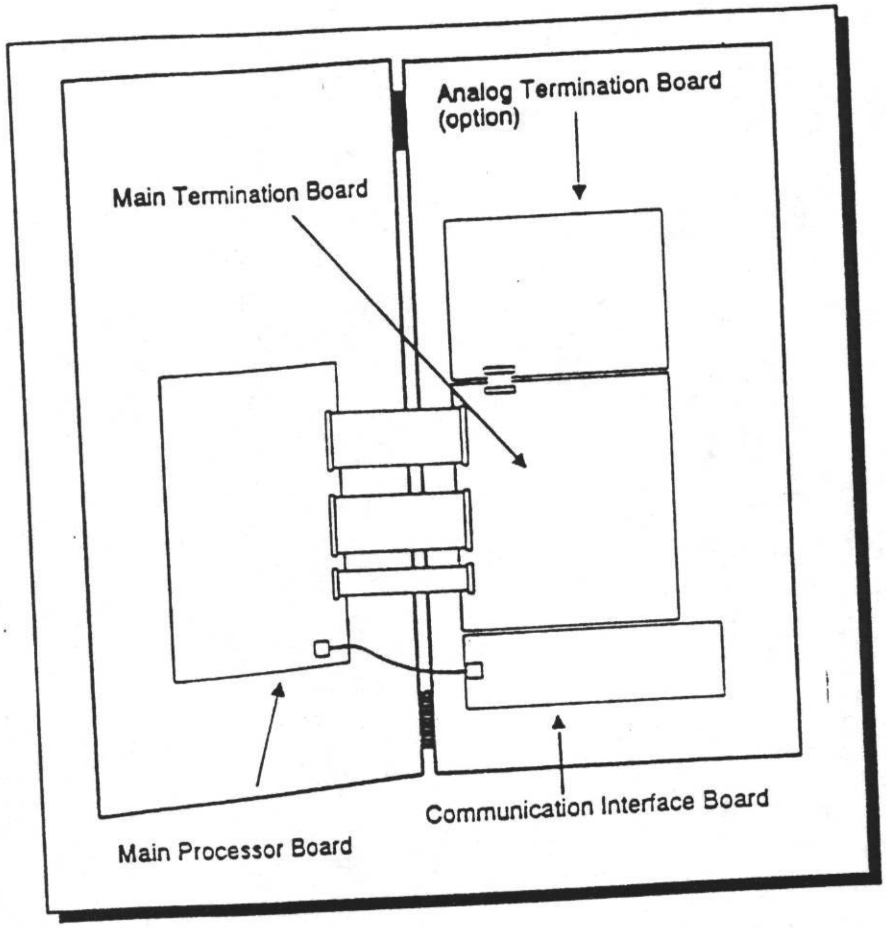


FIGURE 1-1. C180E COMPONENT ARRANGEMENT.
(Source: *Synergistic Installation Manual*, May 1993.)

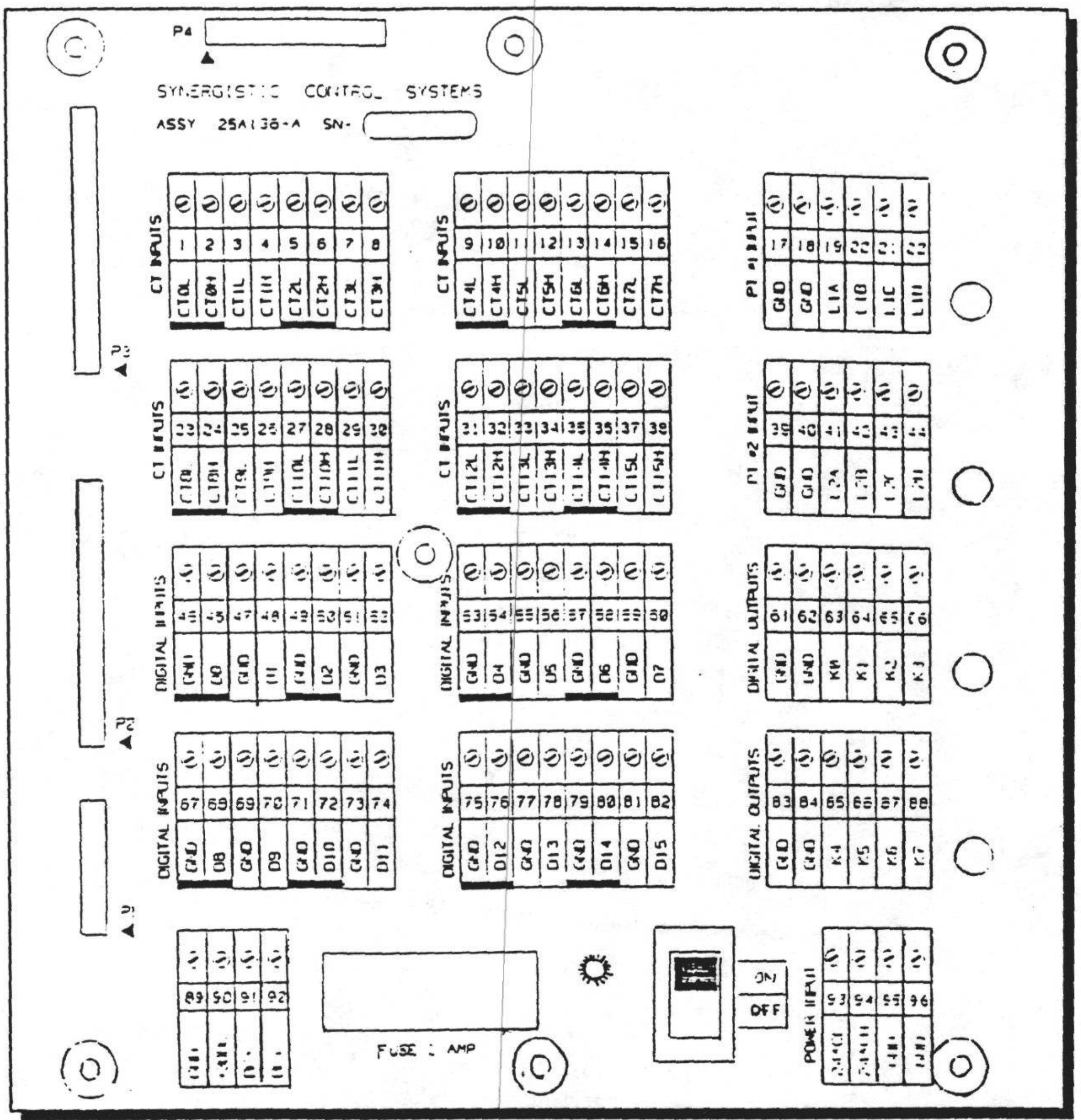


FIGURE 1-2. C180E MAIN TERMINATION BOARD.
(Source: *Synergistic Installation Manual*, May 1993.)

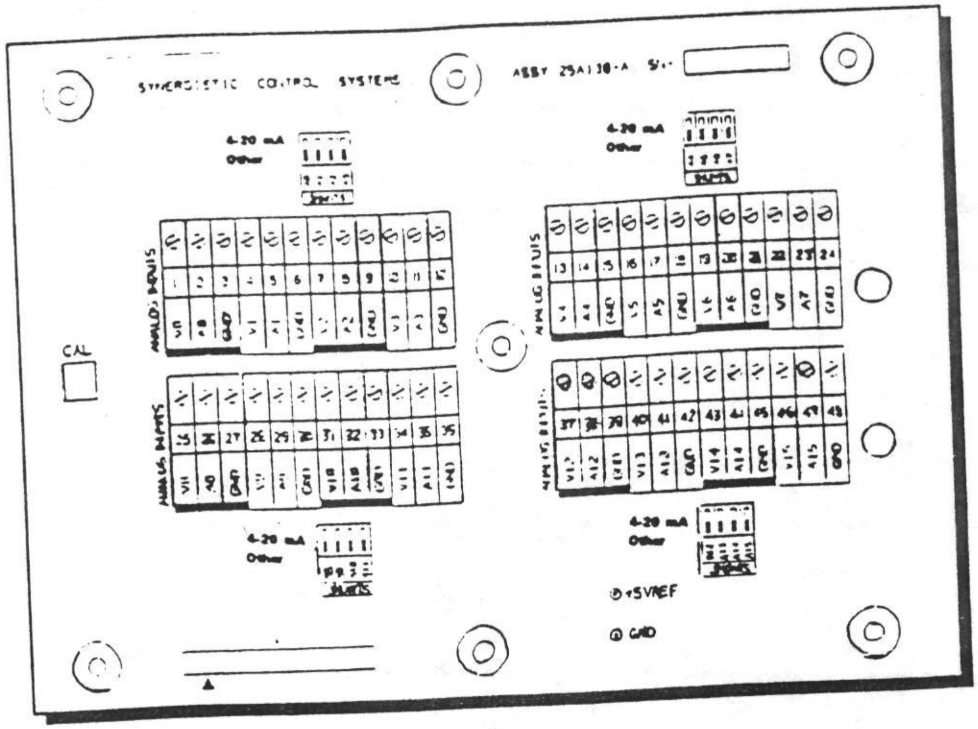


FIGURE 1-3. ANALOG TERMINATION BOARD.
(Source: *Synergistic Installation Manual*, May 1993.)

The termination boards are the same for each size of data logger, except that there are fewer termination points in the smaller units. In Figure 1-2, the termination board for the digital (Dxx), power (CTxx), voltage (L2xx), and power supply (24xx) points are shown. Figure 1-3 shows the termination board for analog channels.

1-2.3 Configuration of the Communications System

Figures 1-4 and 1-5 show the Communication Interface Module and the C180E series Main Processor Board, where the connection to the communication interface module is located.

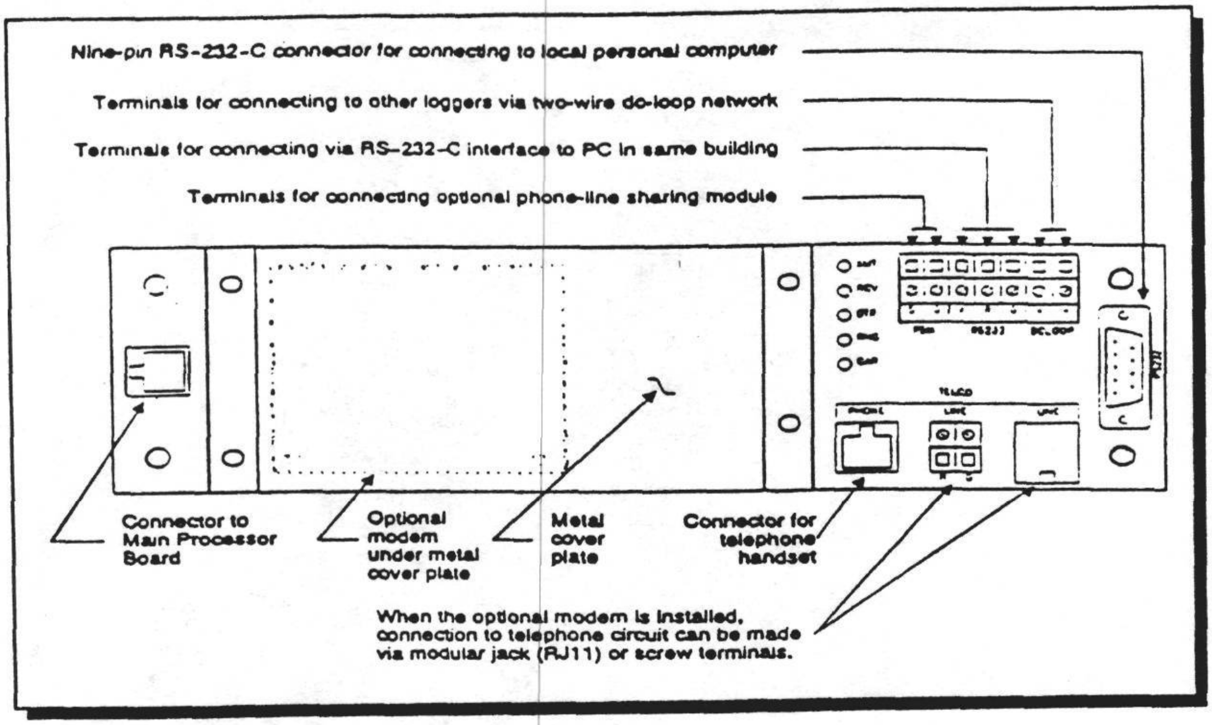


FIGURE 1-4. COMMUNICATION INTERFACE BOARD.
(Source: *Synergistic Installation Manual*, May 1993.)

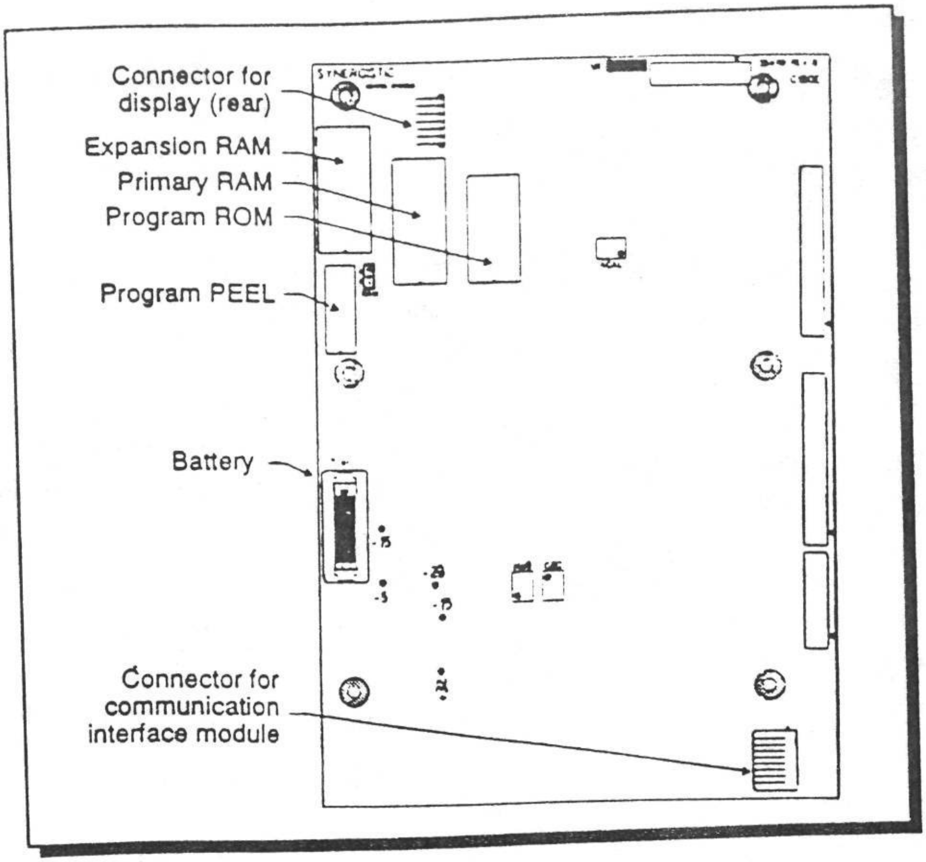


FIGURE 1-5. C180E MAIN PROCESSOR BOARD.
(Source: *Synergistic Installation Manual*, May 1993.)

An RS-232 port and a DC loop communications interface, through which data loggers can be connected to communicate in series through a single modem or RS-232 port, are standard features on the C Series of data loggers, while the DC loop is a no-cost option in the B80. The B80 comes equipped with a RS-232 interface board and an optional 1200/2400 baud modem. A 1200/2400 baud internal modem, which plugs into the DC loop communications interface board, is an option for the C Series.

Selection of communications options depends on whether the data logger is a stand-alone unit or in a DC loop. All stand-alone units and the head end unit (first logger in the series) in a DC loop require a modem to establish telephone communications and to transmit or receive data. Satellite units in a DC loop do not require a modem because telephone communication is established through the head end unit modem. Each satellite and the head end unit requires a DC loop communications interface and a cable to connect the units.

If multiple data loggers are installed at a site, consider taking advantage of the DC loop capability. **This approach can reduce the cost of purchasing multiple modems and telephone lines.** Additionally, it will reduce costs to the facility, which is responsible for the monthly telephone line charges. If it is not possible to run cable from one data logger to the next to install a DC loop, then a modem must be purchased and a separate telephone line installed at each logger. The maximum recommended total cable distance between each logger in a DC loop is 5000 feet.

1-2.4 CT and PT Channel Inputs

Electric power, voltage, current, and power factor are measured by the on-board, solid state watt/watt-hour meters. Required primary input(s) are properly sized CTs and a PT. The data logger integrates current and voltage signals in real time, recording real power and apparent power.

The CTs used with the C180 data logger series are internally shunted with a resistor so they become voltage rather than current devices and can be safely handled in an "open circuit" when installed. They are available in a wide variety of sizes and shapes with full-scale ratings from 5 amps to 3000 amps. The full-scale output of each CT is 333 mV.

The PT provides a low-voltage, low-current, 3-phase reference voltage to the data logger. **More than one PT will be required in cases where multiple voltage sources are being monitored.**

CT Inputs

Figure 1-6 shows a single CT terminated directly to channel "0." In Figure 1-7, the basic connection for a single power signal is shown terminated at channel "0" after it has been combined in a summing module. Summing modules are convenient when multiple CTs can be accumulated into one signal.

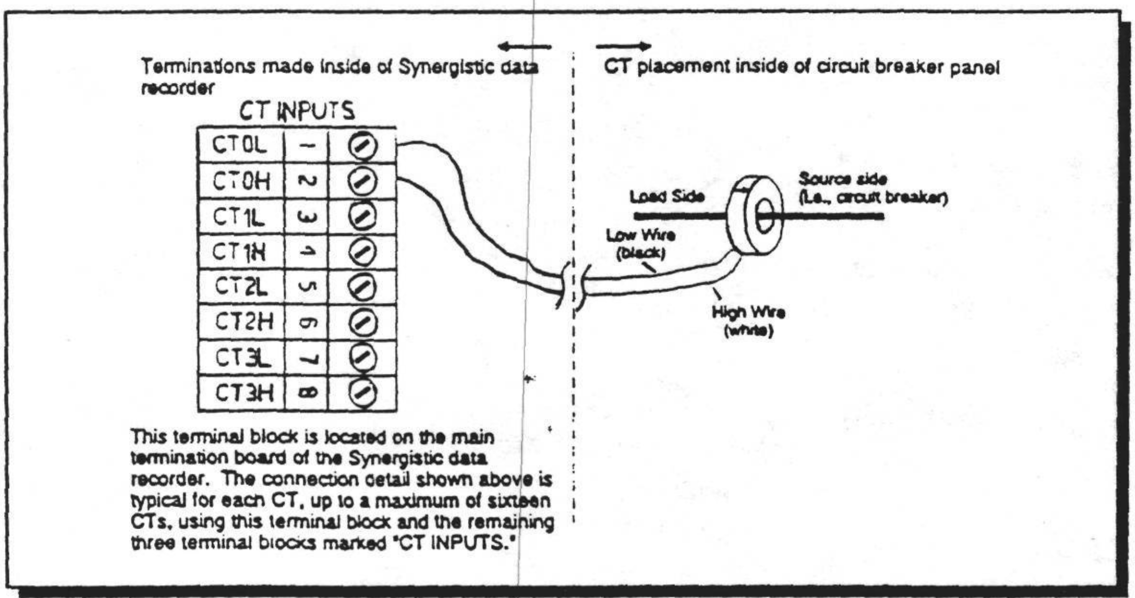


FIGURE 1-6. CT CONNECTIONS.
(Source: *Synergistic Installation Manual*, May 1993.)

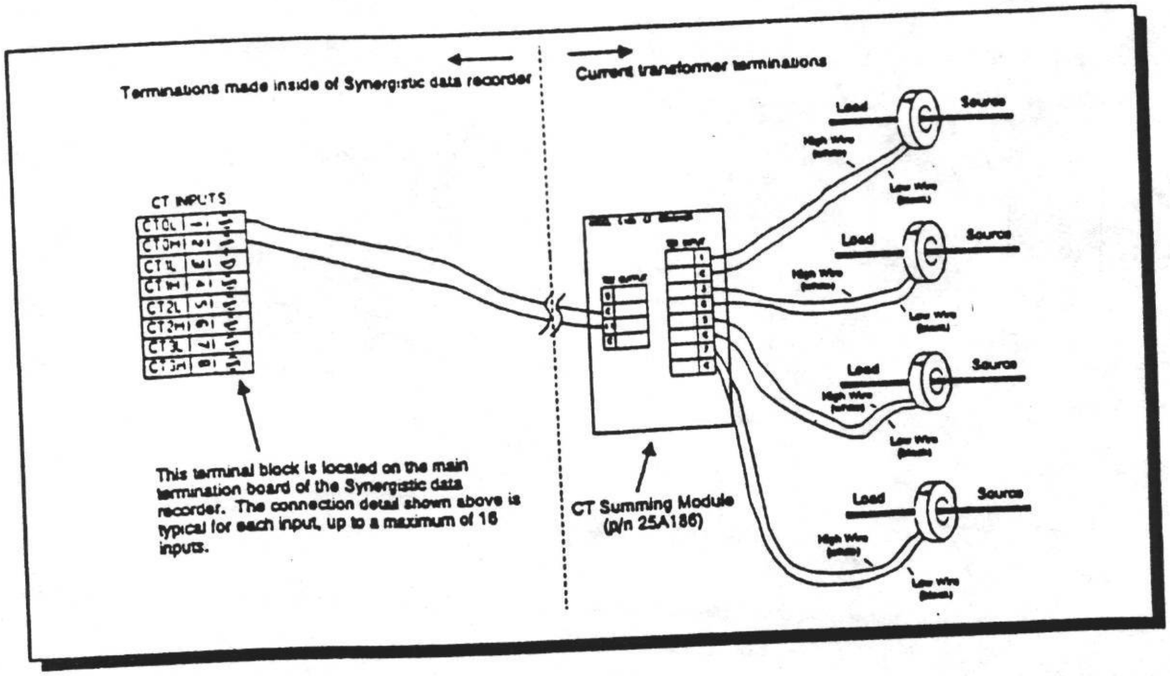


FIGURE 1-7. CT SUMMING MODULE.
(Source: *Synergistic Installation Manual*, May 1993.)

PT Inputs

Figure 1-8 shows the logger in an installation where power is being monitored from three circuits in a 3-phase, 4-wire electrical panel. In this diagram, solid-core, shunted CTs are installed around the monitored circuits. The PT is connected to voltage leads from A, B, and C phases, neutral, and ground to provide reference voltages for the data logger.

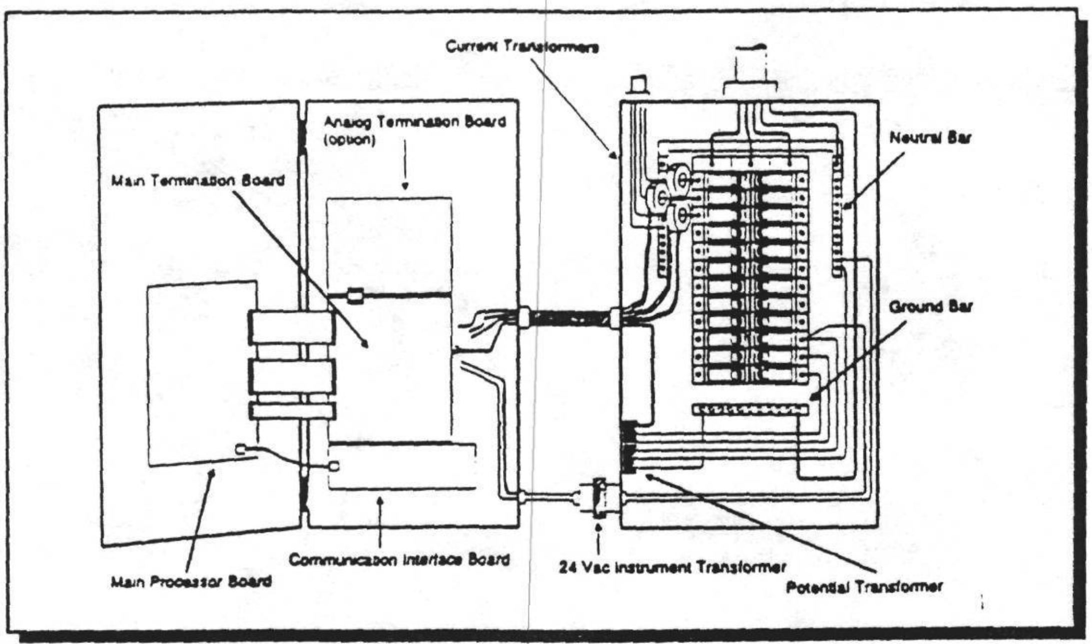


FIGURE 1-8. TYPICAL ELECTRICAL METERING CONNECTIONS.
(Source: *Synergistic Installation Manual*, May 1993.)

Figure 1-9 illustrates connecting the PT to the data logger to provide a voltage reference signal. In order to properly measure power, a PT must be connected to each 3-phase feed being monitored. The C180 and C140 series of data loggers provide one or two PT inputs for 3-phase electrical feeds. Additional feeds require additional loggers.

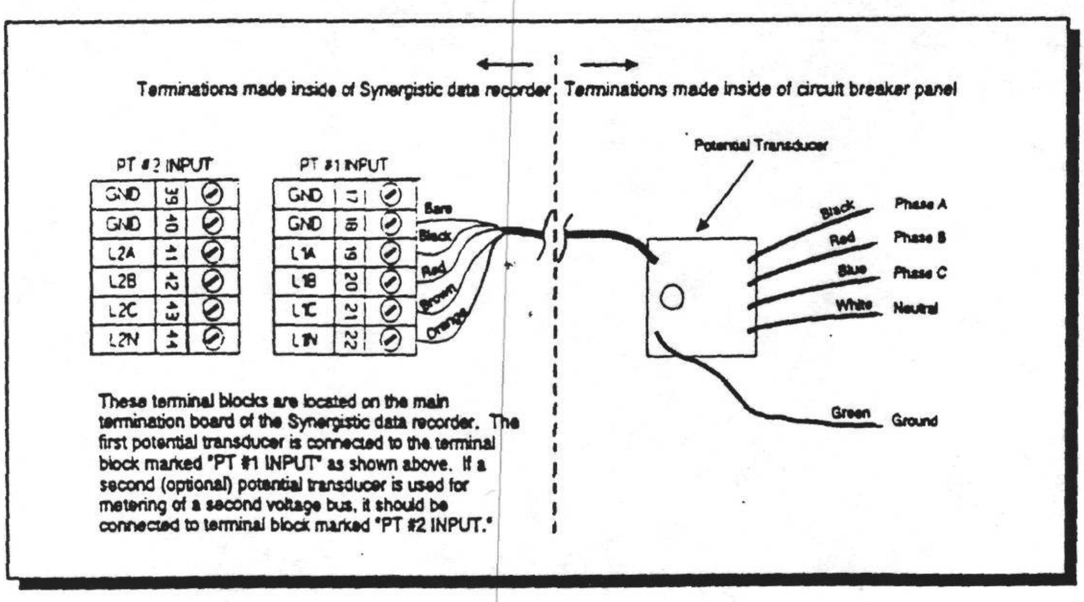


FIGURE 1-9. CONNECTIONS TO POTENTIAL TRANSDUCER.
(Source: *Synergistic Installation Manual*, May 1993.)

Figures 1-10 through 1-13 show how the various configurations of source voltages, single-phase and 3-phase power can be properly monitored.

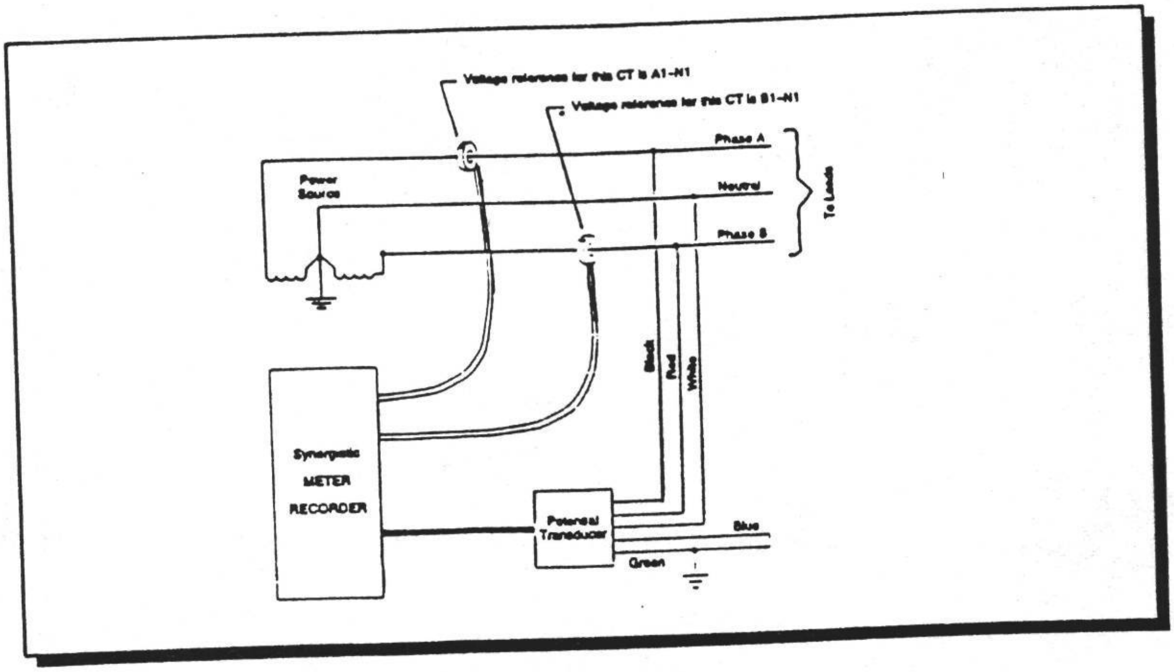


FIGURE 1-10. SINGLE-PHASE, THREE-WIRE RESIDENTIAL.
(Source: *Synergistic Installation Manual*, May 1993.)

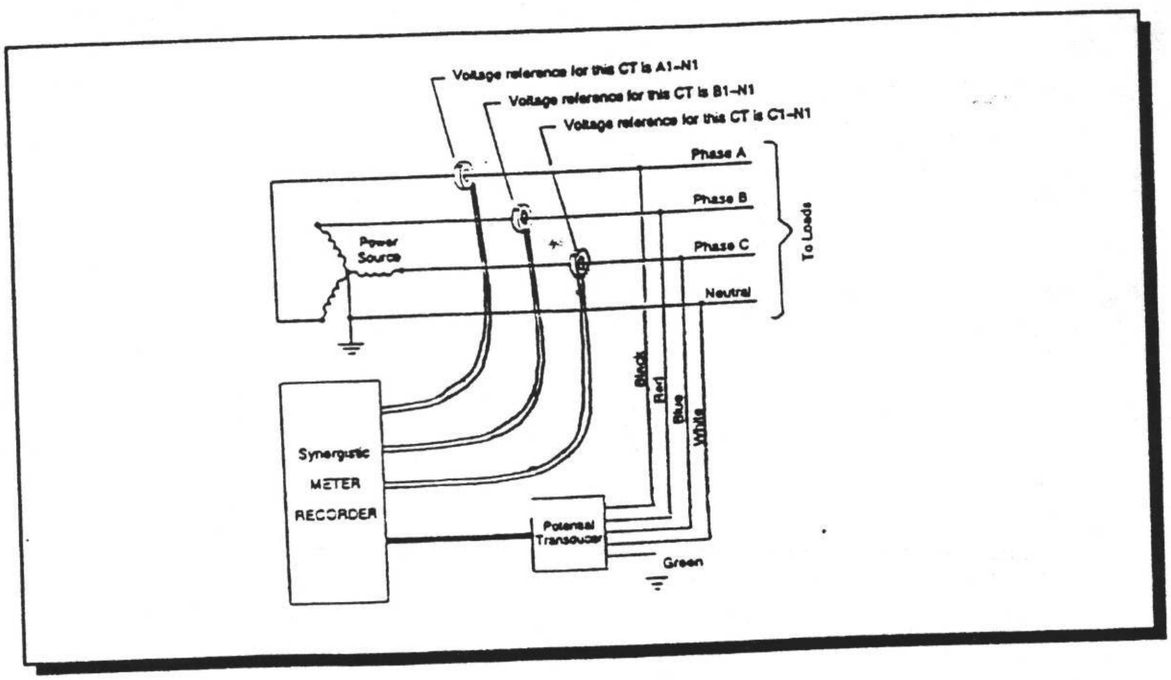


FIGURE 1-11. THREE-PHASE, FOUR-WIRE WYE.
(Source: *Synergistic Installation Manual*, May 1993.)

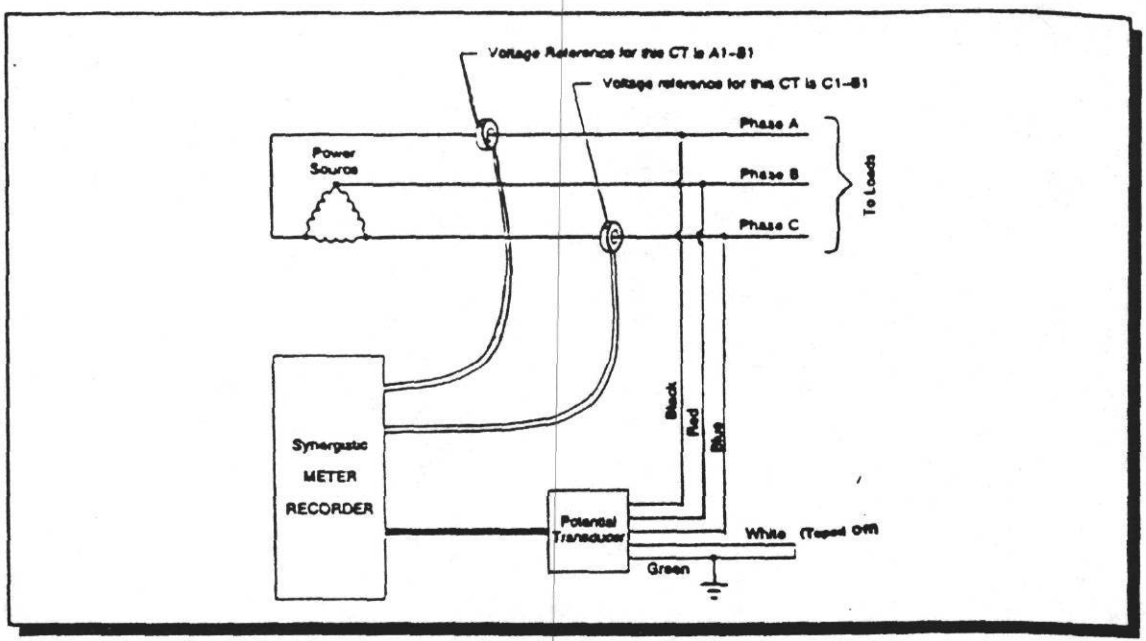


FIGURE 1-12. THREE-PHASE, THREE-WIRE DELTA.
(Source: *Synergistic Installation Manual*, May 1993.)

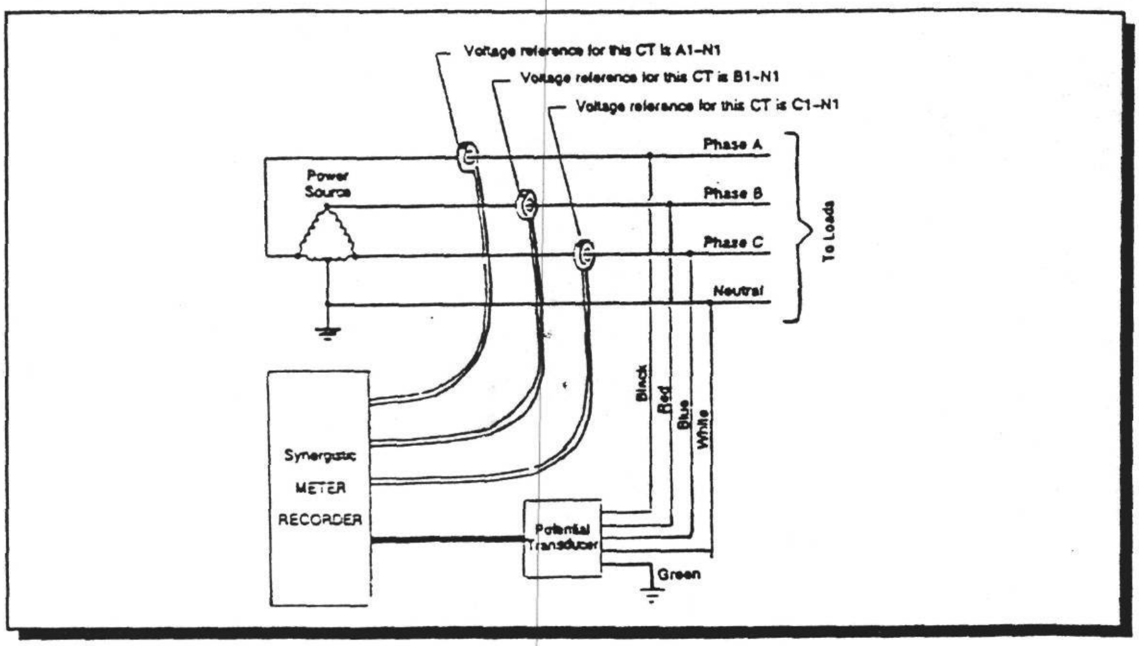


FIGURE 1-13. THREE-PHASE DELTA WITH CENTER TAP.
(Source: *Synergistic Installation Manual*, May 1993.)

1-2.5 Digital Channel Inputs

Digital channels can be used to monitor electrical power, flow, thermal loads, and a variety of other variables by sensing contact closures (pulses), which are proportional to the load.

Connection of a digital pulse signal to the logger is illustrated in Figure 1-14. The on/off pulse signal is carried by 2-wires from a dry-contact telemetering circuit. The leads are connected as shown to digital channel "0" on the main termination board.

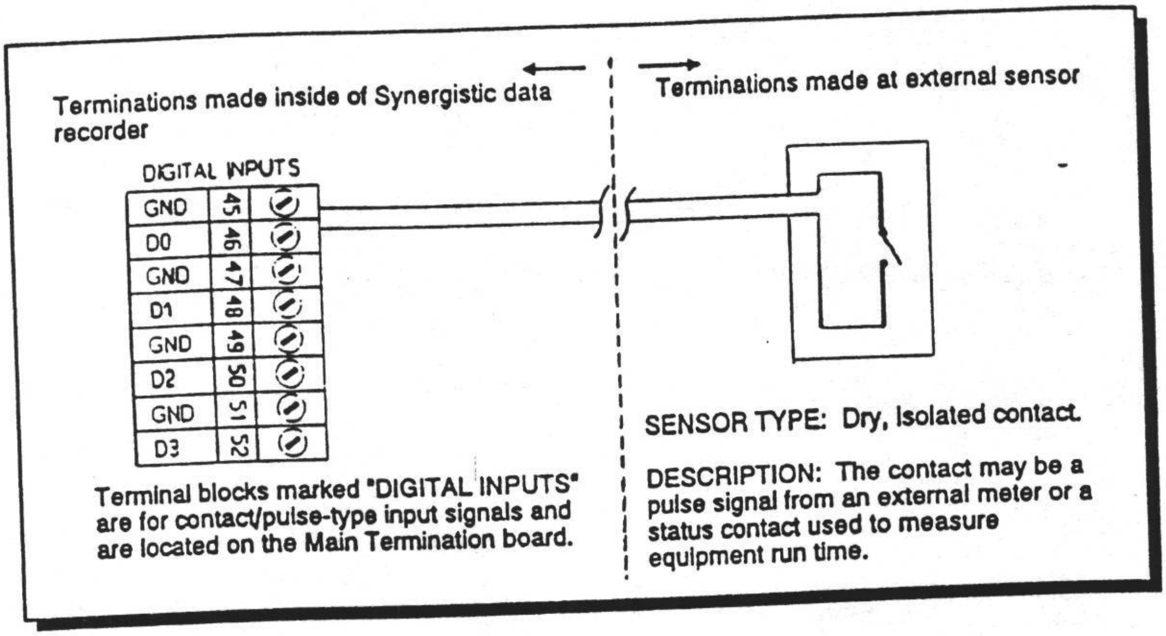


FIGURE 1-14. CONTACT AND PULSE INPUTS.
(Source: *Synergistic Installation Manual*, May 1993.)

1-2.6 Analog Channel Inputs

Analog inputs are used to monitor a variety of loads or conditions at a given site. The analog input board accepts a signal directly from a sensor, or from a sensor equipped with a transmitter. Analog channels are used to monitor such variables as temperature, pressure, solar radiation, wind speed, ambient temperature, relative humidity, and electrical demand. (The main requirement is that the sensor have an analog output signal that is compatible with the data logger.) The primary types of analog signals accepted by the C180 series data logger are resistance, 4-20 mA, and 0-5 VDC.

2-wire resistive RTD analog input

A resistive load can be connected directly to the logger. To prevent generating a ground current loop, the shield wire is grounded only to the logger. Figure 1-15 illustrates connection of an RTD signal to the logger.

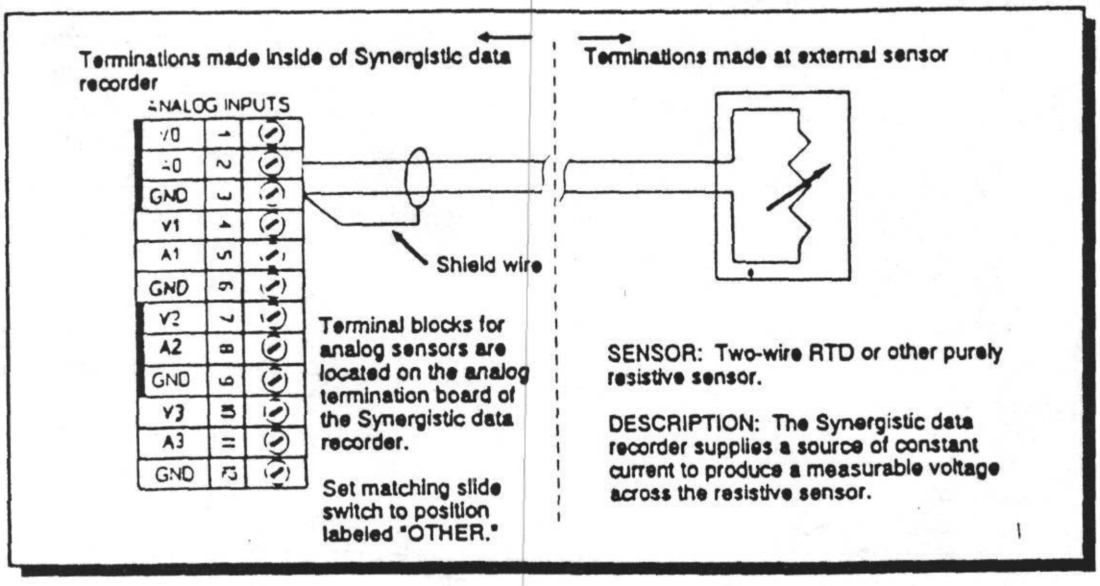


FIGURE 1-15. RTD AND OTHER RESISTIVE SENSOR CONNECTIONS.
(Source: *Synergistic Installation Manual*, May 1993.)

2-wire, 4-20 mA analog input

Figures 1-16 and 1-17 show the connection of a 2-wire, 4-20 mA signal using an internal 200 Ohm resistive header. Instrument power is supplied by the data logger in Figure 1-16 and by a field source in Figure 1-17. In many versions of the C Series Synergistic data loggers, an internal resistive header must be used for the channel with a 4-20 mA signal. The internal header provides a 200 Ohm resistor across the Axx to GND terminals so that the 4-20 mA signal is converted to a voltage, which is then read by the data logger.

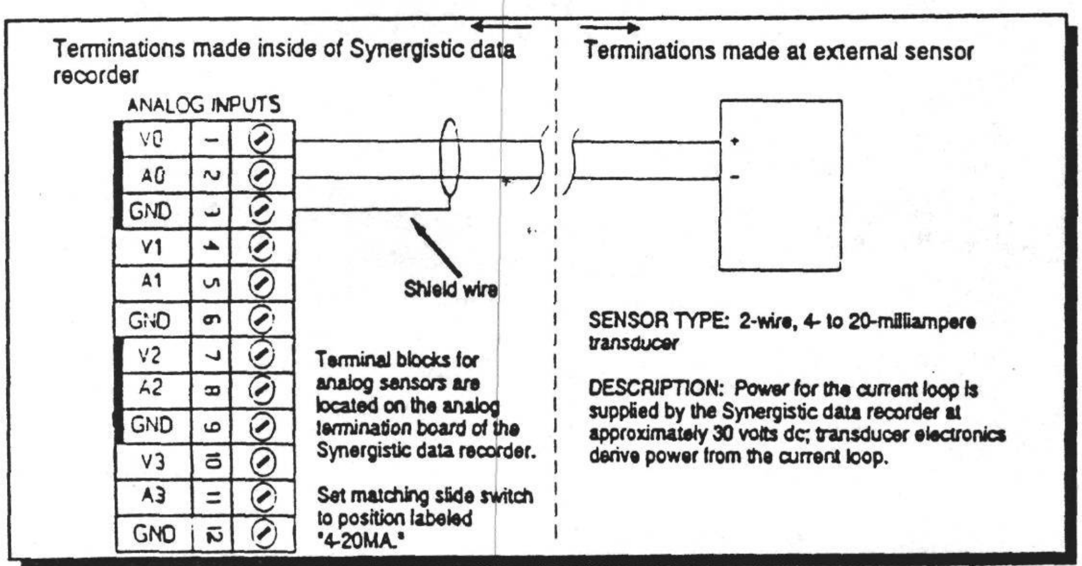


FIGURE 1-16. TWO-WIRE, 4-20 MILLIAMPERE SENSOR.
(Source: *Synergistic Installation Manual*, May 1993.)

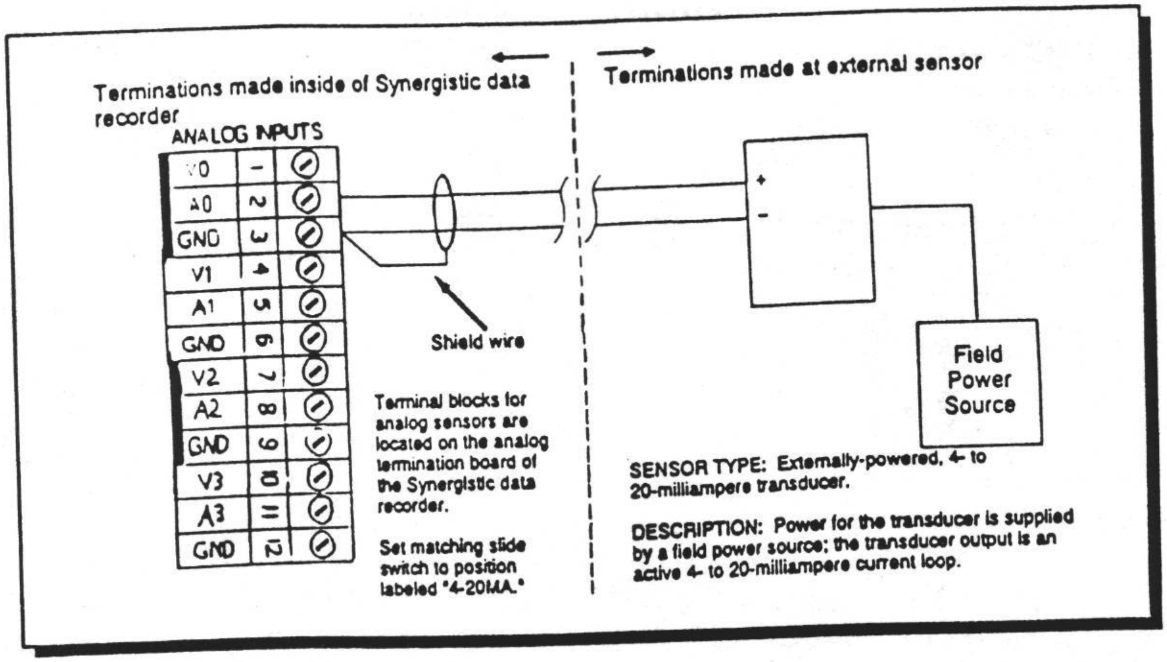


FIGURE 1-17. EXTERNALLY POWERED, 4-20 MILLIAMPERE CONNECTIONS. (Source: *Synergistic Installation Manual*, May 1993.)

3-wire, 4-20 mA analog input

Figure 1-18 shows the connection of a 3-wire, 4-20 mA signal using an internal 200 Ohm resistive header. The instrument power is supplied by the data logger on one wire, and the 4-20 mA loop signal is carried on the other two wires.

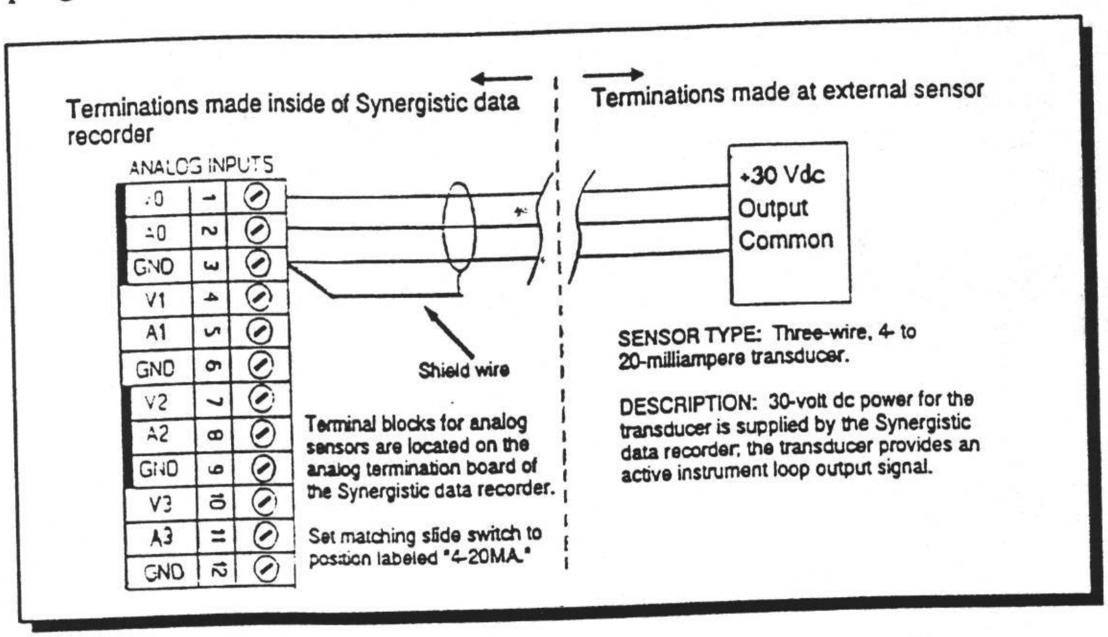


FIGURE 1-18. THREE-WIRE, 4-20 MILLIAMPERE ANALOG SENSOR. (Source: *Synergistic Installation Manual*, May 1993.)

2-wire, ± 5 VDC analog input

Figure 1-19 shows the connection of a ± 5 VDC signal to the data logger. A resistive header is not used for this type of signal. In this figure, power for the instrument is supplied by a field source, but it could be supplied by the data logger as shown in Figure 1-18.

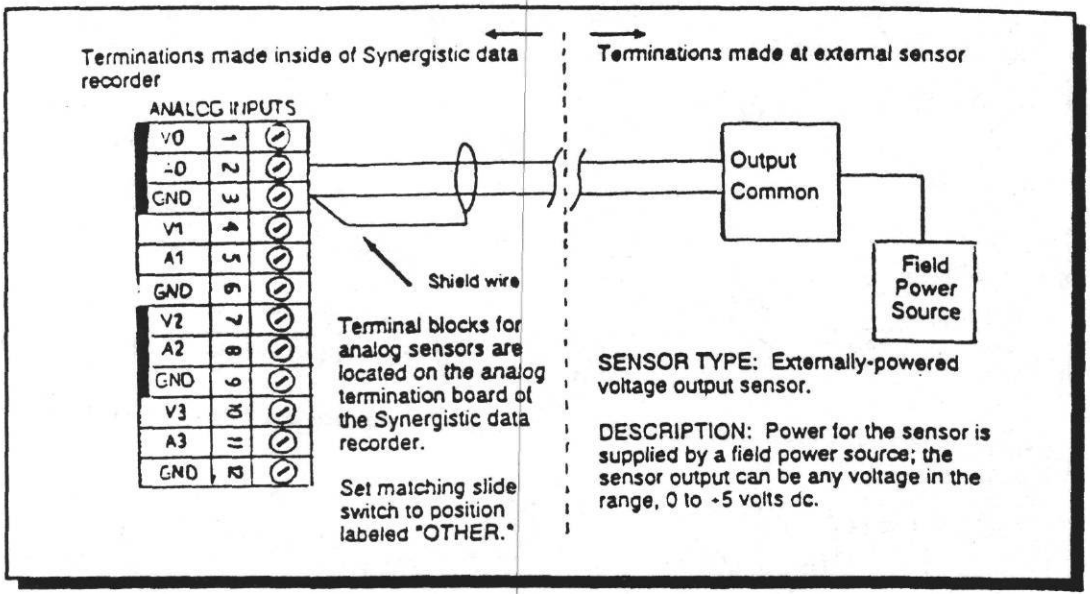


FIGURE 1-19. VOLTAGE OUTPUT SENSOR CONNECTION.
(Source: *Synergistic Installation Manual*, May 1993.)

1-2.7 Integration Period

The integration averaging period for all data logger channels is field-programmable and can range from one minute to 24 hours. A one-hour integration period is most common.

2-0 The PreMAP Process

In the PreMAP process, the DASS and, in most cases, an ESL representative, tour the facility to be monitored. During this tour, the DASS gathers information to assist in defining the monitoring plan, completes appropriate PreMAP forms and some SiteMAP forms (see Section 3), and gathers information to develop a cost estimate for the site. The PreMAP and completed cost estimate are then submitted to ESL for approval. ESL reviews the monitoring plan and either accepts, rejects, or modifies it. If it is modified, the DASS must adjust the cost estimate accordingly. Once the monitoring plan and cost estimate are approved by ESL, the PreMAP process is complete.

It is good practice to avoid overdesigning during the PreMAP process because portions of the design may be cut from the plan. Additionally, cost estimates should be created in a manner that allows them to be easily adjusted.

2-1 Creating the Monitoring Plan From ECRM List

In this process, a preliminary monitoring plan is created, based upon the ECRM list made available by ESL. In some cases, ESL will provide a prioritized list of monitoring points. In other cases, ESL will only provide the ECRM list. Evaluation of the performance of ECRMs frequently creates a need to monitor both electric equipment and thermal loads in order to isolate the energy savings resulting from the retrofits. Typical ECRMs include lighting, Variable Frequency Drives (VFDs), chilled water (CHW), or hot water (HW) system modifications, thermal storage, chiller replacement, and Energy Management Control System (EMCS) installations.

Individual device savings, end-use (e.g., lighting, heating, cooling, etc.) savings, whole-building savings, and whole-campus savings are potential monitoring approaches. It is desirable to monitor any energy loads that will potentially be affected by the installation of ECRMs so that resulting energy savings can be directly determined. Post-retrofit monitoring must also be included in the plan as necessary to be installed after the ECRMs are in place. The limiting factor in developing a monitoring plan is the availability of funding for the installation of monitoring equipment. **LoanSTAR funding for monitoring equipment installation has typically amounted to 3 percent of the total loan amount.**

For example, the Texas A&M University-Galveston site received a campus Energy Management and Control System (EMCS) as the ECRM. As shown in the completed workbook (see Appendix E), the points to be monitored were: whole-campus electric energy, whole-campus gas flow, whole-campus chilled water flow and thermal energy, and central-utility-plant electrical energy. It was necessary to monitor two separate electrical feeds in the central utility plant as there was no utility metering for the plant. Through the monitoring described above, energy savings for the campus were determined. In this case, it was not necessary to return to the facility to install post-retrofit monitoring.

ECRMs in which major new equipment is installed (such as base load chillers or thermal storage), typically require post-retrofit monitoring. It is thus necessary to determine whether post-retrofit monitoring is necessary and to estimate its associated costs when the PreMAP estimate is developed. Sometimes a post-retrofit site visit is required, even though it was not initially expected. This could occur, for example, if the pre-retrofit monitoring equipment is disturbed when the retrofits are installed, or if unanticipated changes are made to the specified ECRMs. It is the combined responsibility of the DASS and ESL to foresee the need for post-retrofit monitoring, as well as to select the pre-retrofit monitoring points that will best isolate equipment and thermal loads to measure future savings.

2-2 Touring the Facility

In order to develop the PreMAP, you must contact the facility to arrange tours as required for electrical distribution systems and heating/cooling distribution systems in individual buildings, as well as any central heating/cooling plants. Take time to explain the purpose of your visit when arranging a tour. The more the facility staff knows about what you hope to accomplish, the easier it will be for them to arrange a tour that will meet those goals.

Points to consider during the tour will include:

- general areas where monitoring might take place;
- location of major pieces of equipment that will receive retrofits;
- feasibility of each desired monitoring point;
- potential equipment mounting locations;
- the presence of utility and facility meters;
- wiring lengths and routes;
- alternate methods of monitoring where necessary;
- service entrance information for all pertinent energy types; and
- any other items that will affect the PreMAP development and the installation.

Depending on the size of the facility and the number of proposed monitoring points, you may opt for a quick walk-through of the facility before making detailed tours of the energy-delivery systems. It may be worthwhile to spend some time reviewing blueprints for the facility buildings before beginning the actual tours. **You should take an assortment of hand tools, including a flashlight and a digital multi-meter, and all necessary forms on the tour (see Appendix B for a tool list).**

As time permits, complete the PreMAP forms and as many of the SiteMAP forms as necessary during the tour. Complete the remaining forms as soon as possible so your memory doesn't fade. It takes time and money to arrange and conduct site tours, even those that are limited to specific items. Consequently, it is important to record as much detail as possible during the tour in order to create the PreMAP estimate. The detailed information will also make the remainder of the installation process easier to accomplish. Focus on touring the facility in as much depth as is necessary. **In complex facilities, you may wish to record your tour with a video camera to aid in recalling monitoring locations when you develop your cost estimate.**

It is not necessary to complete every line on each form of the PreMAP and SiteMAP document forms. Instead, use N/A (Not Applicable) wherever appropriate. However, you should be able to recognize proposed monitoring points that are impossible to monitor and be able to select substitute monitoring points that will satisfy the monitoring plan. This may require an extended tour and additional time at the site. It may also require that sections of the PreMAP forms initially thought to be N/A be completed.

You should advise the facility contact of your schedule in advance so that any necessary facility personnel can be notified. While you may need to be at the facility for as long as two to three days to complete the PreMAP and SiteMAP forms, facility staff need not be constantly present. Aim to minimize your impact on the facility. Remember, too, to record the name of the tour guide on the General Site Information Form and on the Building Tour Information Form for future reference. Also be sure to obtain the names and telephone numbers of other facility personnel you will be working with.

2-3 Completing the PreMAP Forms

The PreMAP forms are completed during the facility tours. **Only those sections of each form that apply directly to the ECRMs and the monitoring plan created from the ECRM list and tour must be completed. Remember, adequate documentation is the foundation for all phases of the project beyond this initial visit.**

There are roughly 18 PreMAP documentation forms that are completed for each installation. This documentation provides guidance into the design of the monitoring plan. For the DASS, the documentation provides an important link between each of the stages of an installation, such as:

- understanding the ECRMs;
- designing the preliminary monitoring plan;
- selecting equipment;
- estimating the cost;
- coordinating the installation;
- installing the equipment;
- programming the DAS;
- verifying the installation; and
- maintaining the equipment.

Beyond that, adequate documentation is critical to both analysts and maintenance personnel who will subsequently use the forms and the associated data.

A description of each form in the PreMAP documentation follows. See Appendices E and F to review blank copies of each form, as well as samples of completed forms. Note that the Site ID must be assigned by ESL before the DAS is programmed.

2-3.1 Form PREMAP1
PreMAP CHECKSHEET FORM

Initial the appropriate location on this form as each of the other forms is completed.

2-3.2 Form PREMAP2
GENERAL SITE INFORMATION FORM

This form is completed to provide the DASS and ESL with a record of all site contacts, utility contacts, addresses, titles, telephone numbers, and number of buildings at the site. **The form is critical for maintenance purposes.** A copy of this page will be included in each building workbook. It may be a photocopy if all information is the same.

2-3.3 Form PREMAP3
GENERAL BUILDING INFORMATION FORM

This form is completed to provide information that is specific to a building or central utility plant. This information includes building contact names, addresses, titles, and telephone numbers. Additionally, note the level of monitoring in the building and circle the thermal energy types and fuels monitored.

2-3.4 Form PREMAP4
BUILDING TOUR INFORMATION FORM

This form is completed to document the date, time, and tour guide for any visits to the site. Tour guides also should be noted as site contacts on Form PREMAP2.

2-3.5 Form PREMAP5
OPERATIONAL/INSTITUTIONAL CONSTRAINTS

This form records special information about the building and the facility, such as constraints on the scheduling of work in the facility, outages of any kind that may be required, special instructions to restart equipment, and the designation of limited access areas. It is important to be aware of this type of information when designing the installation, estimating the cost of the installation, and, of course, during the actual installation process itself.

2-3.6 Form PREMAP6
RISER DIAGRAM

The riser diagram is a one-line drawing of the electrical and gas service for the campus or building. If space allows, both may be on the same page. Start the one-line diagram at the campus or building meter or transformer. Continue the diagram to include all major equipment or branch circuits to be monitored. All electrical and gas distribution points should be labeled and the building floor where these are located should be noted.

2-3.7 Form PREMAP7
RISER INFORMATION FORM

This form is used to detail switchgear and panels fed by main switchboards or main distribution panels. Information included on this form may be limited to those electrical components being monitored. The form is sometimes redundant for very simple monitoring installations, and it may be left blank when adequate information is included in the Riser Diagram and the Switchgear or Panel Documentation Forms (PreMAP 12 and PreMAP 13).

2-3.8 Form PREMAP8
SERVICE ENTRANCE INFORMATION—1

This form details the electric and gas service entrances to the facility. This information is used to help determine which, if any, utility meters already are, or will need to be, fitted with pulse initiators.

2-3.9 Form PREMAP9
SERVICE ENTRANCE INFORMATION—2

This form details the facility or utility steam and condensate (or boiler feedwater) service entrances for the facility. The information is used to help determine if and where the service entrances will be monitored and whether there is existing metering in place.

2-3.10 Form PREMAP10
SERVICE ENTRANCE INFORMATION—3

This form details the facility or utility chilled water, hot water, and oil service entrances for the facility. The information is used to help determine if and where the service entrances will be monitored and whether there is existing metering in place.

2-3.11 Form PREMAP11
BUILDING EQUIPMENT LIST (CONNECTED LOAD INVENTORY)

This form is used to list all electrical and gas-fueled major equipment in the building or facility. It has been standard practice to list only those devices that are pertinent to the monitoring plan at the site. However, this usually includes all major components, such as chillers, chilled and hot water pumps, cooling tower fans, and boilers. In many instances, the supply and return air fans, as well as other similar equipment, are also listed. In those instances when non-HVAC-related equipment is being monitored, it must also be listed.

2-3.12 Form PREMAP12
PANEL DOCUMENTATION FORM

This form is used to detail any electrical panels (electrical distribution component that contains circuit breakers) that may be used for monitoring. The panel is used for monitoring if CTs are installed in it, if it is used to provide instrument power, or if it is used to provide reference voltages. If any monitoring equipment is to be installed in the panel, a Panel Documentation Form must be completed. It may also be necessary to complete the form if the panel is being monitored at another location (on the line side of the panel at a main switchboard or main distribution panel). All equipment fed by the panel should be documented on the form to show exactly what electric loads are present. In a few instances, panels and equipment may not be monitored directly, but instead by subtraction when all loads but the one of interest are monitored, and these panels must also be documented. Use as many forms as necessary to document the installation.

The completed forms provide critical information about sizing, installation, and verification of CTs; the types of loads being monitored; installation of PTs; installation of 24-VAC transformers to power the DAS; and programming the DAS. The remarks section can be used to record further details regarding how the monitoring equipment is installed and its location, as well as routes for signal cable to the DAS.

2-3.13 Form PREMAP13
SWITCHGEAR DOCUMENTATION FORM

This form is used to list any electrical switchgear (electrical distribution component that contains disconnects and/or starters) that may contain monitoring equipment. The switchgear may be monitored wholly or in part, may be used to provide instrument power, or may be used to provide reference voltages. If any monitoring equipment is to be installed in or on the switchgear, a Switchgear Documentation Form must be completed. It may also be necessary to complete the form if the switchgear is being monitored at another location (on the line side of the switchgear at a main distribution panel or main switch board). All equipment fed by the switchgear should be documented on the form to show exactly what electrical loads are being monitored. In a few instances, switchgear and equipment may not be directly monitored, but instead monitored by subtraction, and will need to be documented. Use as many forms as necessary to document the installation.

2-3.14 Form PREMAP14
WATTMETER CHANNEL REQUIREMENTS SUMMARY

This form is used to summarize the DAS power channel requirements. Information is taken from the panel and switchgear documentation forms (the column titled "Channel") and recorded on this form to determine the total number of CT channels required. Also, you may record at this time the digital wattmeter channel requirements as "D" (digital) channels and total them separately. This helps ensure that no power channels are overlooked in the design and also assists in determining the size of the DAS.

2-3.15 Form PREMAP15
FLOW SENSOR REQUIREMENTS SITESHEET

This form is used to summarize the flow sensor, temperature sensor, and BTU totalizer requirements for the site. Any type of flow or BTU metering requirement can be recorded, including chilled water, hot water, condensate, and boiler feedwater. Record all equipment model numbers here to assist in determining equipment needs when ordering.

An attachment to this page is the "Aggie Flowmeter Insertion Depth Tabulator" form, which must be completed for every CHW and HW insertion flow meter. The form details the insertion depth calculation, the S4 dipswitch setting, the parameter set program numbers for flow and BTUs, and a verification worksheet. This form is required in the documentation package.

2-3.16 Form PREMAP16
PHONE LINE ORDER FORM

This form assists in coordinating the installation of a telephone line to the DAS. The telephone jack will be installed where the DAS is to be located. The site contact is usually the Communications Director for the facility and should be noted as such on the General Site Information Form. **Make sure the facility understands that they will be responsible for the monthly telephone charges for this line.**

2-3.17 Form PREMAP17
SPECIAL EQUIPMENT REQUIREMENTS

This form is used to summarize and record any special equipment needs for the site. Items that may be noted include circuit breakers, fuses, PTs, electrical junction boxes, electrical connectors/termination blocks, conduit requirements, and any other needed equipment that is not already recorded.

2-3.18 Form PREMAP18
EQUIPMENT LOCATION and ASBESTOS INSPECTION DOCUMENTATION (EL&AID)

This form documents the location of all major equipment and areas where insulation must be disturbed. It serves as a record of all equipment location tag (ELT) placements. When an ELT is completed, the details for the tag are noted on the EL&AID form. The form guides facility staff in finding locations on piping, walls, or ceilings where the presence of asbestos need to be determined. The form also guides installation subcontractors when estimating the job or installing the equipment. Any asbestos testing results are recorded on the form and test reports are attached and included in the documentation workbook. (See Section 3-5.1 for more information.)

The ELT is filled out as completely as possible to assist the DASS and subcontractors in installing equipment at a later date. The kinds of equipment that typically warrant a tag include DAS, WHTs, BTU Meters, Temperature Sensors, Flow Meters, major junction boxes where other monitoring equipment is installed, and locations where walls or ceilings must be penetrated. Copies of the ELT are not required in the documentation package.

2-4 Selecting Monitoring Points and Equipment

Selecting monitoring points involves three primary tasks:

- selecting the precise piece of monitoring equipment to correctly monitor each of the points described in the monitoring plan;
- selecting alternate monitoring points if they are more cost-effective, or when the points described in the monitoring plan are impossible to monitor; and
- identifying all physical locations to install or mount the monitoring equipment.

Completing all three tasks is necessary to properly estimate the cost and monitor the facility.

The process of developing a PreMAP provides a structure for touring the facility. As each area of the facility is visited and supplemental facility blueprints are reviewed as required, monitoring points are selected and the necessary forms are completed. The PreMAP process typically involves making a number of decisions. For example, you may determine that it would be easier to monitor the total building electricity used for mechanical systems than to monitor the total electricity used for lighting. This would allow lighting electrical energy to be determined by subtraction (i.e., whole-building electrical load — whole-building mechanical systems electrical load = whole-building lighting load).

A similar situation may occur with condensate return monitoring. If it is not feasible to monitor condensate return, look for an alternative, such as boiler feedwater monitoring. **You can recommend and design these changes but ESL approval must be obtained by telephone or through the submittal of the PreMAP and estimate.** In many instances, there will be no need to deviate from the initial monitoring plan.

You must select physical locations where all monitoring equipment will be mounted and attach an ELT. Minor equipment, such as CTs, PTs, small junction boxes, fuse locations, and 24-VAC transformers, does not require an ELT. Selecting the physical location for CHW, HW, or Condensate Return flow meters is usually the most time-consuming. During this process, you must gather enough information to select the precise equipment needed. You should also identify routes and estimate the cable distances while on tour. If time allows, complete the ELTs and affix them in place while touring. **Keep in mind that this is a cost-estimating process; don't spend excessive time designing every detail.**

Monitoring equipment will typically be selected from the list of approved items. The following section details the selection criteria for each type of equipment item. Refer back to Table 1-1 for a list of the standard equipment used in the LoanSTAR program and a brief explanation of the primary selection criteria.

In cases where non-standard equipment is required, you can recommend a particular model of equipment, but ESL approval is required. Selecting most of the equipment will be relatively easy. As equipment is selected, record it on the appropriate PreMAP Forms 12, 13, 15, and 17, and SiteMAP Form 9b. This will assist with ordering and installing the equipment.

2-4.1 Selecting and Planning for the Installation of the DAS

Before attempting to select a data logger, refer to the Synergistic Installation Manual to become familiar with the systems available. Also, Table 1-3 summarizes the DAS model numbers and channel specifications. **The DAS model selected must accept all pre- and post-retrofit monitoring points.** The total number of CT channels, PT channels, digital channels, and analog channels necessary for the installation must therefore be known. PreMAP Forms 8, 9, 10, 12, 13, 14, 15, and SiteMAP Forms 2, 3a, and 3b, must be completed and reviewed. All channel requirements and locations should be designated on these forms.

Generally, selecting the DAS will be simple. However, in some cases, there is more than one option — usually when the use of WHTs may be more cost-effective than monitoring with CTs and PTs.

Multiple data loggers are also an option in some situations. In large sites, it is often more cost-effective to use multiple smaller data loggers than a single larger one. Multiple data loggers can reduce cable distances and the associated cost. Also, there are physical limits to the distances cable can be run, which vary by signal type. For more information, refer to the section on cable recommendations in the Synergistic Installation Manual.

The DAS should be mounted in a location central to the equipment to be monitored. An ELT should be affixed to the wall where the DAS is to be mounted. The DAS requires 24-VAC instrument power, so try to locate near an existing 120-VAC panel with a spare breaker to supply a 24-VAC transformer. Each DAS also requires either a telephone line or a DC loop connection, so be sure that the cable from the telephone company or from the DC loop can be routed to the DAS. If a telephone line is to be installed, it should be noted on the ELT that indicates the location of the DAS. The DAS should be located in a dry area and should not be subjected to temperatures below 40°F or in excess of 90°F. Refer to the Synergistic Installation Manual for further instructions.

2-4.2 Selecting and Planning for the Installation of PTs

PTs deliver a safe, low-voltage reference to the DAS from an existing single- or 3-phase line voltage circuit (up to 480 AC in a facility. Only one type of PT will function properly with the C180 data logger — the Synergistic Model PT-1. The maximum recommended cable length between the PT and the DAS is 500 feet.

PT selection requires determining the number of electrical services to be monitored. The C180 and C140 data loggers have the capability of accepting two PTs if two different electrical services are monitored. The C120 data logger can only accept one PT for a single- or 3-phase voltage reference.

Review PreMAP Forms 6, 7, 8, 11, 12, and 13 to determine if a second PT is required. To make this decision, you should thoroughly understand the facility's electrical system and how many electrical feeds need to be referenced. **Every electrical feed served by its own transformer requires a PT if any loads on the feed are to be monitored.** If more than two electrical feeds need to be referenced, WHTs or an additional data logger must be used.

Each PT is typically mounted in a 6"x6"x4" junction box with cover at a location as close to the reference voltage as possible (usually on the top or side of, or adjacent to, the panel or switchgear where the reference voltage is located). Try to find a spare 3-phase breaker in the switchgear, or three spare single-pole breakers in a panel. If no spare breakers can be located, new breakers can be installed in unused spaces (blanks) in the panel. If no spares or blanks exist, you may have to "share" voltage with a load on a breaker that is never turned off. **In all cases, get approval from the facility to use existing breakers or install new ones.** Install fused protection on the primary side of the PT. The fuses are typically mounted in another covered, 6"x6"x4" junction box next to the PT. When the precise reference voltage monitoring location is identified, record the information on PreMAP Form 12 or 13 and attach an ELT. Record any special instructions to the electrician in the comments section of those forms, such as the precise breaker location in the panel or switchgear, or special instructions regarding routing of signal cable to the data logger.

2-4.3 Selecting and Planning for the Installation of WHTs

Refer to the Ohio Semitronics installation and specifications sheets for the WL-3968 watt-hour transducer. This device has a Form A pulse (dry contact) output, which terminates at a digital input in the data logger. Resistance in the signal cable between the WHT and the DAS must not exceed 500 ohms. The WHT uses instrument power rated at 208 VAC, 240 VAC, or 480 VAC. It accepts shunted CTs with secondary outputs rated at 0 to 333 mVAC .

Use of the WHT is determined by the cost of alternative monitoring approaches and/or the number of electrical feeds that serve the monitored equipment. The goal is to accomplish the monitoring outlined in the PreMAP at the least cost.

When considering the cost of WHTs versus using power channels, compare the total estimated cost of installing WHTs and the B80 data logger to the total estimated cost of the Synergistic C Series of data logger and associated CTs and PTs. Consider such factors as:

- labor to install the WHT;
- the need for three CTs with all WL-3968 WHTs;
- the cost of the B80 data logger;
- the cost of CTs where only two are required for 3-phase, 3-wire system load monitored by a Synergistic C Series DAS;
- the cost of any additional PTs; and
- the cost of additional Synergistic C Series data loggers.

WHTs are usually less costly for small sites with three or less loads to be monitored. For larger sites, it depends on how many electrical feeds serve the monitored equipment. In situations where there are many loads to be monitored and more than two feeds, the cost comparison will be more complicated.

Each WHT should be mounted in a covered, 10"x10"x4" junction box in a location as close to the reference voltage as possible (usually on the top or side of, or adjacent to, the panel or switchgear where the reference voltage is located). Try to find a spare 3-phase breaker in the switchgear or three spare single-pole breakers in the panel to provide instrument power and reference voltage. If no spare breakers can be located, blanks can be used if you install new breakers. If no spares or blanks exist, you may have to "share" voltage with a load on a breaker that is never turned off. In all cases, get approval from the facility for the use of existing breakers or installation of new ones. Fuse protection should be installed on the primary side of the WHT. The fuses are typically mounted in a covered, 6"x6"x4" junction box next to the WHT. When the precise WHT monitoring location is identified, record the information on PreMAP Form 12 or 13. Record any special instructions to the electrician in the comments section of these forms, such as the precise location to mount the WHT, and special instructions regarding routing of signal cable to the data logger. An ELT should be mounted at the location where the WHT is to be installed.

2-4.4 Selecting and Planning for the Installation of CTS

Refer to the Sentran installation and specifications sheets for information on the models typically used in the LoanSTAR Program. Also, read the section on CTs in the Synergistic Installation Manual, and the Ohio Semitronics installation and specifications sheets for Model WL-3968.

It is important to become familiar with the variety of CT sizes and styles available. The CTs used with the Synergistic data logger and the Ohio Semitronics WHT are shunted, which means that the output is a low voltage (0 to 333 mV), which is proportional to the primary current. The CTs are rated for use in electrical equipment up to 600 VAC at specified amperages. Usually, only split-core, or "clamp-on," CTs are specified so that electrical outages are held to a minimum during installation. Solid-core CTs can be used in cases where outages are not a concern. Maximum recommended CT cable length is 500 feet.

Be certain of the exact model numbers and sizes of all CTs to be installed. Don't order CTs based on information from electrical drawings. Instead, open up the switchgear or panel and look at the conductors. Be sure to note whether more than one conductor per phase is present as is common in many service entrances. It is sometimes impossible to install CTs in switchgear or panels. In those cases, an alternative location or method must be identified. This could involve finding another electrical distribution point; mounting CTs in a junction box outside the switchgear or electrical panel and routing the conductors to be monitored outside the electrical panel, through the CTs, and back into the electrical panel; or monitoring other loads to derive the desired load by subtraction and/or summation. When an indirect monitoring method is used, be sure to detail the required equation to calculate the load on SiteMAP Form 4.

When the precise location to monitor a load is identified, record that information on PreMAP Form 12 or 13. You should also record the CT model number with the primary rating and necessary window size. Any special instructions to the electrician should be recorded in the comments section. These comments might include the precise location in the panel or switchgear where CTs are to be installed; identification of all circuits when multiple conductors pass through a single CT; CTs that are to be terminated in parallel inside a junction box at the top of the panel or switchgear; CTs that are to be terminated to a summing module inside the junction box at the top of the panel or switchgear; routing paths of CT secondary leads to the junction box; and the junction box location for terminations of secondary leads to the signal cable. Also, any special instructions regarding routing of signal cable to the data logger should be recorded here.

CTs operate most accurately between 10% and slightly over 100% of their full-scale rating. They can accurately exceed their rating by about 25%. Select CTs based on the known or anticipated peak load of the monitored device(s). Attempt to select a CT sized just over the maximum expected load. **It is safer for the CT rating to exceed the load than to risk using a CT that is too small.**

2-4.5 Selecting and Planning for the Installation of BTU/FLOW Totalizers

Refer to the DK System 90 Series BTU Monitoring System installation and programming instructions.

Typically, only one BTU/flow totalizer model is used, but there are several issues to consider. The inputs into the BTU/flow totalizer are from two temperature sensors and one flow meter. The device has two Form A pulse (dry contact) outputs, which terminate at two digital inputs in the data logger. Maximum recommended resistance in the signal cable to the data logger is 500Ω, and sensors may be located up to 300 feet from the totalizer. If possible, the totalizer should be mounted near a 120-VAC panel for access to instrument power.

Selection of BTU/flow totalizer equipment is based on the type of thermal load being monitored. You must specify chilled water, hot water (with the temperature range), or glycol solution (percent glycol). It is necessary to specify either 120-VAC or 24-VAC instrument power for the device. Selection of power supply voltage is based on how close to a 120-VAC panel the totalizer can be mounted. Cable from a 24-volt transformer to the totalizer may not require conduit.

The ambient conditions at the mounting location should be dry and near room temperatures. Record information regarding the installation on PreMAP Forms 10 and 15. An ELT should be affixed to the wall at the location where the totalizer is to be mounted.

2-4.6 Selecting and Planning for the Installation of Temperature Sensors

Refer to the DK System 90 Series BTU Monitoring System Installation Manual and DI Technical Bulletin No. 41 on hot tap installations.

The MRA-Variable Depth Sensor thermistor is always used with the DK BTU meter (BTU/flow totalizer). There are a number of options regarding temperature range, accuracy, length, and fittings. Maximum recommended cable length between the temperature sensors and the totalizer is 300 feet.

Two temperature sensors are required to monitor both the supply and return water lines. You must specify whether chilled water or hot water is being monitored. As part of the PreMAP process, you must also select the length of the sensor (10" stainless steel is normally specified), the temperature range (0° to 70°C for chilled water, or 0° to 100°C for hot water), the accuracy of the sensor (±.1°C is desired), and sensor fittings, including a 1/4" NPT to 1/4" compression fitting with plastic ferrel.

The temperature sensor is usually mounted in a hot-tapped location (1" valve with 1/2" hole). Taps are usually at the top of the pipe, but approximately 48" clearance is required to complete the tap. One temperature sensor tap should be placed approximately 1 foot downstream of the flow meter tap to simplify installation, reinsulation, and wiring. Refer to the DI Installation Manual for further instructions.

If insulation is present on the pipe before installation, the facility must provide a letter stating that it contains no asbestos. If asbestos is present, it is the responsibility of the facility to have it removed before your installation work can begin. You will be responsible for having the metering station insulated (up to and including the valve) when the installation is complete. Record information regarding the installation on PreMAP Forms 10 and 15. Affix an ELT to the tap installer to the pipe at the location where the hot tap for the temperature sensor is to be installed. Include any special instructions to the tap installer.

It is occasionally necessary to monitor chilled water or hot water temperature separately from the BTU metering. In those instances, 1000Ω RTDs are typically used and are terminated directly into analog channels of the data logger. The process for selecting a location for these devices is identical to the process of selecting a location for temperature sensors used for BTU metering.

2-4.7 Selecting an Planning for the Installation of Insertion Flow Meters

Refer to the DI Series 200 Installation Manual (model No. 225B, option 12R), and the DI Technical Bulletin No. 41 on hot tap installations.

The DI flow meter is normally used with the DK BTU meter. There are no other options for chilled water and hot water installations (with a maximum temperature of 221°F and maximum pressure of 200 psi). Maximum recommended cable length between the flow meter and the totalizer is 300 feet.

The same flow sensor is used for all chilled water, hot water, or condenser water monitoring where the temperature and pressure are within the above-stated ranges and the nominal pipe diameter is 3" or greater. The flow in the loop to be monitored must be common; hence, the flow sensors can be mounted in either the supply or the return line. The sensor is usually mounted in a 2" hot tap (2" valve with 1-7/8" hole) by a certified subcontractor. Taps are best located at the top of the pipe, but approximately 48" clearance is required to complete the tap and install the meter. Install the sensor at any radial location on the top half of the pipe. If a tap is installed in a vertical section of pipe, it should be in one that has an upward flow. There should be a minimum of 10 pipe diameters upstream and 5 pipe diameters downstream from the sensor of straight, unobstructed pipe to allow full development of the flow profile.

If insulation is present on the pipe before installation, the facility must provide a letter stating

that it contains no asbestos or have it removed. You are responsible for having the metering station insulated (except the meter itself) when the installation is complete.

Refer to the DI Installation Manual for further instructions. Record information regarding the installation on the SiteMAP Schematic and on PreMAP Forms 10 and 15. Affix an ELT with any special instructions to the hot tap installer to the pipe at the location where the hot tap for the temperature sensor is to be installed.

2-4.8 Selecting and Planning for the Installation of Condensate and Boiler Feedwater Flow Meters

Refer to the specifications and installations sheets for the ISTA Product No. 1793x turbine flow meters. The meters are rated for flow rates from .4 gpm to 658 gpm at a maximum temperature of 250°F and a maximum pressure of 250 psi. These meters should be used whenever these specifications can be met. Each meter has a Form A pulse (dry contact) output, which terminates at a digital input in the data logger. Maximum recommended cable resistance between the meter and the DAS is 500 ohms.

As you prepare the PreMAP, be advised that these sensors must be installed in a straight, horizontal section of pipe with a minimum of 5 pipe diameters upstream and 5 pipe diameters downstream from the sensor of unobstructed pipe to allow full development of the flow profile. The meter should be installed in a trap configuration with a three-valve bypass so it can be removed for service without causing an outage to the facility.

If insulation is present on the pipe before installation, the facility must provide a letter stating that it contains no asbestos or have it removed. It is your responsibility to have the metering station insulated (except the meter itself) when the installation is complete.

Find a suitable location where all the flow for the building, facility, or boilers can be accurately metered. ESL will usually specify a preference for either condensate or boiler feedwater metering, but you will have to determine if either can be monitored and make alternate recommendations for steam metering when necessary. Determining the appropriate and correct metering station location is sometimes difficult due to the maze of piping in mechanical rooms. It may take time and an experienced tour guide from the facility to find the proper metering location.

The facility must approve the flow metering design and installation plan because an outage is necessary. Therefore, a schematic must be drawn for the installation. It may be necessary to schedule the outage on a weekend, and overtime pay for subcontractors must be considered in the cost estimate. Record information regarding the installation on PreMAP Forms 9 and 15. Affix an ELT to the pipe at the location where the metering station is to be installed.

2-4.9 Selecting and Planning for the Installation of Signal Conditioners and Isolators

There is a large variety of signal conditioners and signal-isolation devices on the market. Although these devices aren't used in every site, the LoanSTAR Program has attempted to standardize their application to reduce human error and increase ease of use. See Table 1-1 for a vendor's list. Also refer to the specifications and installation sheets for detailed instructions on use and installation.

A signal conditioner is used to change a signal from one form to another and transmit the new signal to its destination. Usually, this means conditioning a 4-20 mA signal into a Form A (dry contact) contact closure, which can be used as input to a digital channel of the data logger. However, any signal type may require conditioning, including 4-20 mA, 0-50 mA, 0-1 mA, 0-50 or 0-100 mV, 0-5 VDC, 0-10 VDC, and contact closure signals. Signal conditioning could be necessary if a facility meter signal is available but is not in the proper form for use in the data logger. Signal conditioners can use either 120 VAC or 24 VAC for instrument power. The main reason for using a signal conditioner is to enable an available digital channel in the data logger to be used, but certain analog signals may require conditioning before they can be appropriately terminated at the data logger analog board.

A signal-isolation device is used to isolate the signal transmitted to one device from the signal going to another. It is placed in series with the signal circuit, and accepts a current or voltage (0-20 mA or 0-5 VDC) and provides an isolated identical current or voltage output. Normally, a signal-isolation device is used when sharing a signal with a facility EMCS so that there would be no possibility of any interference in either the EMCS or the DAS due to problems in the other. The devices generally can use either 120 VAC or 24 VAC for instrument power.

The best location for signal conditioners or isolators is at the source of the signal. If this is not possible, they can be mounted anywhere between the source and the data logger or at the data logger. The devices are commonly mounted in an appropriately sized junction box. There is usually 120 VAC near the data logger for instrument power. It is not necessary to affix an ELT for this device. Maximum recommended cable length is 500 feet. Include the device on SiteMAP Form 11.

2-4.10 Selecting and Planning for the Installation of Isolation Relays

Refer to the specifications and installation sheets for the SSI pulse splitters. There are several models that can be used, but most often a Form A or Form C contact closure is split and isolated. This is usually done by the utility company at the billing meter. However, there are instances where other Form A and Form B contact closures are split and isolated. Maximum recommended cable resistance is 500 ohms. An isolation relay splitter might be necessary in cases where a signal from an existing meter can be shared. These devices allow existing metering equipment to be used, rather than requiring new equipment. They are typically used in conjunction with utility electric or gas revenue meters.

The best location to install an isolation relay splitter is in an adequately sized junction box at the source of the signal, but the splitter can be mounted anywhere between the source and the data logger. These devices can use either 120 VAC or 24 VAC for instrument power. An ELT is not necessary, but be sure to show the device on the SiteMAP Form 11.

2-4.11 Selecting and Planning for the Installation of Utility Pulse-Initiating Meters

If the preliminary monitoring plan calls for whole-building or whole-campus gas flow or electric energy monitoring, it may be possible to use utility billing meters. Most electric and gas utility revenue meters can be equipped with a pulse initiator and many are already so equipped. You should investigate this possibility while touring the facility. The main facility contact may know — or be able to find out — where all the billing meters are, and should have contact names for utility personnel. The utility should be contacted to arrange for pulse initiator installation or the installation of an isolation relay if a pulse initiator is already installed and in use. Alternatives to using a utility revenue meter exist. For electricity, this involves finding a place to monitor the service entrance with CTs and a PT or with a WHT. For gas service to a boiler, it involves installing a pressure-compensated, pulse-initiating gas meter or finding a place to monitor boiler feedwater or condensate return.

If the utility will install a pulse meter or isolation relay, you must coordinate and pay for the installation. The utility charge for this service has typically been about $300. The utility usually installs the pulse initiator and a junction box with termination lugs where the signal cable back to the DAS is attached. The main consideration in selecting a utility revenue meter for monitoring purposes is whether or not a signal cable can be installed from the data logger to the utility meter. If this can be done without a great deal of trenching, especially through concrete or pavement, it is usually the most cost-effective method to monitor the service. Give careful consideration to alternatives if there is a long distance to trench.

The utility will be able to provide the value of the meter pulse constant in kWH per pulse or cubic feet per pulse. Normally, the pulse will be Form C for electric meters, and either Form

C or Form A for gas meters. If Form C is provided, the pulse constant must be doubled in software. Verification will be discussed later, but you should get the pulse constant value and any other necessary calibration data from the utility while arranging the installation.

The utility meter signal terminates into a data logger digital channel. Maximum recommended cable resistance is 500 ohms. Include the device on SiteMAP Form 8. It is not necessary to affix an ELT for this device.

2-4.12 Selecting and Planning for the Installation of Fuses and Circuit Breakers

Whenever possible, LoanSTAR monitoring equipment requiring electrical power should be served by a dedicated breaker or disconnect. Fusing adds additional protection and isolation. Most facilities have ample spare breakers or disconnects that can be used for instrument power and reference voltage requirements. It is important for the DASS engineer to locate a source voltage for all equipment power and reference voltage requirements, as well as switchgear and panels that have available spares, while touring the facility.

Be sure to obtain permission from the facility to use its spares. If the facility does not allow the use of spares, or if there are no spares available, you must locate blanks and record the appropriate specifications on the switchgear or panel documentation forms so that breakers can be purchased and installed.

The data logger, BTU meter, and other signal-conditioning equipment need 120 VAC (or 120 VAC to 24 VAC) for instrument power. A single-pole, 15-amp breaker (or 20-amp breaker if a 15-amp is not available) will adequately serve any of those equipment power requirements. If all the equipment can be mounted in one location, then use just one breaker. If equipment is in various locations, find and use a single-pole, 120-VAC breaker at each location. If 120 VAC is not available at all locations, it may be possible to specify equipment with 24-VAC instrument power requirements. Then, low-voltage signal cable can be installed from a 24-VAC transformer mounted at a 120-VAC panel to the 24-VAC monitoring equipment. Costs will probably be manageable if conduit is not required. Fuse the 120-VAC side of all equipment with a 1.5-amp, in-line fuse for added protection and isolation. Fuse the secondary side of any 24-VAC transformers with a 1-amp, fast-acting fuse to protect the transformer.

PTs and WHTs require 3-phase voltage for instrument power and reference voltage. If there are no spares or blank locations to mount a new breaker, a journeyman electrician should obtain the necessary voltage in an alternate manner that will still satisfy electrical code requirements. PTs and WHTs are typically fused with three 1.5-amp, in-line fuses housed in a covered, 6"x6"x4" junction box mounted adjacent to the monitoring equipment. The fusing protects and isolates the monitoring equipment. All high-voltage junctions are made in the junction box with the fuses, and low-voltage junctions are made in the junction box with the PT or directly at the WHT.

Record exactly how the voltage is supplied to the equipment, as well as all fuse locations, and update PreMAP Forms 12, 13, and 17, and SiteMAP Forms 2 and 11. Also note PT and WHT locations on the PreMap Schematic (see Section 2.5).

2-5 Creating the PreMAP Schematic

The PreMAP Schematic is a simple diagram that provides an overview of the monitoring installation for a site. It shows:

- all monitored loads;
- the type of monitoring equipment used and its location;
- the DAS channel used to monitor each load; and
- the ECRMs being monitored.

The schematic is also useful during the installation of the monitoring system, and when servicing equipment in the future. In complex sites, the schematic allows the installation to be quickly understood.

The PreMAP Schematic is submitted with the PreMAP Cost Estimate and becomes the SiteMAP Schematic when the PreMAP design is accepted by ESL. A sample PreMAP Schematic is located in the Appendix E on the pages following SiteMAP Form 12. In all sites, the schematic will be completed and submitted accompanying SiteMAP Form 12 in the documentation workbook.

2-6 Creating the PreMAP Cost Estimate

There are many components to estimating costs. You'll need to consider costs such as:

- equipment costs per monitoring point;
- DAS and miscellaneous equipment costs for the site;
- utility company costs for individual monitoring points;
- individual subcontractor labor and materials cost for each site;
- DASS cost to design, coordinate, install, verify, and document a site;
- travel and per diem;
- DASS overhead for subcontractors, equipment, and travel; and
- DASS management cost for the site.

Estimates are typically expressed as round numbers. Installation time for each of the areas mentioned above is also estimated. Subcontractor materials and utility meter installation costs can be based on telephone bids or known costs. Subcontractor labor can be based upon DASS time estimates for the subcontractor to complete the work and known labor costs in the area.

The PreMAP cost estimate should show the cost for all monitoring points as they appear in SiteMAP Forms 2, 3a, and 3b. An example of a PreMAP cost estimate format is shown below in Table 2-1. A further example is provided in Appendix E. There is no separate PreMAP form for the cost estimate.

Table 2-1. PreMAP Cost Estimate Example.

Monitoring Points	Material, DASS and Subcontractor Cost Descriptions	Cost Totals
Whole Campus Electric	Pulse Splitter	$ 200
Whole Campus Gas	Pulse Meter Installation	500
Whole Motor Control Center Electric	(3) CTs	250
CHWP Electric, (3) 30-hp Motors	(6) CTs	500
Whole-Chiller Electric, (3) 350 Ton	(6) CTs	500
Whole Maintenance Building Electric	By Addition	0
Whole-Campus CHWF and CHWB (1) Loop	Equipment Taps and Reinsulation	1,200 1,100
Telephone Installation	Installation	100
DAS and Related Costs	C-140E-N1 and PT and Modem Misc. Elec. Parts and Signal Cable	2,223 427
Electrical Subcontractor Costs	24 Hrs Jm. and Appr. and Truck	1,440
DASS Labor, Travel, Per Diem, and Overhead	Travel and Per Diem Overhead on Equip, Subs, and Travel DASS Labor (Project Engineer) DASS Management	1,000 1,135 3,038 632
DASS Total For Site		$14,245

2-7 Submitting PreMAP Cost Estimate and Schematic

The PreMAP Cost Estimate and Schematic are submitted to ESL for review and approval. If ESL makes modifications, the DASS must subsequently change the cost estimate and probably the schematic. Whether or not the modifications are simple to make depends on how thoroughly the facility was toured, the level of detail recorded during the tour, the detail of the cost estimate developed, and the level of modification requested. Generally, the PreMAP estimate and the schematic can be faxed or mailed to ESL for review and approval. When all requested modifications are complete and both ESL and the DASS are satisfied with the PreMAP Cost Estimate, a contract is implemented. When the contract is signed by all parties, the SiteMAP process begins.

3-0 The SiteMAP Process

The SiteMAP Process involves further installation preparation. When the PreMAP is approved and a contract amendment is in place, the SiteMAP process begins. At this point, all SiteMAP documents should be completed or revised if any modifications were made to the PreMAP by ESL. Equipment should be ordered, subcontractors secured, the installation coordinated with the facility, and the communications (telephone line) installation arranged. **You must coordinate all plans with the facility contact, as well as coordinate subcontractors and equipment delivery for the installation.**

In some large installations, it may be necessary to return to the facility to finalize equipment mounting locations and to meet with subcontractors for tours to secure bids. The final design decisions that must be made prior to ordering equipment include:

- selecting the DAS;
- selecting CT sizes and shapes;
- specifying signal wire requirements; and
- identifying miscellaneous electrical and plumbing parts requirements.

You or your subcontractors may provide miscellaneous parts. The DAS program can be written in advance and monitoring equipment may be pre-tested, labeled, and marked as it is received.

Facility approval must be secured for the installation plan and timeline, as well as for any subcontractor tours. As has been previously mentioned, in locations where insulation must be removed, where ceiling tiles must be moved, or where walls must be penetrated, the facility must provide documentation that asbestos is not present or undertake abatement if it is. If welding is necessary, you must coordinate with the facility's fire or safety department to assure that no alarms are triggered and that appropriate safety precautions are observed. Coordinate any necessary outages with the facility. Parking permits or clearance and access to facility keys and equipment storage areas should also be coordinated at the facility during this time. Further details about these requirements can be found in Section 3.5.

3-1 Completing the SiteMAP Forms

The SiteMAP documents should be fully completed after any final revisions of the PreMAP are completed by ESL. There are 11 SiteMAP forms to be completed for each installation. It is especially important to complete these forms prior to ordering equipment since the forms serve as a guide in selecting and ordering equipment. As with the PreMap forms, it is not necessary to complete all sections in each form — only those sections that apply directly to the monitoring plan. A description of each form in the SiteMAP documentation follows. Refer to Appendices E and F to review samples of completed forms and blank copies of each form.

3-1.1 Form SITEMAP1
SITEMAP CHECKSHEET

Initial the appropriate locations as each form is completed.

3-1.2 Form SITEMAP2
ELECTRIC POWER CHANNEL ASSIGNMENT FORM

This form compiles information recorded on PreMAP Forms 12 and 13 and is used as a guide to programming the kW inputs (CT and PT inputs) in the data logger. The form is used with all Synergistic C Series data loggers (it is not applicable when a B80 data logger is used). Writing the program (parameter set) for the kW channels is greatly simplified when this form is completed first. All sections should be filled in or marked N/A when not applicable.

This form is also necessary for troubleshooting the installation and parameter set because it is time-consuming to find information on PreMAP Forms 12 and 13. In complex monitoring installations, it is also possible to locate design mistakes when compiling the design onto one form. The form is to be completed when the design is finalized.

3-1.3 Form SITEMAP3a
DIGITAL CHANNEL ASSIGNMENT FORM

This form compiles information recorded on PreMAP Forms 12, 13, and 15, and is used as a guide to programming the digital inputs to the data logger. Any monitoring equipment with a digital output, such as WHTs, BTU/Flow totalizers, utility electric meters, utility gas meters, in-line flow meters, and others with digital outputs, must be included here. The form is used with all data loggers. Writing the program (parameter set) for the digital channels is simplified when this form is completed first. All sections should be filled in or marked N/A when not applicable. Additional information not required to develop the parameter set may be recorded in the comments section.

This form is also necessary for troubleshooting the installation and parameter set because it is time-consuming to find information on the PreMAP forms. In complex monitoring installations, the form is to be completed when the design is finalized. In simple installations, the form must be completed for final submittal.

3-1.4 Form SITEMAP3b
ANALOG CHANNEL ASSIGNMENT FORM

This form compiles information recorded on PreMAP Forms 12 and 13 and is used as a guide to programming the analog inputs to the data logger. Any sensors with an analog output, such as 4-20 mA, 0-5 VDC, or RTD signals, will use analog channels and should be recorded here. The form is used with all data loggers with an analog option (it is not applicable when a B80 data logger is used). Writing the program (parameter set) for the analog channels is greatly simplified when this form is completed first. All sections should be filled in or marked N/A when not applicable. Additional information not required to develop the parameter set may be recorded in the comments sections.

3-1.5 Form SITEMAP4
EQUATIONS FORM

This form is completed to help ESL understand which channels in the data logger correspond to the various points in the monitoring plan. Often, multiple channels are used to monitor one end-use, such as chilled-water-pumping electrical energy. For example, two kW channels (kW0 and kW1) channels can be used to monitor a motor load such as a chilled water pump motor (CHWP). If this was the only CHWP monitored, the monitoring equation would read as follows: CHWP=kW0+kW1. When multiple CHWP motors (or any other specific kind of load) are monitored using more channels (CHWP #1 on kW0 and kW1, and CHWP #2 on kW2 and kW3, for example), then the monitoring equation would read: CHWP=kW0+kW1+kW2+kW3. This applies to any kind of load that corresponds to a specific end-use in the approved PreMAP design monitoring plan.

Equations must be written for all kW, digital, and analog channels. The form shows many of the abbreviations for the types of loads typically monitored.

3-1.6 Form SITEMAP5
CT REQUIREMENTS WORKSHEET

This form is completed to compile all shunted (333 mV output) CT requirements for the installation. The form facilitates writing the purchase order for the CTs, and it can be completed at any time after the PreMAP is approved by ESL.

3-1.7 Form SITEMAP6
NON-SHUNTED CT REQUIREMENTS WORKSHEET

This form compiles all non-shunted (current output) CT requirements for the installation. It is rare when non-shunted CTs are required. Therefore, the form is usually completed with N/A.

3-1.8 Form SITEMAP7
CABLE REQUIREMENTS WORKSHEET

This form is completed during or after the facility tour to determine the total cable requirements for the installation. It is good practice to list every length of cable to every sensor and every piece of associated equipment that requires cable for signal transmission or instrument power.

3-1.9 Form SITEMAP8
MULTI-PAIR CABLE GUIDE

This form guides the installation of all cable. Every cable run must be listed on the form showing the location of each end of the cable, the cable type, the colors of the conductors, the sensor or equipment served at one end of the cable, the DAS channels connected at the other end of the cable, and the marker number placed on both ends of the cable. Other cable sizes, such as 1-pair, may be inserted on the form if they are not present.

The form is critical for installation and for troubleshooting various problems. It is mandatory to complete the form and almost impossible to complete terminations without it.

3-1.10 Form SITEMAP9
INVENTORY CONTROL, HARDWARE REQUIREMENTS FORM

This form serves as a guide to site equipment needs and sources. It can be used to record the equipment that must be purchased, as a record of purchases, to record transfer of equipment, to list the various subcontractors, and to record serial numbers of all equipment. It may be completed any time after the PreMAP is approved. It can also be completed before the PreMAP to assist in developing the PreMAP Cost Estimate.

The form should be updated when the site installation is complete, prior to submitting the documentation workbook.

3-1.11 Form SITEMAP10
NOT USED

3-1.12 Form SITEMAP11
DATA LOGGER EQUIPMENT LOCATIONS

This form serves as a summary of locations for all major electronic equipment, including data loggers, PTs, 24-VAC transformers, BTU meters, and WHTs. The following items are recorded for each equipment item:

- physical location of installed monitoring equipment;
- power supply source location;

- reference voltage supply location;
- location of fuses added for isolation and protection; and
- the source voltage for the fuses.

The form assists in locating equipment and power or reference voltage sources when installing or servicing the equipment.

3-1.13 Form SITEMAP12
SITEMAP SKETCH

This form is used to sketch equipment mounting locations. A floor plan is drawn with major facility equipment (especially equipment being monitored) shown and monitoring equipment locations noted throughout. The sketch is useful in locating equipment mounting locations during the installation and for servicing the equipment at a later date.

3-2 Equipment and Cable Purchases

3-2.1 Equipment

Equipment purchases over $100 should be made by purchase order (P.O.). The P.O. should include specific model numbers, item descriptions including requested modifications or special features, price of each item, total price, applicable discounts, shipping and billing instructions, and vendor and purchaser contacts and telephone numbers. A sample P.O. appears in Appendix H.

Credit arrangements should be made in advance. Prompt payment of equipment suppliers is critical. Many DASS use the same suppliers and good customer relations is important to the overall success of the installation. If a vendor requires advance payment or C.O.D. for LoanSTAR because of the payment problems of a DASS, everyone suffers.

3-2.2 Cable

The specified cable for LoanSTAR is plenum-rated, 22-gauge, stranded, twisted-pair cable with an overall shield and a drain wire. Single-pair, two-pair, and four-pair cable will be used as appropriate. The specified telephone wire is 22-gauge solid cable with plenum-rated insulation. Refer to Chapter 2 of the Synergistic manual for more information on cable recommendations.

Cable suppliers include:

- Anixter — Austin, Dallas, Ft. Worth, and Houston
- TIC Cable — Austin, Dallas, Houston, and San Antonio
- Newark Electronics — Local telephone numbers in Austin, Corpus Christi, Dallas-Ft. Worth area, El Paso, Houston, and San Antonio. (Cable is shipped from central warehouse. Order from catalog.)
- Multi-Cable Corp. — Dallas
- Network Products, Inc. — Bristol, Connecticut

If credit arrangements are made with cable suppliers in advance, rapid delivery can usually be obtained. It is often difficult to make accurate estimates of cable distances in the PreMAP and SiteMAP processes, and overnight delivery of cable is sometimes necessary.

3-3 Subcontractor Selection and Agreements

When selecting subcontractors, it is good to ask the on-site facility managers for a recommendation. Usually, they will know contractors who they trust and who are familiar with the facility. If the facility manager does not have a recommendation, obtain approval from the facility for any subcontractors chosen. Remember to obtain competitive bids when possible and make every effort to solicit Historically Underutilized Businesses (HUBs).

Subcontractors may be secured on a time-and-materials contract (typical for electrical contractors) or on a fixed-price bid (typical for welding and insulation work). A Purchase Order should be issued, specifying the terms of the agreement. A DASS technician familiar with the job should review the subcontractor's invoice before payment to ensure accurate billing.

3-4 Permits, Clearances, Permission, and Access

As the DASS, you are a guest at the facility. You have not been hired by the facility, and furthermore, you have no contractual relationship with the facility. Your work must be closely coordinated with the facilities personnel at the site and your work must not interfere with their ongoing responsibilities.

Your initial task, once a site has been assigned, will be to arrange a tour of the facility with the facility representative. This initial tour is part of the PreMAP process, which is described in detail in Section 2.3.

While arranging the tour, it is important to carefully explain the monitoring project to the facility representative, and describe what is involved in the monitoring equipment installation process. Make clear what you will be doing to the mechanical and electrical systems in the building, and identify the buildings where the monitoring will take place. Be particularly clear if you are doing intrusive monitoring where techniques such as hot-tapping will be required. If possible, discuss your proposed work schedule with the facility representative. By doing so, any scheduling bottlenecks can be quickly identified and appropriate permission to conduct monitoring can be obtained.

Issues such as building access and security should also be addressed on the PreMAP tour. It is critical to meet all facility requirements regarding security and access and to note how and under what circumstances you can gain access to the facility. If utility services outages will be required, they should be noted and discussed as early in the installation planning process as possible (the initial tour is the perfect time to introduce the topic), and coordination requirements should be clearly spelled out. Simple issues such as parking locations for contractor trucks and the location of any special contractor gates can be stumbling blocks and should be identified as soon as possible. For example, some medical research facilities have very strict rules about entering and working in their areas. Access issues such as these need to be identified at the beginning of the project so that they can be considered when the PreMAP budget is developed.

The State of Texas generally inspects its own facilities, so electrical or mechanical permits typically are not required. It is important, however, to determine whether any construction permits are required whenever you enter a new jurisdiction. Facilities often have an individual with designated responsibility for inspecting construction work at the facility. You should check with that person to determine if any permits are required or if the facility has any other special requirements you need to be aware of. For example, some facilities require all signal cable to be run in conduit, even though it may not be required by local codes.

The most important thing to remember regarding permits, clearance, permission, and access is that you are a guest at the facility. You must minimize your impact and be as unobtrusive as possible. Monitoring is a requirement of the LoanSTAR program, but your job will be a lot easier if you establish and maintain a cooperative working relationship with the facility.

3-5 Codes, Safety, and Liability Insurance

While monitoring instrumentation work in state facilities is typically inspected by facility personnel rather than by an independent building code official from a local jurisdiction, appropriate building electrical, mechanical, fire, and safety codes still apply. In particular, all instrumentation work must meet the National Electrical Code, as well as other code-related provisions of the subcontract between you and ESL. Code compliance responsibilities will typically be passed by you to mechanical and electrical subcontractors, and appropriate provisions related to code compliance should be included in their subcontracts. It is the responsibility of the DASS project manager and field engineers to be knowledgeable about code compliance issues related to monitoring equipment installation and to ultimately ensure that all such issues are appropriately addressed.

Workplace safety is another of your key responsibilities. All field personnel must be properly trained in workplace safety, and all Federal and State Occupational Safety and Health workplace standards and guidelines must be met. It is critical that you do not create a safety hazard as a result of work done in a facility. There are several key areas related to the installation of energy-monitoring equipment where health and safety issues are critical:

3-5.1 Asbestos

Asbestos is likely to be encountered in pipe insulation and ceiling tiles, and it may be present in other building materials as well. While asbestos abatement is not your responsibility, it *is* your responsibility to obtain certification that asbestos is not present before pipe insulation or ceiling tiles are disturbed or any other construction takes place that may disturb asbestos-containing materials at the site. (See PreMAP Form 18.) Certification that asbestos is not present must be obtained from facility personnel and typically is the result of on-site inspection and laboratory testing. Most facilities have already had thorough asbestos inspections conducted, and the results should be on file. If asbestos is determined to be present in a manner that would interfere with the installation of monitoring equipment, no construction can take place until the asbestos is abated. **The cost of asbestos abatement is the responsibility of the facility.**

3-5.2 Installation of CTs

There are several electrical safety issues related to the installation of CTs that go beyond the technical aspects of installation. Installation of solid-core CTs requires a power outage to insert the CT around the wire. Proper "lockout" procedures must be employed whenever a power outage is required so that the circuit is not accidently energized. Furthermore, proper workplace safety procedures must be employed while power is disrupted. For instance, battery-powered lighting may be necessary if lights in the work area are interrupted. Power outages must be arranged well in advance if an entire building or individual critical circuits (computers, laboratory experiments, etc.) are to be interrupted.

Split-core CTs are designed to separate into two pieces so they can be installed around an energized wire. **Extreme care must be used when installing split-core CTs since the electrician often will be working in an energized panel or distribution center. Installing these CTs around bus bars requires particular caution because of the exposed conductors and close tolerances commonly encountered. It is much better to error on the side of caution and de-energize the circuit if the situation appears at all dangerous.** Installing CTs inside an electrical panel, even split cores, is the job of a licensed journeyman electrician, not a field engineer or technician.

3-5.3 Installation of WHTs and PTs

Monitoring equipment such as WHTs and PTs often require 480V electrical service. Since these devices are typically mounted in junction boxes and are usually associated with low-voltage equipment and signal cable, it is critical that the box containing them be marked with a voltage warning so that an instrument technician does not unwittingly come in contact with line voltage wiring.

3-5.4 General Electrical Safety

As an instrumentation and monitoring contractor, you will have the opportunity to inspect parts of the facility's electrical system. You have the opportunity to help the facility by noting any electrical safety problems you encounter. If the cost of the repair is negligible, have your electrician make the repair and notify the facility; otherwise notify the facility about what you found and what you think needs to be done to correct the problem. There have been instances where monitoring contractors have identified major safety concerns and prevented facilities from facing potentially serious liabilities.

3-5.5 Welding and Hot Tap Work

Insertion-type flow meters and temperature sensors are used in the LoanSTAR program. This equipment is installed via a "hot tap" technique, which permits installation without draining a chilled or hot water pipe and hence shutting down a HVAC system. This technique involves high-quality welding and the associated liability of cutting into a pipe through which thousands of gallons of water could be discharged into a building. All hot tap work must be undertaken with the highest standards of workmanship and safety. Only highly experienced, certified welders are to be used on the LoanSTAR project. Evidence of previous experience should be obtained and evaluated prior to engaging a hot tap contractor. Hot tap contractors should conduct all work using, as a minimum, the **University of Texas Physical Plant Safety Standards for Welding.**

3-5.6 Insurance

Because of the nature of the risks involved in performing as a DASS for the Texas LoanSTAR Program, it is essential to pay particular attention to insurance. The liability and workers compensation insurance requirements for a DASS are spelled out in the subcontract between you and ESL. **It is a critical that you ensure that all subcontractors working for you maintain liability and workers compensation insurance at or exceeding the levels required of you.** You should also be named as an additional insured on the certificate of insurance provided by the subcontractor as proof of insurance.

4-0 The INSTALL Process

The installation (INSTALL) process requires on-site coordination with the facility and subcontractors to assure a quality installation while minimizing interference with the facility's operations. The number of DASS and subcontractor visits to the facility should be minimized. **As the DASS, you must closely supervise work performed by mechanical and electrical subcontractors at the site.** Years of experience have demonstrated that it is usually much more cost-effective to directly oversee the work performed by subcontractors than to attempt to provide instructions that allow the subcontractor to complete the job without supervision. Qualified DASS staff may complete the installation of low-voltage devices, cable runs, and equipment labeling, or, alternatively, may just oversee the subcontractors. Cable and data logger termination is usually reserved for qualified DASS staff. Additionally, DASS staff must complete field verification on individual components as they are installed and terminations completed. The DASS must also ensure that the facility is kept informed of the progress, upcoming activity, and outages. Ultimately, DASS staff are responsible for programming the DAS and verifying all channels.

Finally, you must complete any remaining documentation required for the installation process. This will consist of adding additional information or changes to the PreMAP and SiteMAP forms, and completing the INSTALL forms. If necessary, you may need to recopy forms as they have a tendency to become tattered as they are used during the installation process. All forms are submitted to the ESL when the installation and verification of all equipment is complete. **All forms must be completely legible.**

4-1 Installation Activity and On-Site Coordination

Prior to beginning the installation process, the following tasks should be compete:

- all final design decisions must be made;
- coordination with the facility for access, outages, asbestos clearances, and fire and safety clearances must be accomplished;
- all monitoring parts and equipment should be ordered, received, inspected, and serial numbers recorded;
- subcontractors should be secured;
- telephone service should be installed;
- utility company metering purchase orders should be in place and pulse initiators or splitters installed; and
- PreMAP documents should be updated.

As the DASS, you should support and coordinate each subcontractor's activities and needs, as well as facilitate overall project coordination. For example, it is necessary to coordinate any outages just prior to their occurrence as well as in advance. Outages must be minimized and constant communication is required. Restart of equipment must also be coordinated and verified with the facility. Specialized contractors may be required to restart certain HVAC equipment.

As will be discussed later in Section 4-7, verification of sensor and DAS operation is one of your most critical tasks.

4-2 Completing the INSTALL Forms

The INSTALL documents will be completed both before and during the installation. Eight forms are required for each installation. Forms 1, 2, and 6 should be completed prior to starting the installation and the remaining five forms are completed as the monitoring equipment operation is verified. The verification forms provide proof that equipment was properly functioning when it was installed. Verification methods will be discussed in Section 4-8. Following is a description of each form. Refer to Appendices E and F to review samples of completed forms, as well as blank copies of each form.

4-2.1 Form INSTALL1
PRE-INSTALLATION CHECKLIST

This form is completed prior to starting the installation. It serves as a reminder of some potential coordination tasks that may need to be accomplished. It will often be necessary to add other pre-installation coordination tasks to those listed. Some of those listed may be extraneous.

4-2.2 Form INSTALL2
Request for Permission to Interrupt Service (Outage)

This form is important when outages are difficult to arrange or when affected equipment is critical to some process. An individual form should be completed for each different type of outage, such as electric circuits, motors, chillers, or thermal delivery systems. You can make a list in the blank area of the form if many similar equipment items are involved, rather than completing an individual form for each equipment item.

In many instances, there will be no outages, or outage coordination will be simple enough that completing this form will not be necessary. However, whenever any critical facility service is involved, such as computers, medical equipment, experiments, or research, the DASS site engineer should complete this form and have it signed by the proper facility authority. This will assist in coordination and will share responsibility for the outage with the facility. **Dealing with outages is a "zero-defect" task. You cannot afford to make a mistake.**

4-2.3 Form INSTALL3
ELECTRIC POWER CHANNEL VERIFICATION FORM

This form is completed during the installation to verify the operation of CTs, PTs, and the associated kW channels. The information on the left side of the table (CHAN through Full-Scale AMPS) is copied from SiteMAP Form 2, and the rest of the form is used to record verification information. The DAS real time data is compared to calculations based on hand-held meter readings for volts, amps, and watts. Other real time data readings may also be verified, including power factor and, by calculation, kVA. You may also use facility or utility metering for verification where necessary. A sample of each type of verification calculation should be shown on the bottom or back of the form. Samples of verification calculations and techniques can be found in Section 4-8. The form will be especially useful if any phasing problems exist in the installation.

This form will be reviewed by ESL to verify that all monitoring equipment was functioning properly when the installation was completed. The completed forms are also useful for troubleshooting.

4-2.4 Form INSTALL4a
DIGITAL CHANNEL VERIFICATION FORM

This form is completed during the installation to verify the operation of all monitoring equipment connected to digital channels. The information on the left side of the table is copied from SiteMAP Form 3a, and the rest of the form is used to record verification information. The DAS real time data is compared to hand-held meter readings, facility or utility meter readings, and pulse-count/stop-watch readings. A sample of all verification calculations should be shown on the bottom or back of the form. Further information and samples of verification calculations and techniques can be found in Section 4-8, "Verification."

This form will be reviewed by ESL to verify that all monitoring equipment was functioning properly when the installation was completed.

4-2.5 Form INSTALL4b
ANALOG CHANNEL VERIFICATION FORM

This form verifies the operation of all monitoring equipment using analog channels. The information on the left side of the table (CHAN through SCALE) is copied from SiteMAP Form 3b, and the rest of the form is used to record verification information. You will need to add a column for "OFFSET" as needed for some analog channels. The DAS real time data is compared to calculations based on hand-held monitoring equipment. A sample of all verification calculations should be shown on the bottom or back of the form. Further information and samples of verification calculations and techniques can be found in Section 4-7.

This form will be reviewed by ESL to verify that all monitoring equipment was functioning properly when the installation was completed.

4-2.6 Form INSTALL5
INSTALLATION CHECKLIST

This form is completed while the installation is in progress. Review the form and be aware that all items on the list must be accomplished before the installation is complete. Many of the tasks listed on the checklist can be completed while installing or verifying the equipment. A check mark is placed in each of the 11 blanks on the form when the associated task is completed.

ESL will inspect the site (see line 8) to see that all tasks are complete and that all equipment is functioning properly.

4-2.7 Form INSTALL6
INVENTORY TRANSFER

This form is used to document the transfer of equipment purchased for one site to another, or from ESL to a site. After you have completed several sites, it is likely that a small stock of equipment will remain, which may be used at new sites when appropriate. Also, ESL may allow some of its stock to be used to facilitate the installation of certain monitoring equipment. In either case, the form is to be completed to document the source of the equipment. Equipment that you specifically purchase for the site is recorded on SiteMAP Form 9, not on this form.

4-2.8 Form INSTALL7
EQUIPMENT CHANGE FORM

You will not use this form during an installation. Rather, it is used for changes in the system due to modification at some later date, or to document the repair or calibration of equipment at a site.

4-2.9 Form INSTALL8
TIME SERIES RECORD PLOT CHECK FORM

This form is completed when it is necessary to verify DAS TSRs. It may be used with kW, digital, or analog channels. This form is particularly useful to verify the performance of monitoring equipment over time. A piece of equipment may function accurately during an instantaneous measurement and not provide an accurate time series record. This could be due to:

- inaccurate integration;
- the equipment's inability to function over the range of loads encountered;
- intermittent data logger failure;
- intermittent signal transmission problems; or
- incorrect parameter set programming.

This form will be reviewed by ESL to verify that all monitoring equipment was functioning properly when the installation was completed. The completed forms are also useful for troubleshooting.

4-3 Monitoring Equipment Installation

As has been noted previously, all installations by electrical contractors must adhere to The National Electric Code (NEC), appropriate local codes, and all facility codes and regulations. All work in electrical switchgear and panels must be done by qualified personnel from properly licensed and bonded electrical contractors. Similarly, all installations by mechanical contractors, welding contractors, insulation contractors, and other crafts must be conducted by properly qualified staff from licensed and bonded contractors.

You must be very careful not to perform work for which you are not properly qualified. For example, engineers are not qualified to install CTs unless they also hold a journeyman electrician's license and work for a licensed electrical contractor.

4-3.1 CT Installation

The watt transducer will integrate a 3-phase signal into a single-pulse output, representing kWH for the entire device. Record these channels on SiteMAP Form 3a.

Before CTs are installed, the building electrical system phasing must be properly understood. If it was not possible to verify the phasing of electrical system components during previous inspections, it is critical that the phase relationship be determined at this point in the installation process. An electrician should be available to assist in confirming the exact phasing of each relevant electrical component.

Begin phase confirmation at the highest point in the distribution system that will be monitored. Establish a relationship between 3-phase color designations as installed in the building (usually black, red, and blue for 120/208-volt service, and brown, orange, and yellow for 277/480-volt service) and the phase letters that will be used in the installation documentation (A, B, and C). From that point, phase-verify the next lower panel in the distribution system, and so on until the phase relationship of all monitored panels with a common voltage source (fed from the same service entrance or transformer) have been confirmed. Clearly label all panel feeders and other primary conductors with phase tape or other identifying markings. The color/phase legend should be written on the riser diagram and on the Panel Documentation Forms. This step is crucial to the rest of the installation procedures.

If panels or circuits are discovered to be incorrectly phased on the Panel Documentation or the Switchgear Documentation Forms, the paper copy must be corrected by entering the correct phase letter of the panel bus and providing explanatory notes as necessary. The discovery of incorrect phasing may result in changes to the SiteMAP. The implication of these changes must be evaluated before any sensors are installed. Changes in the phasing may require changes to the configuration files for the DAS. (See Section 4.4, "DAS Programming and Installation," for more information.)

If monitoring on the load side of transformers is required, a specific phase relationship must be established. Each transformer has independent secondary voltages (it is considered a separate service requiring separate PTs) requiring their own phase designations. Each monitored panel below the transformer must be phase-verified back to the transformer as described above.

Each monitored panel or switchgear will require the installation of various CTs. The Panel and Switchgear Documentation Forms show the CT requirements in sufficient detail to serve as an installation blueprint. Using this documentation, the DASS field engineer will guide the electrician during installation of the CTs.

In all cases, the occupants MUST be well informed of expected power outages. Even installation of split-core CTs sometimes results in momentary power outages, and the occupants of the space need warning. Notify the occupants of CT installation activity before the panel covers are even removed, as this, too, can result in accidentally tripped breakers.

Extreme care must be applied to circuits that absolutely cannot be disturbed. Power interruptions should be timed to minimize inconvenience to the occupants, and the period without power should also be minimized. In some cases, it may be necessary to install CTs after business hours. Some circuits may require special restart procedures and/or the resetting of timing circuits. Before turning the breaker off be certain that a qualified individual is available to accomplish the restart. Perhaps the most sensitive circuits are those related to computer systems, health care or academic research activities, security (alarms), safety (fire alarms), and HVAC. These deserve special attention and, in many cases, split-core CTs must be used.

CTs are mounted with the polarity arrow pointing toward the source of the voltage. Figures 1-10 through 1-13 show how CTs can be connected to various single-phase and 3-phase power connections. Note that only two CTs are required to monitor a 3-phase, 3-wire system.

Any 3-phase unbalanced load must be monitored on all three phases. This includes packaged HVAC units that may incorporate 3-phase as well as single-phase devices. As a general rule, balanced multiple-phase loads can be monitored on one less phase than the number of phases (not counting ground or neutral) serving the load. Thus, a 2-phase load can be monitored on one phase. A 3-phase, 3-wire (delta) load can be monitored on two phases. A 3-phase, 4-wire (wye) load requires monitoring on all three phases. In all of these cases, the monitored phases (hi-ref) must be referenced to the non-monitored phase (Lo-ref). In the 3-phase, 4-wire case, neutral is the Lo-ref.

Exception: Any load monitored with a dedicated watt transducer must be monitored on all of its phases.

In situations with more than one wire per phase serving a device (parallel feeds), each of the wires on the monitored phases must be monitored. It is not safe to assume that multiple conductors on the same phase will always carry identical currents, due to variations on the resistance of the wire terminations. Either all the wires on a phase must be grouped together and routed through a single CT, or multiple CTs should be used to monitor all of the wires.

Some measurement plans may call for a single CT to be installed around multiple wires. This CT can be difficult to install correctly, since each individual wire must be connected to the same phase and be routed in the same direction through the CT. It is most effective to have the DASS field engineer following the Panel or Switchgear Documentation Forms while the electrician installs the CTs.

In the course of installing CTs, the electrician may discover situations where a split-core CT is preferable to a solid, even though the latter was specified in the SiteMAP. If the DASS technician agrees that safety or convenience justifies such a change, a split-core CT may be used.

CT secondary wires are labeled (numbered), routed, and secured inside the electrical panel with wire ties and routed through a chase nipple either directly into the data logger if its is adjacent, or into a junction box mounted outside the electrical panel. Junction boxes must be firmly secured to the switchgear or panels with one or two chase nipples or other appropriate mounting hardware. The electrical contractor must take care to assure that metal shavings, cut-out pieces, and knock-outs are kept from entering the electrical cabinet. Signal cable is neatly routed from the junction box through a short length of conduit or through a romex clamp connector and ultimately back to the data logger. The junction box should be large enough to contain enough wire to ease making junctions. Remember the CT leads are 600V-rated, but signal cable is not. **Signal cable cannot be routed into electrical panels. The junction with the CT leads must be made outside.** Also, a messy junction box is difficult to verify.

Excess signal cable should be cut off or bundled, and excess CT secondary wire should be bundled and the wire tied neatly inside the switchgear. It is important when you plan to reuse CTs to keep secondary wires as long as possible to avoid future splicing inside an electrical panel. Wire markers on the signal cable and the CT secondaries must be reattached when the wires are cut. **Wire numbering and coding errors must be scrupulously avoided. They can be difficult to identify in the verification process.** When splicing, strip a minimum amount of wire insulation from the signal cable and CT secondaries so the chance of short-circuits to ground or other signal wires is eliminated. Wago brand cable connectors are almost exclusively used for splicing or making junctions in the LoanSTAR Program. These connectors are much more efficient and secure than traditional butt splices and wire nuts.

Several different types of CT terminations are possible. They are discussed in detail below.

Single CT, direct connection: Some CT leads may be pulled directly into the data logger enclosure and can be directly connected to the watt meter channel terminal strips. The CT leads are numbered with the channel number and are connected accordingly. Refer to Figure 1-7 for the location of the CT terminations. Polarity is as follows: The white wire from the CT should be terminated on the HIGH (H) terminal for each channel and the black wire on the LOW (L) terminal.

Single CT, through junction box and cable: When the CT leads are not long enough to reach

Single CT, through junction box and cable: When the CT leads are not long enough to reach the data logger, connect them to a pair of leads of a multiple-pair signal cable in a junction box and route the cable to the logger. Assign the color- or number-coded pairs of wire to channels on the multi-pair cable guide (Form SiteMAP8). Make the connections in the junction boxes using Wago connectors. Terminate the logger end of the multiple pair cable to the CT termination board as described above.

Multiple CT, parallel connection: Multiple identical CTs on the same logger channel can be combined in parallel if their lead lengths vary by less than 1 foot. **When a solid and a split-core CT are used on the same channel, they require a combiner board (see below)**. The black and white leads are separately combined. If the leads reach the logger, they can be connected to it directly. Otherwise, multi-pair extension cables must be used, as described above.

Multiple CT, parallel connection, using summing modules: Multiple CTs of the same current rating may be combined by using CT summing modules either at the data loggers or in junction boxes at the electrical panel where the CTs are located. The Electric Power Channel Assignment Form in the SiteMAP identifies which channels require summing modules. Note that if the lead lengths are equal (+1 foot), the CT combiner board is not necessary. Ultimately, a single pair of wires will leave the combiner board output side. The white lead goes to the numbered terminal and the black goes to "C" (common terminal).

Combiner boards can themselves be combined in parallel. There is no maximum number of CTs that can be combined through combiner circuits. The practical limitation is in terms of complexity of organization and physical room to gang the CT combiner boards. A reasonable maximum would be three connector boards or 12 CTs in parallel. If more than one summing module is needed for a given channel (i.e., more than four CTs used), each board is connected to the next by connecting the output sides in parallel: number-to-number and common-to-common. Ultimately, a single pair leaves one summing module and carries the signal to the logger; it may be connected to the output side of any one of the combined boards. Refer to Figure 1-6 for details.

Virtual CTs: On a channel combining several CTs of rating X, you can also include combinations of CTs of lower rating with equal lead length connected in parallel to add up to X.

Example: Most CTs on a given channel are rated at 100 amps. Two 50 amp CTs could be used if they were combined in parallel to make a virtual 100-amp CT. The outputs of actual and virtual CTs of rating X must be fed into a summing module.

The restrictions that apply to connecting CTs are summarized below:

- the lead lengths in the parallel circuit must be equal (within +1 foot for 22 AWG wire) or a resistance-matching summing module must be used;

- the full-scale current rating for all of the CTs (or virtual combined CTs) must be the same. CTs with different full-scale current ratings cannot be connected in parallel, except as a virtual CT;
- if split-core and solid-core CTs are used on the same channel, they must be connected with a summing module; and
- the equivalent full scale current seen at the data logger channel is the sum of the full scale currents for all of the CTs connected in parallel.

4-3.2 PT Installation

To increase the safety of the data-collection system, special reference voltage PTs have been designed. These PTs transform the high voltage inputs into low current signals with secondary voltages less than 6 VAC.

Each separate monitored electrical service entrance, as well as the secondary side of each transformer that has loads to be monitored, must have its own PT. Also, each logger must have an individual PT even if multiple loggers are monitoring the same set of reference voltages.

The PT is a small, plastic brick (3"x3"x 3/4") that has separate A, B, C, and neutral inputs. The primary wires of the PT are connected to the voltage source and the shielded secondary wire is routed to the data logger. The brick itself may be mounted in any convenient

location in a separate junction box. It should be grounded using its ground wire or the ground fitting in its case.

The voltage source should be provided through a dedicated breaker if at all possible. The PT draws virtually no current from the service and is classified as a high-impedance device, covered under NEC, Section 230-82, Exception 4. Therefore, the code allows it to be powered directly from the panel or switch service lugs if installation of a breaker is not feasible. It is often convenient to install a separate multi-pole breaker for both the PT and the bell transformer powering the logger (see below). **The phase relationship of the power leads must be carefully noted as this determines the phase relationship of the output signals to the logger.**

The output of the PT must be routed in a separate 4-conductor twisted, shielded cable or in a multi-pair cable to the data logger. The PT cable drain wire must be continuous from the PT to a ground terminal at the logger.

Figure 1-1 shows the general layout of the logger terminations and other components. The PT connections are made to the PT inputs on the logger as shown in Figure 1-9. All of the referenced voltages must be connected for the PT signals to be received correctly. Figures 1-10 through 1-13 show wiring diagrams and the channel configuration for four common service types. A label is affixed to each junction box describing the equipment in the junction box, the level of voltage present in the junction box, and the source of the voltage.

4-3.3 Bell Transformer Installation

The data loggers require single-phase 24 VAC for operation. Standard bell transformers that convert 120 VAC to 24 VAC are suitable for this purpose. One is supplied with each data logger.

Each logger requires its own transformer, but multiple transformers may be powered from a single 120-volt breaker. Each data logger consumes approximately 20 watts. The transformers must be protected by a circuit breaker, preferably no larger than 20 amps. The breaker installed for the PTs can be used to power the bell-type transformers also.

The transformers must be installed in junction boxes. Pull the 24-VAC secondary to the logger and terminate it at the logger as shown in Figure 4-1 on terminals 93 and 94. Polarity at these terminals does not matter. It is recommended that a 1-amp, in-line, fast-acting fuse be installed on the transformer secondary to protect it from an accidental short-circuit. A label is affixed to the junction box describing the equipment in the junction box, the level of voltage present in the junction box, and the source of the voltage.

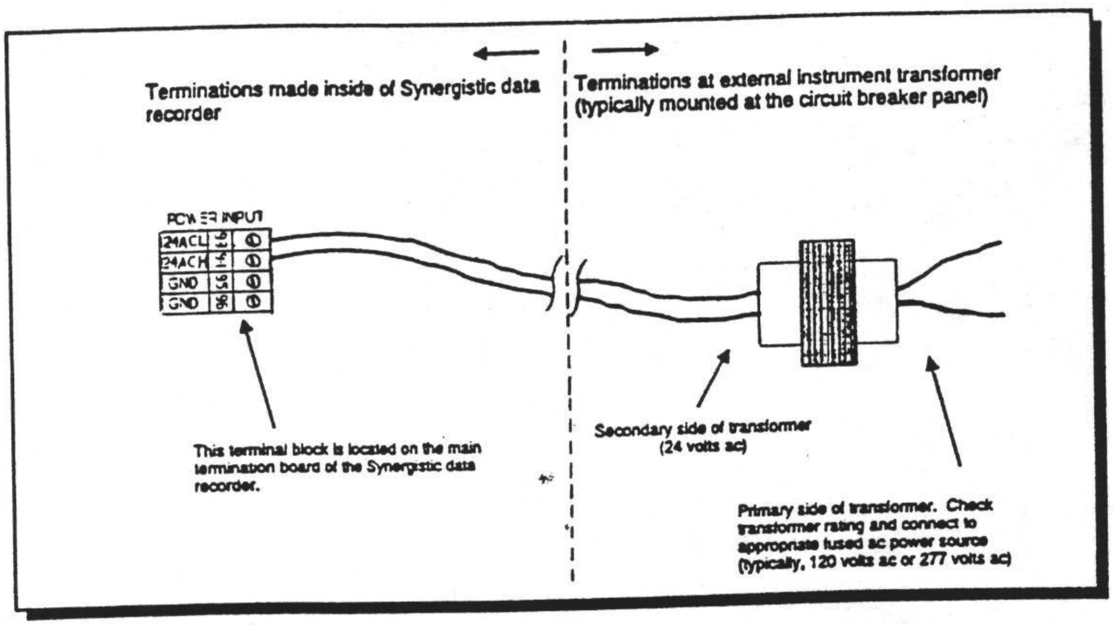


FIGURE 4-1 CONNECTION FOR POWER TRANSFORMER
(Source: *Synergistic Installation Manual*, May 1993.)

4-3.4 Digital Inputs Installation

WHT Installation

The Ohio Semitronics WHT and the low-voltage output shunted CTs are to be installed by a qualified electrical contractor according to the manufacturer's specifications, at the locations specified in the SiteMAP.

Each WHT is typically mounted in a covered, 10"X10"x4" junction box at a location close to the reference voltage. The voltage source for the load being monitored is phased and supplied to the WHT as both reference voltage and instrument power. Use dedicated breakers where available and install fused protection on the primary side of the WHT. The fuses are typically installed in a covered, 6"x6"x4" junction box mounted next to the WHT.

Three shunted CTs are installed on the current-carrying conductors of the loads to be monitored. The secondary side of the CTs are terminated at the CT inputs of the WHT.

The signal output from the WHT is a Form A (dry contact) pulse. The two leads of the output signal from the WHT are connected to a digital input using two-conductor, 22-ga, solid copper, plenum-rated wire as shown in Figure 1-14.

The WHT will be labeled with an ampere rating. This rating represents the full-scale amps per phase that will produce an output of 0.1 pulse/kWH (assuming a power factor of 1.0). Compute the pulse constant (scaling factor) as follows:

Pulse Constant = (Full-scale, installed CTs per phase / WHT amp rating) * 0.1

Wires are terminated at the WHT as follows:

Terminal Number	
1	Aø voltage reference
2	Bø voltage reference
3	Cø voltage reference
4	Neutral or ground
5	Aø CT white wire
6	Bø CT white wire
7	Cø CT white wire
8	All CT black wire
9	Jumper from terminal 3
10-11	Jumpered together
12	Jumper from terminal 2
13-14	Pulse output to data logger

The data logger must be programmed to apply the correct multiplier to the accumulated pulses to produce an accurate representation of kWH consumption. Total kWH consumption for each integration period is stored by the data logger.

A label is applied to each junction box describing the equipment in the junction box, the level of voltage present in the junction box, and the source of the voltage.

Utility Meter Pulse-Initiator Installation

Each utility electric meter used for monitoring must be configured with a pulse output suitable for connection to the digital channels of the data logger. The utility will typically provide and install a 3-wire (Form C) KYZ output. However, only two wires will be used, representing a simple contact closure. Either the KY or KZ terminals should be connected to a digital input using two-conductor, 22-ga, solid copper wire as shown in Figure 1-14.

The utility company will install the pulse-initiating meter and a junction box with a terminal strip and fuse. Normally, a fuse on the K wire will suffice, though in some areas, meter technicians may require a fuse on each wire. The meter personnel will make the terminations on the meter side of the fuse. Note that the voltage on the open K contact is 5 VDC through 3.3 K ohms of resistance. The K wire is generally red. The Y and Z wires are equivalent for LoanSTAR purposes.

It is usually necessary to mount a second covered, 2"x2"x4", weather-tight junction box (Bell Box) to cover the penetration through the wall of the building. The location and manner of all penetrations must be approved by the building contact. Drill a neat hole of the smallest possible size and seal it with RTV (or other suitable sealant) to prevent water or air leakage. In addition to covering the penetration through the building wall, the junction box is also used to secure either weather-tight conduit or EMT, which is installed from the wall penetration junction box to the utility meter junction box.

The utility meter service technician or the utility customer service representative will provide the meter pulse constant. Calculate the scaling factor and program the DAS to apply the correct multiplier to the accumulated pulses.

Gas Utility Pulse-Initiator Meter Installation

At its discretion, the gas utility will install a pulse output device on the existing meter, or install a replacement pulse-initiating meter. The pulse initiator will be equipped with either a Form C (KYZ) or a Form A (KY or KZ) output. Either the KY or KZ terminals should be connected to a digital input at the DAS using two-conductor, 22-ga, solid copper wire as shown in Figure 1-14.

It is usually necessary to mount a covered, 2"x2"x4", weather-tight junction box (Bell Box) on the exterior wall of the building near the gas meter to cover the penetration through the wall.

The location and type of penetration must be approved by the building contact. Drill a neat hole of the smallest possible size and seal it with RTV (or other suitable sealant) to prevent water or air leakage. The junction box covers the hole drilled in the wall, through which the signal wire penetrates the structure and is also used to secure weather-tight conduit, which must be installed from the junction box to the meter output terminal. The utility company may require that a fitting, which stops vented gas from entering the building (often called a "Seal Out") be installed at the meter or at the junction box.

The meter service technician or the utility customer service representative will provide the meter pulse constant. Calculate the scaling factor and program the DAS to apply the correct pulse constant multiplier to the accumulated pulses.

In-Line Turbine Flow Meter Installation for Condensate and Boiler Feedwater

In-line flow meters must be installed by a qualified contractor according to the manufacturer's specifications, at the locations specified in the PreMAP. Before an in-line flow meter can be installed, the following conditions must be met:

- the design and installation location for the metering station must be approved by the facility;
- the facility must provide proof that asbestos insulation is absent or that asbestos abatement has been completed; and
- a qualified and insured mechanical contractor has been secured to fabricate and install the condensate or boiler feedwater metering station.

The meter must be installed in a trap configuration with a three-valve bypass so that it can be removed for service without causing an outage to the facility. The metering station must be pressure-tested for leaks prior to installation. The installation must be coordinated with facility personnel to schedule the necessary condensate and fire alarm system outage.

The metering station must be installed in a straight, horizontal section of pipe with a minimum of 5 pipe diameters of straight, unobstructed pipe upstream and 5 pipe diameters downstream from the sensor to allow full development of the flow profile. The flow sensor must be mounted with the head pointing upward. Approximately 5 to 8 feet of pipe must be cut out to install the metering station with the trap-bypass.

Upon completion of the installation, the condensate flow will be routed through the meter and a final leak test completed. You will be responsible for insulating the metering station (except for the meter itself) upon completion of the installation. The insulation may be accomplished by the mechanical contractor or by a separate qualified and insured insulation contractor.

The signal output from the flow meter is a Form A (dry contact) pulse which is preset to represent a specific number of gallons. The two leads of the pulse output signal are connected to a digital input using two-conductor, 22-ga, solid copper wire as shown in Figure 1-14. The specifications for the meter will provide a multiplier value, which represents the number of gallons per pulse. Use this value as the scale factor in the data logger parameter set. The value stored in the TSRs is usually gallons per hour. The serial number of the flow meter is recorded on SiteMAP Form 9.

BTU Meter Installation

BTU meter installation involves the following:

- BTU/Flow Totalizer Installation;
- Insertion Temperature Sensors Installation; and
- Insertion Flow Meter Installation.

BTU/Flow Totalizer Installation

A BTU/flow totalizer requires either 120V or 24V instrument power. Hence, the installation location and use of a line voltage circuit must be approved by the facility. Refer to the DK System 90 Series BTU meter for installation and programming instructions. A qualified electrical contractor must be used to complete the installation.

The electrician will mount the totalizer at the location indicated by the ELT and complete the installation of 120V or 24V instrument power. The totalizer has mounting brackets with four holes, which are used to secure the enclosure to the wall. If 120V is used for instrument power, conduit is run directly from the electrical panel to the totalizer. If a 120V to 24V transformer is used for instrument power, the transformer is typically mounted in a covered, 6"x6"x4" junction box at the electrical panel, and 22-ga solid copper wire is installed to bring the 24V power to the totalizer. Qualified DASS personnel can make all low-voltage terminations.

The totalizer is factory-programmed to function accurately for a given temperature range and a given specific heat. The totalizer is field-programmed for the pulses/output of the flow meter and BTUs per contact closure. The field programming consists of setting two dip switches (S4 and S1) as described in the DK installation and programming manual. ESL has created set of tables, titled "Aggie Flowmeter Insertion Depth Tabulator" (see the attachment to PreMAP Form 15), which should be used to determine the S4 and S1 settings.

The totalizer has two Form A pulse (dry contact) outputs, which terminate at two digital inputs on the data logger. The pulse output signals are terminated using four-conductor, 22-ga, solid copper wire as shown in Figure 1-14. Program the data logger to apply the correct multiplier to the accumulated pulses. The value of the multiplier is shown in the tables of the "Aggie Flowmeter Insertion Depth Tabulator." A label is affixed to the totalizer detailing the source and voltage of instrument power.

Insertion Temperature Sensors Installation

Before an insertion temperature sensor can be installed, the following conditions must be met:

- the hot tap locations must be approved by the facility;
- the facility must provide proof that asbestos insulation is absent, or have completed asbestos abatement; and
- a qualified and insured mechanical contractor must be secured to complete the hot taps at the locations specified by the ELTs.

Refer to the DK System 90 Series BTU Measurement Installation Manual and DI Technical Bulletin No. 41 on hot tap installations.

Two 1" hot taps for the two insertion temperature sensors are required for each BTU metering installation (one in the supply line and one in the return line). The taps are completed by the contractor as follows: The mechanical contractor removes approximately 1 square foot of insulation from the pipe at the location where each hot tap is to be completed. A 1" thread-a-let is then welded to the pipe, a 2-1/2" brass nipple is installed, a 1" gate or ball valve is installed, and each installation is pressure-tested. The contractor then drills a 1/2" hole in the pipes using a hot tap tool. The insulation and covering is replaced on the pipe surrounding the tap, and the plumbing parts are insulated up to the top of the new valve. The insulation may be accomplished by the mechanical contractor or by a separate qualified and insured insulation contractor.

The mechanical contractor will then install a 1"x1/4" galvanized bushing and a 1/4" NPT to a 1/4" compression fitting with plastic ferrel on the top of the new valves. The MRA-Variable Depth Sensor thermistors are then installed through the fittings and valve to a depth of 1-1/2" in the flow. A covered box is mounted at the top of each insertion temperature sensor to house the terminations and to secure the signal wire conduit if required by the facility. The two leads of each thermistor are connected to the appropriate inputs of the BTU/flow totalizer using a single-pair, 22-ga, twisted, shielded cable with drain. The drain wire is open at the thermistor and is terminated at the common terminal input in the totalizer.

Insertion Flow Meter Installation

Before an insertion flow meter can be installed, the following conditions must be met:

- the hot tap locations must be approved by the facility;
- the facility must provide proof that asbestos insulation is absent, or that asbestos abatement has been completed; and
- a qualified and insured mechanical contractor is secured to complete the hot tap at the location specified by the PreMAP.

Refer to the Data Industrial Series 200 owners manual (model No. 225B, option 12R), DK

System 90 Series BTU Measurement Installation Manual, and the DI Technical Bulletin No. 41 on hot tap installations.

One 2" hot tap for the insertion flow meter is required for each BTU metering installation. The tap is completed by the contractor as follows: The mechanical contractor removes approximately 1 square foot of insulation from the pipe at the location where the hot tap is to be completed. A 2" thread-a-let is then welded to the pipe, a 2-1/2" brass nipple is installed, a 2" full port gate or ball valve is installed, and each installation is pressure-tested. The contractor then drills a 1-7/8" hole in the pipe using a hot tap tool. The insulation and covering are replaced on the pipe surrounding the tap, and the plumbing parts are insulated up to the top of the new valve. The insulation may be accomplished by the mechanical contractor or by a separate qualified and insured insulation contractor.

The mechanical contractor will then install a brass 2" close nipple and a galvanized 2" coupler on the top of the new valve (the nipple and coupler are installed to give added clearance between the paddle wheel of the flow meter and the moving parts of the valve during the installation of the flow meter). A DI hot tap insertion tool (Model No. 225H; See DI Technical Bulletin No. 41) is used to install the flow meter into the pressurized line. Calculations for the proper installation depth measurements are shown in the PreMAP forms. (See the attachment to PreMAP Form 15, "Aggie Flowmeter Insertion Depth Tabulator.") When the flow meter is installed to its proper depth, the flow meter alignment is adjusted such that the paddlewheel is perpendicular to the flow with the arrow on the meter pointing with the flow. The three sets of lock nuts are then tightened on the threaded rods to hold the meter at the exact location. The three leads of the flow sensor are terminated to a single-pair, 22-ga, twisted, shielded cable with drain. The drain wire is connected to the bare wire of the sensor. At the totalizer, the signal cable drain wire is terminated with the flow reference lead at the input of the totalizer. The other wire is terminated to the flow input terminal. Record the serial number of the flow meter on SiteMAP Form 9.

4-3.5 Analog Sensor Installation

Install analog devices as specified by the manufacturer. Either you or a qualified subcontractor can mount and terminate the analog sensors.

Analog sensors come with a variety of signal outputs. See Figures 1-15 to 1-19 for illustrations of wire terminations. In all cases, the drain wire is grounded at the data logger but not at the sensor. Depending on manufacturer, sensor type, and application, any of the following outputs could be specified.

2-wire, 4-20 mA output

Most analog equipment used in the LoanSTAR Program has a 2-wire, 4-20 mA signal. The cable used is 22-ga, plenum-rated, stranded, twisted-pair, shielded, with drain. The cable drain wire is grounded only to the logger to avoid a ground loop.

Connection of a 2-wire, 4-20 mA (logger-powered) signal with the use of an internal 200 Ohm resistive header is shown in Figure 1-16. The sensor is powered by the data logger at approximately 30 VDC. Terminal V connects to the positive side of the sensor. Terminal A connects to the negative side of the sensor.

Connection of a 2-wire, 4-20 mA (externally powered) signal resistive header is shown in Figure 1-17. The sensor is powered by a field power source. Terminal A connects to the positive side of the sensor. The negative side of the sensor is connected to the logger ground.

3-wire, 4-20 mA analog output

These devices, though rarely used, may be configured for any type of monitoring situation. The cable used is 22 AWG, plenum-rated, stranded, twisted-pair, shielded, with drain. The cable drain wire is grounded only to the logger to avoid a ground loop.

Connection of a 3-wire 4-20 mA (logger-powered) signal resistive header is shown in Figure 1-18. The sensor is powered by the data logger at approximately 30 VDC. Terminal V connects to the positive side of the sensor. Terminal A connects to the negative side of the sensor. The common terminal of the sensor is connected to the logger ground.

2-wire, 5 VDC analog output

These devices are common when sharing facility monitoring equipment. The sensor is powered by a field power source (externally powered). The cable used is 22 AWG, plenum-rated, stranded, twisted-pair, shielded, with drain.

Connection of a 5 VDC signal to the data logger is shown in Figure 1-19. The cable drain wire is grounded only to the logger to avoid a ground loop.

3-wire, 5 VDC analog output

These devices, though rarely used, may be configured for any type of monitoring situation. The cable used is 22-ga, plenum-rated, stranded, twisted-pair, shielded, with drain. The cable drain wire is grounded only to the logger to avoid a ground loop.

The sensor is powered by the data logger at approximately 30 VDC. Terminal V connects to the positive side of the sensor. Terminal A connects to the negative side of the sensor. The common terminal of the sensor is connected to the logger ground.

2-wire resistive RTD analog output

Resistive temperature sensors, such as 1000Ω RTD, are sometimes used instead of the insertion-type thermistor temperature sensor previously described. The same insertion installation procedure is followed, and the sensor is terminated directly to an analog input at the DAS. The

DAS supplies a constant-current source to produce a measurable voltage across the resistive sensor. One side of the resistor is connected to terminal A, and the other side is attached to the logger ground terminal as shown in Figure 1-15. The resistor terminals are equivalent.

The cable used is 22-ga, plenum-rated, stranded, twisted-pair, shielded, with drain. The shield wire is grounded only to the logger to avoid a ground loop. **NOTE: The use of a 2-wire RTD usually limits the length of the analog signal because of the resistance that is added by the intervening wire.** Any 2-wire RTD should be field- or laboratory-calibrated with the exact length of lead wire to assure that the extra resistance from signal wire is accounted for in software. Each 2.1 ohms added to the circuit (70 feet of 22 AWG cable) raises the indicated temperature by 1°F.

4-3.6 Fuse and Circuit Breaker Installation

As noted previously, the data logger, BTU meter, and signal-conditioning equipment need 120 VAC (or 120 VAC to 24 VAC) for instrument power. A single-pole, 120V, 15-amp breaker will adequately serve any or all of those equipment power requirements. If all the equipment can be mounted in one location, then use just one breaker as a power source. For equipment in various locations, use a single-pole, 120-VAC, 15-amp breaker at each location as specified

in the SiteMAP documents. If 120 VAC is used for instrument power, conduit is run directly from the electrical panel to the monitoring equipment.

If 120 VAC is not available at all locations, a 120V to 24V transformer can be specified for instrument power requirements. The transformer is typically mounted in a covered, 6"x6"x4" junction box adjacent to the electrical panel, and 22-ga solid copper wire is installed to bring the 24V power to the monitoring equipment. Qualified DASS personnel can make 24V terminations, but all line voltage work must be completed by a qualified electrical contractor.

PTs and WHTs require 3-phase voltage for instrument power and reference voltage. These devices are typically fused with three 1.5-amp, in-line fuses housed in a covered, 6"x6"x4" junction box mounted adjacent to the monitoring equipment. The fusing protects and isolates the monitoring equipment. All high-voltage junctions are made by the electrician in the junction box with the fuses.

If there are no spares or blank locations to mount a new breaker, the electrician must find the necessary voltage at a shared location that will satisfy code requirements. The monitoring equipment should be fused in the same manner described above whether there is a dedicated breaker, disconnect, or a shared voltage.

All monitoring equipment and junction boxes must be labeled to show the voltage source and voltage level present at that location.

4-4 Cable Installation

4-4.1 Incoming Telephone Line

If possible, coordinate the installation schedule so that you and the telephone company technician are on site at the same time. The technician will be instructed to locate the telephone jack adjacent to the data logger that will control communications. Confirm the correct telephone number after the line is installed.

If the line was previously installed, call ESL or the operator for a line check using a handset plugged into the telephone jack. The called party will be asked to return a call to the number identified in the telephone installation. If the telephone line does not function, contact the telephone company for repair if necessary.

Once you know the telephone number, enter it in the QUEUE screen of Synernet, for use when polling the site remotely. Also, verify that the telephone number is recorded correctly on PreMAP Form 16.

4-4.2 Communication Network

Two conductors connect the communication network to each of the data loggers from the controlling logger (the logger with the modem). Plenum-rated telephone wire or any solid copper conductor 22 AWG or larger will be satisfactory. Connect the loggers in parallel at the "DC Loop" screw terminals on the communication boards. (Refer to Figure 1-4.)

When the data loggers are powered up, the DTR light should come on and stay on, but the other lights on the communication board will be off after a self-check.

This is a convenient time to terminate the telephone line for the site. The terminal block installed by the telephone company should be removed and the telephone wire should be run into the controlling logger — the one with a modem installed. The telephone wire conductors should be terminated on the "Telco Line" screw connectors in the controlling logger. The terminations are verified by plugging in a hand set to the "Phone" RJ connector and listening for the dial tone. The polarity is confirmed by verifying that an outgoing call can be made through the DAS with a touch-tone telephone. Also, green to red on the telephone line should measure about +50 VDC.

4-4.3 Cable Network

In many cases open wiring consisting of multiple-twisted pair, plenum-rated, shielded cable will meet code and facility requirements. This will eliminate the need for conduit covering. However, if all other wiring in a space is enclosed in conduit, then the signal cable should be likewise enclosed. If danger of physical damage is present because of the nature of the activities of a space, then enclose the cable in conduit. Pay attention to aesthetics. The conduit and cable runs must be level and as neat as possible. **Unsightly cable or conduit runs greatly detract from an installation and reflect badly on both the DASS and the LoanSTAR Program.**

CT Cables

If the lead lengths of the CTs are inadequate to reach the nearest data logger, you must install plenum-rated, twisted, shielded, multiple-pair cables between the data logger(s) and the junction boxes receiving the ends of the CT leads. The SiteMAP will provide information on the required number of wire pairs between each junction box and logger.

Strip both ends of the multiple-pair cables back approximately 8 inches, exposing the individual wire pairs and the shield. Ground the shield at the logger enclosure and tape it off at the service panel. **To prevent current loops, the cable shielding and drain wire should never be grounded anywhere other than the data logger.** Each multiple-conductor cable in the building must be uniquely coded with wiring numbers or colored tape labels. Fully document the cable configurations using multi-pair cable guide forms (SITEMAP Form 8), and leave copies in each logger to simplify diagnosing future problems.

Other Sensor Cables

Always use plenum-rated cable unless conduit is required. Connect cables from analog and digital sensors to the data loggers as prescribed in the SiteMAP. The installed cable lengths must not exceed those specified for each sensor type. Typically, the maximum analog sensor cable length is 500 feet.

When installing cable to RTDs, be sure to measure or calculate the resistance of the wire (complete circuit) and entering the proper offset in software.

4-5 DAS Installation and Programming

4-5.1 DAS Installation

The electrician will mount the data logger(s) at the location(s) indicated in the SiteMAP Sketch. The data logger enclosure should be secured to a wall or other suitable permanent surface using screws or other removable fasteners to studs or other structural members. Four holes are provided in the corners of the enclosure for mounting. It is not necessary to remove the electronic components during mounting unless excessive vibration will be induced in the enclosure. The use of impact drills or fasteners require the removal of the electronic components before mounting the enclosure. Shavings should be blown from the bottom of the enclosure after mounting.

For loggers with analog expansion boards where RTDs are to be connected, confirm that the loggers will be located in a space where the temperature is maintained between 60° and 95°F. Logger temperatures outside of this range will induce greater than 0.5°F error in real time data readings. If it is not possible to install these analog loggers in such a conditioned space, an LM34 temperature sensor must be installed at the logger to track its deviations from the allowed range.

4-5.2 DAS Operation

The power switch on the main termination board must be in the OFF position when the logger is installed. Turn on the breakers to provide power to the bell transformers and the PTs. Then turn the power switch for each logger to the ON position. The "Highland Technology" copyright message should scroll on the logger display, and the LED on the main termination board should flash once per second. For data loggers with analog expansion boards, both LEDs on this board should be on constantly.

4-5.3 DAS Programming

Basic Commands for Programming the Data Logger

This section provides an overview of setting up and polling a logger. Each example provides enough details to illustrate the basic steps involved. Only the SYNERNET, CONFIG, QUEUE, and PARSET commands, necessary to accomplish setup and polling, are discussed. For more information about the SCHEDULE, and MESSAGE commands, refer to the Synernet Manual.

Allow ample time to become familiar with SYNERNET. Practice on an existing site or two if they are available.

SYNERNET

SYNERNET is the menu-driven software provided by the manufacturer to configure and poll a logger. It is a DOS-based program that operates on IBM and compatible computers. When the PC is connected to a data logger, an operator uses SYNERNET to program the data logger and customize it for the intended application. SYNERNET may be operated from a computer directly connected to the data logger through an RS-232 port, or operated remotely using a modem.

SYNERNET contains five sub-programs that can be used to perform the different functions shown in Figure 4-2. Each of the five sub-programs can be executed by typing the executable name (e.g., PARSET <Enter>), or by beginning a session with SYNERNET and working through the menu tree. SYNERNET always begins a session by checking the PC's time and date.

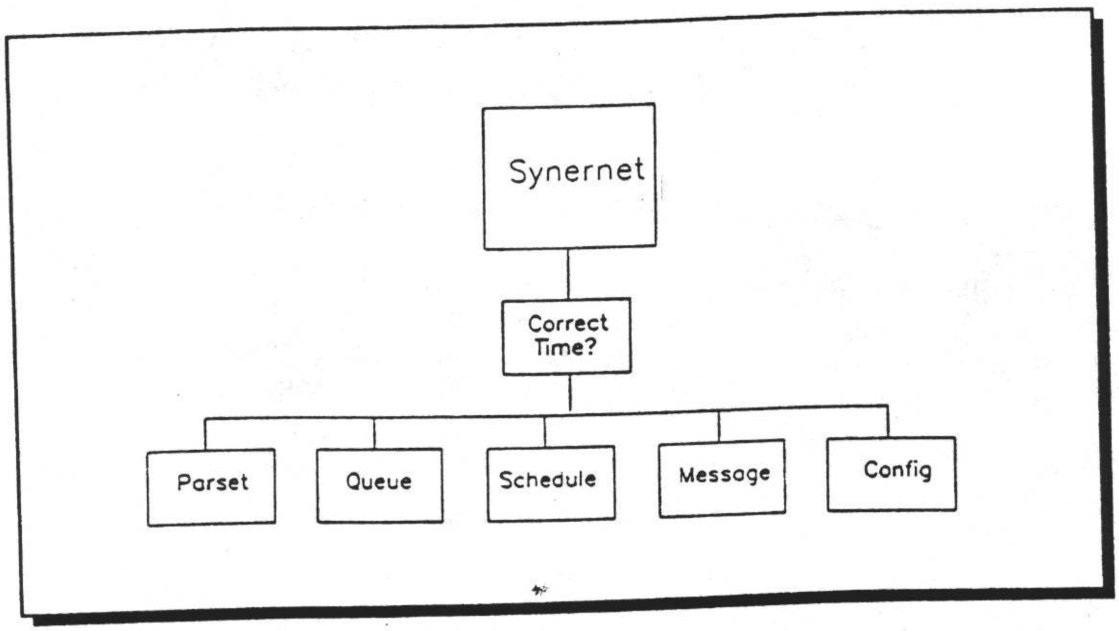


FIGURE 4-2 MAIN MENU DIAGRAM FOR SYNERNET PROGRAM
(Source: *Synergistic Installation Manual*, May 1993.)

CONFIG

After installing SYNERNET software on your PC, set up the configuration file, which tells SYNERNET important features about the PC. Setting up the configuration file is accomplished by running the CONFIG routine. Figure 4-3 outlines the questions that must be answered in CONFIG. To exit the CONFIG menu (and most other SYNERNET menus), press the <F10> key. This key will save what has just been entered on the CONFIG screen.

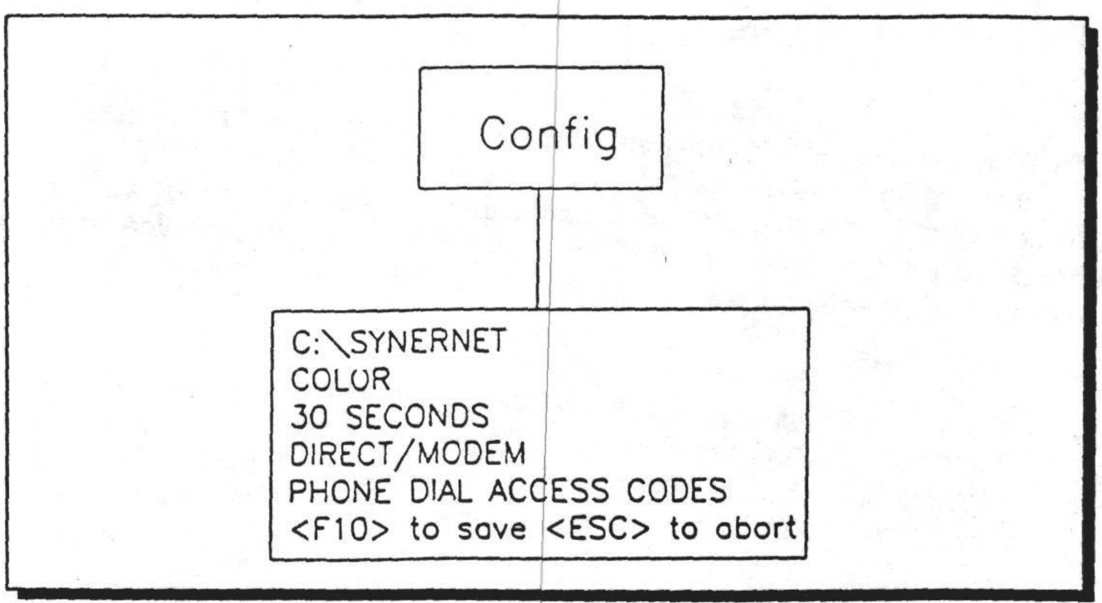


FIGURE 4-3 CONFIG(uration) SETTINGS FOR TYPICAL SOFTWARE SETUP
(Source: *Synergistic Installation Manual*, May 1993.)

QUEUE (For configuration setup and control of a network of data loggers)

Figure 4-4 illustrates the basic configuration of the QUEUE program. The QUEUE program is used to enter the data logger telephone number into an electronic file and to remove a data logger from the network. The logger ID, serial number, and the parameter set code all can be modified by using the EDIT screen within the QUEUE program.

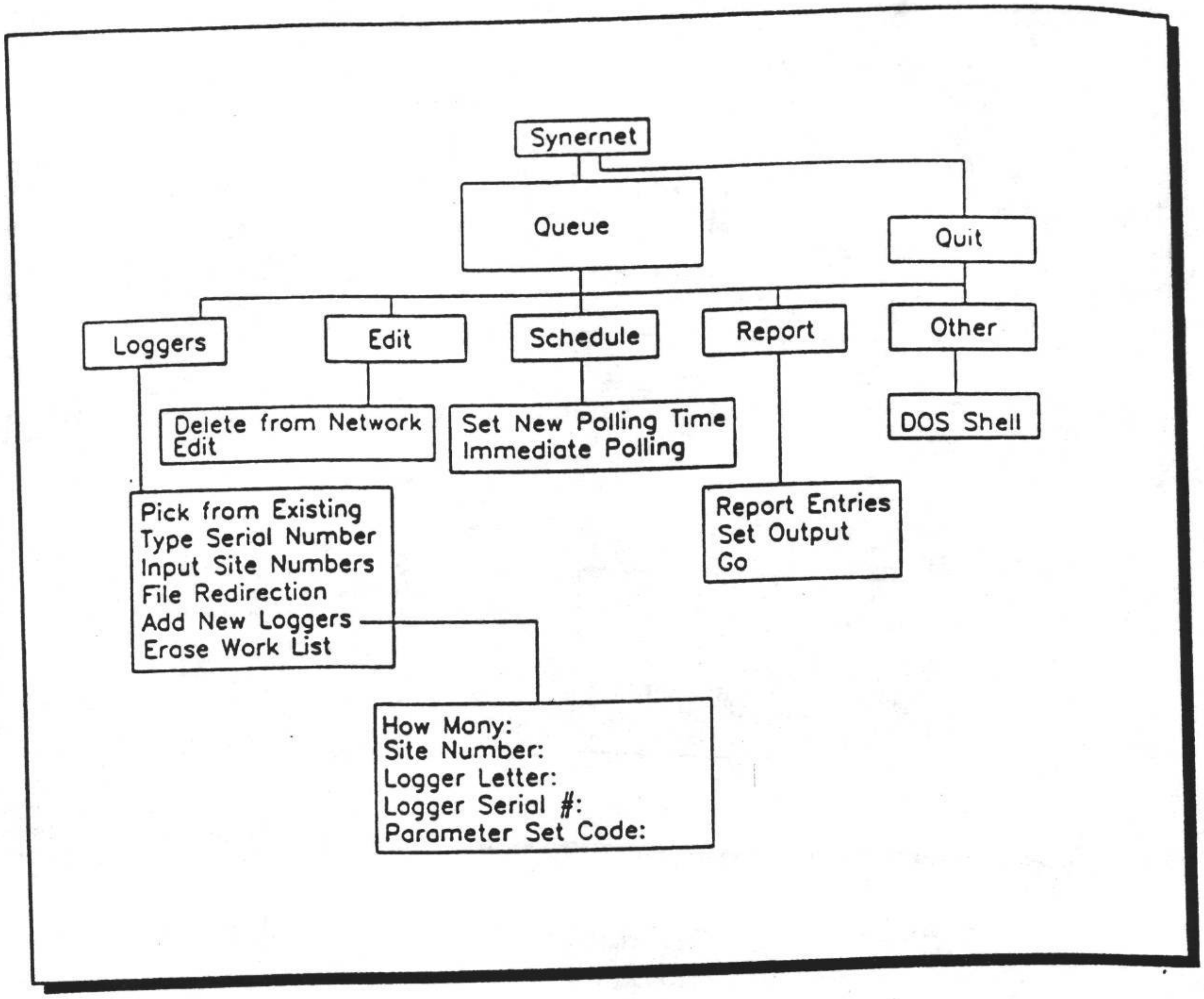


FIGURE 4-4 DIAGRAM FOR QUEUE PROGRAM
(Source: *Synergistic Installation Manual*, May 1993.)

Either QUEUE or PARSET (see next section) can be used to activate a logger. The main advantage to using QUEUE is that loggers are listed by site number. In PARSET, the loggers are listed in the order that they were added, which could create a problem with a large numbers of loggers.

PARSET (For configuration setup and manual control of a data logger)

PARSET is used to add a logger to the network, configure channels in a logger, manually poll a logger, view real time data, and/or download data. Figure 4-5 illustrates PARSET'S menu.

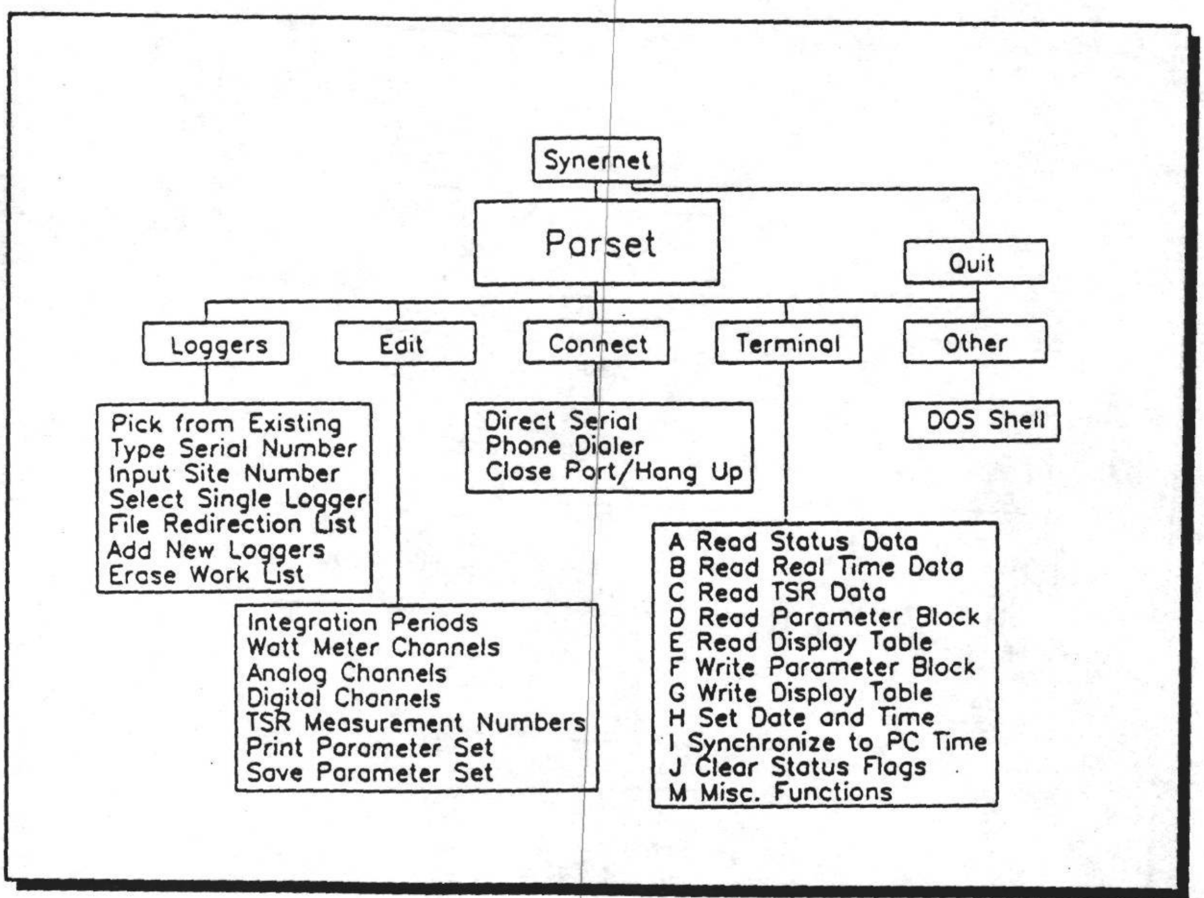


FIGURE 4-5. DIAGRAM FOR THE PARSET PROGRAM.
(Source: *Synergistic Installation Manual*, May 1993.)

Parameter Set Entry

You can use the PARSET program to set up most of the data logger configuration files prior to actually installing the logger. From the Synernet main menu, select PARSET ("Parameter Setting and Manual Logger Control"). Using the Channel Assignment forms from the SiteMAP, enter the logger configuration files into PARSET. Refer to the SYNERNET User's Manual and the on-screen help function for more information.

- From the main PARSET menu, select "Loggers" and "Add New Loggers." Follow the menu prompts.

When all new logger identifications have been entered, select "Pick from Existing Loggers." Highlight each logger at the site by pressing the space bar, and press <Enter> when finished.

- From the main menu, select "Edit" and "Choose from Work List." Select one logger at a time to enter the parameter sets.

Integration Periods

Set to one hour unless another integration period has been requested by ESL. For troubleshooting purposes, it is sometimes useful to set the integration period to a short interval, such as one minute. If you have changed the integration period, be sure to set it back to the designated period before leaving the site.

Watt Meter Channels

Description: Enter as written on the Electric Power Channel Assignment Form.
STA (status): ON for each active channel and OFF for inactive channels.
Load: Choose 3-phase or 1-phase.
HI and LO: Enter phase references.
VMult: 1 unless the service monitored is above 480 VAC.
Amps: Enter full-scale CT current for each channel.
Vlt (voltage) TSR flag: On once for each phase of each reference voltage.
Amp (current) TSR flag: Not used — leave off.
kW (real power) and kVA (apparent power) TSR flags: Flagged for each active channel and off for inactive channels.
kWh and kVAh flags: Not used — leave off.

Press F10 to exit. Type S to save. Do this after each screen.

NOTE: Care must be taken to properly align the CTs by phase, both on the termination board and in the logger software. *This one of the most common mistake made in any logger installation.*

Analog Channels

Description: Enter as written on the Analog Channel Assignment Form.
STA (status): ON for each active channel and OFF for inactive channels.
Scale: Enter the scale if it is known at this time.
Offset: Offsets will generally not be known until after the device in question has been installed.
Units: Choose from the pre-defined list provided.
TSR flag: Flagged for each active channel and off for inactive channels.
Snapshot flag: On when end-of-interval reading is required instead of an average over the interval.
Gate: When this flag is set, the logger will only integrate the analog data for the channel when the corresponding digital input contact is closed. In this case, the corresponding digital channel must be set to collect run-time data (see digital channels below).

CType (channel type): Select from the list of pre-defined types. (For 4-20 mA output sensors, select 0-5 VDC.)

Digital Channels

Description: Enter as written on the Digital Channel Assignment Form.
Search String: Not used.
STA (status): ON for each active channel and OFF for inactive channels.
Scale: Scale factors for utility meters will not be obtained until pulse-initiating meters are installed. Enter factors for other sensors if they are available.
Units: Type in up to eight characters as shown on the Digital Channel Assignment Form.
TSR: Flagged for each active channel and off for inactive channels.
AVG: Flagged for each active channel (except perhaps run-time sensors) and off for inactive channels.
RTS (run-time sensor flag): Flagged when using a run-time sensor, to accumulate run time in seconds. If the AVG flag is also set, the resulting data will be in percent run time during the interval.

TSR Measurement Numbers

To assign unique sequential numbers to all measurements at the site, press F9. For logger A, start with measurement number 1. Note the final measurement number on logger A, and use the next number to begin numbering on logger B. Continue thus through all loggers at the site.

As-Installed Measurement Plan

After the data monitoring equipment installation is complete and fully documented, enter the scaling factors for electric and gas meters into the configuration files in Synernet. The scaling factors for any other digital or analog output devices should also be entered into the configuration files. If any modifications were made to the SiteMAP during the course of the installation, the changes must be entered in the logger configuration files as well. The configuration files and now ready to be loaded into the DAS. Until these files are loaded, disregard the information on the logger displays.

Load Logger Configuration Files

Use a portable computer to configure each of the loggers at the site. Connect a cable from the RS-232 port of the portable computer to the 9-pin RS-232 connector on the communication board of any of the loggers. Enter the Synernet program and perform the following steps:

1. Select the previously defined serial numbers using the Loggers/Pick from Existing Loggers function.
2. Get into the Edit functions and "choose one" of the loggers from the set of loggers you have selected for the work list.
3. Establish direct serial communication.
4. Enter the terminal, and verify communication with each logger at the site. Use the "read status data" and the "choose one" functions in the menu to verify communication with each logger.

5. Set the clocks at the site, using the "Synchronize to PC Time" function (I) to synchronize each logger clock at the site to the clock on the portable computer.
6. For each logger, load the parameters (F) and load the display table (G). Then clear status flags (J).

4-6 Workmanship and Site Clean-Up

4-6.1 Clean-Up

The electrician should neatly secure all wires and CTs in all electrical panels. The wires and terminations in all loggers and junction boxes should also be neat and secure. Sloppy terminations reflect badly on both the DASS and the LoanSTAR Program. **ESL will reject sites that are terminated in an unsightly fashion.** Furthermore, all locations within the site where activity took place must be clean and tidy. All equipment moved must be replaced and all installation debris, including stripped wire ends, must be cleaned up and removed.

Place LoanSTAR Monitoring Equipment stickers on all loggers and monitoring equipment enclosures. Place information stickers on all monitored electrical panels. The stickers will clearly show the telephone numbers for information and emergency response.

4-6.2 Site Contact Approval

After the installation is complete, the site contact, as a representative of the building operator, should be escorted through the building and shown all the equipment installed, including the breakers that power monitoring equipment. Correct any deficiencies noted by the site contact prior to leaving the site.

4.6-3 Installation Checklist

As a final step in the process, the DASS technician should complete and initial the Installation Checklist (INSTALL Form 5) and include it as part of the Installation Submittal Package. The site is then ready for verification and then final inspection by ESL.

4-7 Verification and Troubleshooting

Installation of the monitoring system is not complete until the proper operation of all components in the monitoring and communications systems has been verified. Verification data must be recorded on the appropriate INSTALL Forms. Refer to Appendix E to view completed sample verification documents.

The verification techniques presented here are suggestions that can be used in many cases, but they do not cover every contingency. Methods for verifying each individual component and the system as a whole are presented. Additionally, troubleshooting hints are offered.

4-7.1 KW Channel Verifications and Troubleshooting

Preliminary Reasonableness Checks

Once the configuration files have been loaded into the loggers, the output of each logger can be read on the screen of a properly connected laptop computer by executing the "Read Real Time Data" command in PARSET. Examine each channel for reasonableness based on documentation of the loads connected to the individual channels.

The data logger display can also be used for examining the real time data. The display shows one item at a time from a matrix of data. Users can navigate through the matrix using the arrow keys by the display. See the Synergistic Installation Manual for further details.

<u>KW Channels</u>

Reasonableness checks include:

- **Line Voltage:** Is the line voltage reasonable for the type of service that is being monitored?
- **Amps:** Is the current reasonable for the number and type of CTs connected to the channel?
- **Power:** Is the power positive? Are there any reversed CTs, which are indicated by a negative power value?
- **Power Factor:** Is the power factor reasonable for the kinds of devices connected? Are there phase reference problems?
- **Phase Balance:** Is the power consumed in each phase of a poly-phase device roughly the same?

Obvious errors such as reversed CTs and improper connections can be located and corrected by using these reasonableness checks. Your ability to identify and solve installation errors will increase over time. **Don't be discouraged if troubleshooting seems to take an inordinate amount of time during your first few installations.**

Update of Configuration Files

Any errors that may have been discovered during the initial reasonableness check must be corrected. If any parameters have changed, the appropriate PreMAP, SiteMAP, and INSTALL Forms, as well as the parameter set in the Synernet program must be updated and the parameters must be reloaded to the logger.

Problems that can be fixed by changing the configuration files include:

- Phasing errors (CTs referenced to the wrong phase);
- CT scaling errors (wrong Full Scale Amps value); and
- Scaling errors on other sensors (wrong scaling factor).

Problems that require some change in the installed hardware include:

- Reversed CTs;
- Parallel or summing module CT connection problem (phase mixing, CT size mixing, etc.); and
- Bad wire connections.

Direct Verification of CT Channels

Each CT must be verified manually by comparing the CT's logger channel reading with measurements made using a hand-held ammeter or wattmeter. If there are any channels in the system with near zero power (loads are turned off), now is the time to ask the facility manager to turn them on if possible, so that the channel can be verified. As logger readings are compared to direct measurements, note both values on the appropriate Channel Verification Form. Any channels where the DAS and directly measured power values vary by more than 5 to 10 percent need to be investigated. **Be careful when using a hand-held wattmeter. If one voltage clip should become disconnected and go to ground while the other remains attached to an energized lug, you could short-circuit the building's electrical system and probably cause a serious power outage. You could also be injured.**

4-7.2 Digital Channel Input Verifications and Troubleshooting

Digital channels are used to monitor electrical power, flow and thermal loads by sensing contact closures that occur at the monitoring equipment.

It is important to record the verification method used, the equipment used, and the calculations completed. Verification is to be recorded on INSTALL Form 4a. Add pages if you need more space to adequately and neatly show the verification technique and results.

Verification of digital monitoring equipment installations will require a variety of hand-held meters, including:

- Digital Multimeter;
- Watt Probe;
- Digital Temperature Sensor; and
- Stop Watch.

Watt-Hour Transducers (WHTs)

Confirming the proper operation of a WHT requires verification of the CT function and the WHT pulse output.

To complete the CT verification, the current of each phase is read and recorded using a hand-held amp probe. Then the mV output of each CT is read and recorded using a hand-held volt meter (digital multimeter). The two readings are compared by converting the mV reading to amps as follows:

amps = (mV reading * CT rating)/333

where: amps = effective CT amp reading, converted from mV
mV reading = volt meter reading of the CT secondary output in mV
CT rating = primary rating of the CT
333 = full-scale output of the CT

If an error is identified in the CT verification, check all wiring and repeat the verification one CT at a time. It is possible that the load changed during the time that the meter readings were made. It is also possible that the CTs were terminated incorrectly at the WHT. It may be necessary to trace the CT secondary leads from the WHT to the CT to be sure that the CT marker numbers are correct.

Upon completion of the verification of all CTs, complete the WHT verification. If possible, use a watt probe to measure the kW and record that reading. If it is not possible to use a watt probe, current and voltage readings for each phase should be recorded. These readings will be used to calculate kW using an estimated power factor. Note that, in some cases, it may be necessary to read facility analog amp meters to determine the current in each phase.

Instantaneous power is calculated as follows:

P = (I * V * pf)/1000

Where: P = instantaneous power in kW
I = instantaneous line amperage
V = instantaneous line voltage
pf = estimated power factor (approximately 0.85 to 0.95)

Whichever method outlined above is used, the value obtained will be compared to the WHT output. The pulse output of the WHT can be observed visually and timed (an LED flashes each time a pulse occurs). Each flash represents one pulse, which is equal to the kWH scale factor of the WHT. You should time five to 10 pulses (depending upon the frequency of the pulses) to avoid timing errors. Record the number of pulses and elapsed time, and the calculate kW as follows:

P = (x pulses * kWH scale factor * 3600)/time

Where:
P = instantaneous power in kW
x pulses = number of pulses counted
kWH scale factor = pulse value in kWH per pulse from specifications
3600 = conversion of time from seconds to hours
time = the time in seconds for the pulses to occur

If an error is identified in the WHT verification, repeat the readings and recalculate. It is possible that the load fluctuated in the time it takes to complete the readings, so it may be necessary to complete the readings simultaneously. If the error still exists, check the phasing of the reference voltage to the WHT. The reference voltage of each phase to the WHT must match the phase to which each CT is mounted. Any error in phasing will significantly lower the pulse output rate of the WHT.

When the function of the WHT is verified, check to see that the data logger real time data display or the local display on the DAS face is receiving the pulses from the transducer. This is accomplished by viewing the DAS RTD and counting pulses at the WHT simultaneously. The timed pulses at the WHT should be equal to the accumulated pulses in RTD. If the pulses are not being recorded at the data logger, check the signal cable for an open circuit and check all terminations.

Once the verification is complete, record the method of verification and the values calculated, and record the values read onto the Digital Channel Verification Form (INSTALL Form 4a).

Electric Utility Pulse Initiator Meter

The pulse count accuracy of the data logger should be confirmed by comparison with the meter reading over time. To do a quick check, count the pulse output using an ohm meter while watching the meter disk rotate. The meter will have a specified number of pulses per disk revolution, which can be verified immediately. It is usually assumed that the utility meter is correct and calibrated. However, this does not prove that the pulse constant, which is provided by the utility, is correct.

When verifying an electric utility meter, it is usually not possible to use a watt probe to measure power (kW), and, in most cases, it is not possible to measure current with a hand-held amp meter. If local kW meters are available in the facility; they may be used for verification. More commonly, however, verification is accomplished by comparing the output of the pulse initiator with facility analog amp and volt meters. These facility readings will be used to calculate kW using an estimated power factor. Instantaneous power is calculated as follows:

$$P = (I * V * pf)/1000$$

Where:
P = instantaneous power in kW
I = instantaneous line amperage
V = instantaneous line voltage
pf = estimated power factor (approximately 0.85 to 0.95)

Whichever method outlined above is used, the value will be compared to the utility meter pulse output. The pulse output of the meter can be timed using a DC volt meter at the data logger digital input for the meter (the voltage will change from 5 VDC to 0 VDC and back to 5 VDC for each two pulses of the utility meter). You should time approximately 10 pulses (depending upon the frequency of the pulses) to avoid timing errors. Record the number of pulses and elapsed time, and then calculate kW as follows:

$$P = (x \text{ pulses} * \text{kWH scale} * 3600)/\text{time}$$

Where:
P = instantaneous power in kW
x pulses = number of pulses counted
kWH scale = pulse value in kWH per pulse from specifications
3600 = conversion of time from seconds to hours
time = the time in seconds for the pulses to occur.

The value of each pulse is determined by the CT ratio, the PT ratio, the meter constant kh, and the number of pulses per disk revolution as shown in the following formula:

$$\text{kWH/Pulse} = (CTR * PTR * kh * R/P)/1000$$

Where
kWH/Pulse = kilowatt-hours per pulse
CTR = Current Transformer Ratio
PTR = Potential Transformer Ratio
kh = meter constant
R/P = one revolution for a given number of pulses
1000 = conversion to kWH

It is possible that the load fluctuated in the time it takes to complete the readings, so it may be necessary to complete the readings simultaneously. If the error still exists, check the kWH/pulse scale factor for the meter.

When the operation of the utility meter is confirmed, verify that the data logger is receiving the pulses from the meter. This is accomplished by viewing the DAS RTD and counting pulses at the meter simultaneously. The timed pulses at the meter should be equal to the accumulated pulses in RTD. If the pulses are not being recorded at the data logger, check the signal cable for an open circuit and check all terminations.

When the methods outlined above are not possible, use the following technique: To verify function of the meter and the scale factor, read both the electric meter and the data logger accumulated pulse count, and then read both again after a period of time (on the hour). You can then compare the logger time series records for the test period to the meter reading.

Once the verification is complete, record the method of verification, the values calculated, and the values read on the Digital Channel Verification Form (INSTALL Form 4a).

Gas Utility Pulse Initiator Meter

Gas meters usually have a digital or analog display, which can be compared to the pulses. This is usually a real time verification to prove that the pulses out of the pulse initiator output match the meter readings. It also verifies that all pulses at the initiator reach the data logger (i.e., pulses timed at one end equal actual pulses at the other end).

Gas flow is often too slow to complete a verification while watching. If the flow rate is high enough, you can observe the meter to see when a pulse occurs (or use an ohm meter to verify the occurrence of the pulse). You can then check the real time data to see if the pulse was recorded. It might be helpful to have two people with hand-held radios, one at the gas meter and one at the data logger, to complete this verification. Another technique to verify the meter's function is to read both the gas meter and the data logger accumulated count and then read both again after a period of time (on the hour). You can then compare the accumulated counts for the test period to the meter reading. This method also assists in determining if the correct scale factor, for the engineering units used, has been properly programmed into the data logger.

If the pulses are not being recorded at the data logger, check the signal cable for an open circuit and check all terminations. If the pulses are being recorded but the scaling is incorrect, check the calculation for the scale factor and the value programmed in the parameter set.

Once the verification is complete, record the method of verification, the values calculated, and the values read on the Digital Channel Verification Form (INSTALL Form 4a).

In-Line Turbine Flow Meter

In-line flow meters usually have an analog display, which can be compared to the pulses. This is a real time verification to prove that the pulses from the pulse initiator match output from the meter readings. It also verifies that all pulses from the meter reach the data logger (i.e., pulses timed at one end equal actual pulses at the other end).

It may be possible to actually verify the flow rate by observing and estimating the volume of fluid evacuated from a condensate receiving station through a sight glass and comparing that estimate to the counts received in the real time data. Otherwise, it may be possible to estimate the flow into the boiler or in the line through discussion with facility personnel, and then compare that value to the TSR. If there are pre-existing flow meters at the facility that are functioning properly, compare those readings with the new meter and the data recorded. Typically, facility meters are old or in need of calibration, so they may not be accurate.

If the pulses are not being recorded at the data logger, check the signal cable for an open circuit and check all terminations. If the pulses are being recorded but the scaling is incorrect, check the meter's pulse constant in the specifications and compare it to the value programmed in the parameter set.

Once the verification is complete, record the method of verification, the values calculated, and the values read on the Digital Channel Verification Form (INSTALL Form 4a).

BTU Meter

The following BTU meter components must be verified after they are installed:

- Insertion Flow Meter (Tangential Paddlewheel Meters);
- Insertion Temperature Sensors (Thermistors); and
- BTU/Flow Totalizer.

Insertion Flow Meter (Tangential Paddlewheel Meters)

The verification of the flow meter is accomplished at the BTU/flow totalizer. Therefore, the installation of the flow meter, signal wire, and totalizer (including instrument power) must all be complete. Verification of flow is usually not absolute. You may find functioning facility flow metering equipment that can be used for comparison purposes. Other sources of comparison data include the following:

- facility estimates of the flow rate;
- pump curves or other pump-performance data; and
- chiller performance data from which a good estimate of the flow rate can be made.

Flow in the range of 3 to 7 feet per second is most common, but it may be slightly higher or lower. Calculate flow rate (gpm) by timing the pulse output from the totalizer and calculating flow as shown below. To avoid error, time 10 or more pulses.

gpm = (x pulses * scale factor)/time

where: gpm = gallons per minute
x pulses = the number of pulses timed
scale factor = the scaled value of each pulse in gallons

time = the time in minutes for x pulses to occur

If error is identified, there are several possible points to troubleshoot:

- Check the wiring for bad or open connections;
- Check the programmed values of the S1 and S4 dipswitches;
- Check the flow meter alignment and depth;
- Check the voltage supply to the totalizer and the flow meter; and
- Check the frequency of the flow meter output (the red LED in the totalizer flashes at the frequency of the flow meter).

Once the verification is complete, record the method of verification, and the calculated and observed data on the Digital Channel Verification Form (Install Form 4a).

Insertion Temperature Sensors (Thermistor)

It is necessary to find and read facility in-line temperature sensors or have a hand-held digital thermometer, which can be placed on an uninsulated section of pipe, to complete this verification. Temperatures should be read and recorded at (or as close as possible to) both the supply and return thermistor locations. Measure resistance for each thermistor at the totalizer using a digital multimeter. The actual temperatures should be compared to the measured resistance readings using the temperature versus resistance chart.

If an error is identified, check the wiring for bad or open connections.

Once the verification is complete, record the method of verification and the calculated and observed data on the Digital Channel Verification Form (INSTALL Form 4a).

BTU/Flow Totalizer

When flow and temperatures are verified, the BTU verification is a calculation to determine if the change in temperature (ΔT) measured by facility or hand-held temperature sensors matches the ΔT calculated from timed pulses from the totalizer flow and BTU outputs. ΔT for the flow loop is measured as described in the section discussing verification of thermistors.

Simultaneously time the flow output pulses and one or two BTU output pulses. The elapsed time should be recorded and used to calculate gpm and BTUs per hour for further verification. ΔT is calculated as shown below:

ΔT = (x BTU Pulses * BTU Scale) / (x Gallons Pulse * Gallons Scale * D * Cp)

where:

ΔT = totalizer temperature difference
x BTU Pulses = the number of BTU output pulses timed
BTU Scale = the scaled value of each pulse in BTUs
x Gallons Pulse = the number of gallon output pulses timed
Gallons Scale = the scaled value of each pulse in gallons
D = Density in pounds per gallon (8.33 for water)
Cp = Specific Heat in BTU/lb (1 for water)

If an error is identified, there are several possible points to troubleshoot:

- Check the wiring for bad or open connections;
- Check the resistance (temperature) of the two thermistors at the totalizer and compare to local or hand-held temperature readings;
- Check the programmed values of the S1 and S4 dipswitches;
- Check the flow meter alignment and depth;
- Check the voltage supply to the totalizer and the flow meter; and
- Check the frequency of the flow meter output (the red LED in the totalizer flashes at the frequency of the flow meter).

As noted previously, the timed pulses can also be used to calculate gpm and BTU per hour. It is sometimes possible to compare the BTU per hour calculation with facility records, facility metering equipment, or estimated building energy consumption.

Once the verification is complete, record the method of verification and the calculated and observed data on the Digital Channel Verification Form (INSTALL Form 4a).

4-7.3 Analog Channel Input Verification and Troubleshooting

Verification of an analog sensor will usually be accomplished using hand-held meters to provide a comparison with the installed device. Hand-held meters can be used to verify temperatures, relative humidity, solar radiation, and wind speed. If it is not possible to use a hand-held meter for verification of the sensor, the facility may have monitoring equipment installed that can be used as a reference for verification. Failing that, a check for reasonableness should be accomplished.

As with all verification, it is important to record the method used, the equipment used, and the calculations completed. Verification data must be recorded on the INSTALL Form 4b. You may need additional space to adequately and neatly show the technique and results.

On-site verification of analog monitoring equipment will require a variety of hand-held meters, including:

- Digital Multimeter;
- Watt Probe;
- Digital Temperature Sensor;
- Relative Humidity Probe;
- Thermal Anenometer or Portable Wind Speed Indicator; and
- Calibrated Pyranometer

The verification process involves comparing hand-held meter readings to the DAS real time reading. This may be somewhat difficult to accomplish at times when the sensor is distant from the data logger. In this case, it may be helpful to have two people equipped with two- way radios.

2-wire resistive RTD analog channel

Measurement of resistance at the sensor or at the data logger should be accomplished using a hand-held ohm meter (digital multimeter). The measured resistance is then converted to temperature using the temperature versus resistance chart for the RTD. That temperature is compared to the DAS real time display for the device. Additionally, a hand-held digital thermometer or a facility thermometer should be read and compared to the RTD. If an error exists, check the signal cable for bad or open connections. Also check the parameter set programming for an error.

The method of verification and the calculated and observe data should be recorded on the Analog Channel Verification Form (INSTALL Form 4b).

2-wire, 4-20 mA; 3-wire, 4-20 mA; and 2-wire, 0-5 VDC analog channels

Temperature, solar radiation, wind speed, relative humidity, pressure, kW, or other sensors may have these types of analog signals. Verification consists comparing a hand-held instrument, facility instrument, or documented data for the measured quantity to the RTD, TSR data, or digital multimeter readings. For an explanation of how the data logger converts a 4-20 mA signal to a voltage, see the analog channels section of the Synernet Manual.

If possible, compare hand-held meter readings to the data logger real time reading. This may be somewhat difficult to accomplish when the sensor is distant from the data logger. In this case, it may be helpful to have two people equipped with two-way radios.

If an error is identified, check the wiring for bad or open connections. Check the sensor to see if it is functioning and has the required instrument power. Also check the parameter set programming for an error.

Once the verification is complete, record the method of verification and the calculated and observed data on the Analog Channel Verification Form (INSTALL Form 4b).

4-7.4 Data Logger Time Series Record (TSR) Verification and Troubleshooting

TSRs can be viewed on a laptop computer connected to the data logger or on a computer connected by modem from any location. Communication for either approach is established through the Parset program. The TSRs can be viewed on the screen or downloaded to disk for review later.

The review should compare the TSRs to the verified values as calculated during the completion of the INSTALL Forms. Constant loads such as motors or chillers will be easily verified. Any loads that vary with time will require some thought. Look for values that are out of the expected range, or negative values.

INSTALL Form 8 should be used to compile the information used for TSR verification. ESL will review this form for proof that the DAS is operating properly when the documentation workbook is submitted at the end of the job.

4-7.5 Communications System Verification and Troubleshooting

Both serial and modem communications should be checked. It is not necessary to document these verifications.

Serial communication is established through the Parset program. Successful serial communication will allow programming, viewing real time data, and downloading TSRs to a laptop computer. If problems occur, there are several points to troubleshoot:

- Check to see that the data logger is turned on. Check to see that the proper serial number for the data logger is programmed in the parameter set;
- Check the configuration (Config) file for correct programming of the communications ports, baud rate, and type of monitor;
- Check the connections between the laptop and the data logger; and
- Check the communications interface cable connections at the interface module and the main processor board;

Modem communications can be checked by calling the data logger from a laptop computer connected to a telephone line in another location while a DASS technician remains at the data logger. Communication is established through the Parset program. A successful communication will allow programming, viewing real time data, and downloading TSRs to the laptop. If problems occur, there are several points to troubleshoot:

- Check the connections between the laptop and the telephone line;
- Check to see that the telephone number is correct and functional (connect a portable telephone to the communications board and have someone call it). If the telephone works and data logger communication is still unsuccessful, replace the modem and/or the communications interface board;

- Check to see that the data logger is turned on;
- Check the configuration (Config) file for correct programming of the communications ports, baud rate, and type of monitor;
- Check to see that the proper serial number for the data logger is programmed in the parameter set. Turn the data logger off for a few seconds and then on again to reset the modem; and
- Check the communications interface cable connections at the interface module and the main processor board;

DC loop communication can be checked in the same way as described above for serial and modem communications. If the system is operating properly, it will be possible to communicate with all data loggers in the loop through either serial or modem connection. If problems occur:

- Check wiring and terminations of the DC loop cable(s); and
- Check the voltage present on the DC loop (approximately 29 VDC is correct).

Successful communication in both serial and modem mode can be observed in the data logger by viewing LEDs on the communications board.

4-8 Documentation Submittal and Site Acceptance

Upon completing installation and verification, review, update, and recopy the documentation forms. Attach copies of the supplemental information pages, SiteMAP Schematic, subcontractor invoices, and equipment specifications sheets for the site. Submit the documentation to ESL, along with a copy of the parameter set on diskette. Indicate the date that final verification of all channels was completed. ESL will review the documentation, inspect the site installation, review data records, and issue a "punch list" if any deficiencies exist. You will be responsible for correcting any deficiencies and reporting the completion to ESL. The installation will remain under warranty by the DASS for the agreed-upon period.

APPENDIX A

Abbreviations

The following acronyms and abbreviations are in common usage in the LoanSTAR Monitoring Program:

AC	Alternating Current
AHU	Air Handling Unit
AHUI	Air Handling Unit, Individual Energy
AHUN	Air Handling Units, Total Energy
Amp	Current
AWG	American Wire Gauge
BTU	British Thermal Unit
CHIL	Chiller Unit
CHW	Chilled Water
CHWB	Chilled Water BTUs
CHWF	Chilled Water Flow
CHWP	Chilled Water Pump
COND	Condensate
CT	Current Transformer or Transducer
CTF	Cooling Tower Fan
CTFI	Cooling Tower Fan, Individual Energy
CTFN	Cooling Tower Fans, Total Energy
CTR	Current Transformer Ratio
CW	Condenser Water
CWP	Condenser Water Pump
CWPI	Condenser Water Pump, Individual Energy
CWPN	Condenser Water Pump, Total Energy

DAS	Data Acquisition System
DAS RTD	Data Acquisition System Real Time Data
DASS	Data Acquisition System Subcontractor
DC	Direct Current
ECRM	Energy Conservation Retrofit Measure
ELT	Equipment Location Tag
EMS	Energy Management System
EMCS	Energy Management and Control System
ESL	Texas A&M University Energy Systems Laboratory
GASF	Gas Flow
HP	Horsepower
HVAC	Heating, Ventilating and Air Conditioning
HW	Hot Water
HWB	Hot Water BTUs
HWF	Hot Water Flow
HWP	Hot Water Pump
HWPI	Hot Water Pump, Individual Energy
HWPN	Hot Water Pumps, Total Energy
Kh	Electric Meter Constant
kVA	Kilovoltamperes
kVAH	Kilovoltampere-hours
kW	Kilowatt
kWh	Kilowatt-hour

LITE	Lighting Energy
LoanSTAR	Loans to Save Taxes and Resources
MECH	Mechanical Energy
MTRA	Meter A (any gas utility electric metering device or any WHT)
NCAT	National Center for Appropriate Technology
NEC	National Electrical Code
NG	Natural Gas
NMEC	Non-Mechanical Energy
NPT	National Pipe Thread
PreMAP	Preliminary Monitoring and Analysis Plan
PT	Potential Transformer
PTR	Potential Transformer Ratio
Pulse	A digital Signal — typically a voltage change between 0 and 5 or 5 and 0 VDC
RAF	Return Air Fan
RAFI	Return Air Fan, Individual Energy
RAFN	Return Air Fans, Total Energy
RefVlt	Reference Volts
R/P	Electric Meter Revolutions per Pulse
RTD	Resistive Temperature Detector
SECO	State Energy Conservation Office
SiteMAP	Site Monitoring and Analysis Plan
STEM	Steam

TB	Terminal Block
TSR	Time Series Record
V	Voltage
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
WHT	Watt-Hour Transducer

APPENDIX B

Tools

The following electronic equipment and hands tools will be needed to install energy monitoring equipment in the LoanSTAR Program:

Portable IBM Compatible Laptop Computer and Synernet Software
Electronic Scientific Calculator
Digital Multimeter (Fluke Model 77 or Equivalent)
Portable Watt Probe (Tif Model 2000A or Equivalent)
Amp Probe
Electronic Thermometer (Fluke Model 51 or Equivalent)
6-Foot Fiberglass Stepladder
Flashlight and Spare Batteries
Toolbelt and Basic Electrical Tech. Tools
22 Gauge Wire Strippers
Miniature Standard Blade Screwdriver
Clipboard & Graph Paper
Basic First Aid Kit
25-Foot Tape Measure
Telephone

APPENDIX C

Equipment Specifications

TABLE 1.2 MODEL C180E SPECIFICATIONS

Item	Specification
Packaging	NEMA 1 enclosure with hinged door and key lock. Equipped with eight-character, alphanumeric, vacuum-fluorescent display and flat membrane key pad. NEMA 4 enclosure is optional.
Basic configuration	14 inches high × 12 inches wide × 4 inches deep; 6 inches deep for NEMA 4 enclosure
Expanded configuration	24 inches high × 12 inches wide × 4 inches deep (accommodates optional expanded monitoring capability); 6 inches deep for NEMA 4 enclosure
Electrical Metering System	
Items metered	rms current . . . 16 rms voltage (three-phase service) . . . 2 rms power (kilowatt), bipolar . . . 16 Power factor . . . 16 Integrated power (kilowatt hour), bipolar . . . 16 Integrated apparent power (kilovoltamperehour) . . . 16
Current transformer	UL- or ETL-listed current transformer with integral shunt resistor; output is 0.3333 Vrms at rated full-scale current. Intended for mounting outside the data recorder enclosure.
Potential transducer	ETL-listed potential transducer provides low voltage signal for polyphase electrical services up to 480 Vac. Intended for mounting outside the data recorder enclosure.
Accuracy	Amperes and volts: ±0.5 percent of full scale Power factor: ±0.02 PF from 100 percent to 5 percent of full-scale input Kilowatt and kilowatthour: ±0.5 percent of reading from 100 percent to 1 percent of full-scale input, unity to 0.5 PF, excluding CT error
Contact Closure Inputs	
Type	Sixteen independent floating form A contact closures to system common. Each input may be independently configured to accumulate either pulse counts or on-time—for measuring equipment run-time.
Electrical pull-up	+5 volt, 3.3 kilohm
Transient immunity	500 volts, 10 microsecond
Count rate	10 hertz maximum
On/off duration	40 millisecond minimum
Contact bounce	20 millisecond maximum
Digital Outputs	
Type	Eight independent open-collector transistor relay drivers with clamping diode.
Capacity	0.2 amperes current sink (direct current); 35 volts maximum energizing voltage.
Analog Signal Inputs (optional)	
Type	Fifteen independent, single-ended voltage inputs, all referenced to system common. Built-in precision shunt resistors accommodate 4- to 20-milliampere instrumentation loops.
Range	0 to +5.00 volts direct current
Input impedance	10 megohm minimum
Resistance inputs	Any channel may be programmed to measure two-wire resistance sensors using an internal constant current source. Linearization is provided for 1,000 ohm platinum RTD.
Accuracy	±0.25 percent of full scale
Resolution	Voltage: 1.0 millivolt Resistance: 0.3 ohm Temperature: 0.1 °C, platinum RTD or LM34/35 integrated circuit temperature sensor.

Transducers and Transformers for Current, Voltage, Power and Energy

Short Form Catalog

SPLIT APART Current Transformers/Transducers - ACmV or ACmA Per Amp Output (0.5% special order)

Model 1AF1:	20A - 100A	+/-1% ACmV Out,	60' phase error	1/2" Window	50Hz-1KHz
Model 1AF2:	50A - 400A	+/-1% ACmV Out,	60' phase error	1" Window	50Hz-1KHz
Model 4LN2:	5A - 100A	+/-0.5% ACmV Out	60'phase error	0.4" Window	10Hz-5KHz
Model 4LN3:	50A - 400A	+/-0.5% ACmV Out	30' phase error	0.75" Window	10Hz-5KHz
Model 4LS2:	100A- 800A	+/-1% ACmV Out	60' phase error	Select Window	50Hz-1KHz
Model 4LS3:	100A- 800A	+/-1% ACmV Out	60' phase error	Select Window	50Hz-1KHz
Model:4LS3:	1000A-5000A	+/-1% ACmV Out	60' phase error	Select Window	50Hz-1KHz
Model 4AS2:	100A - 800A	+/-1% ACmA Out,	60' phase error	Select Window	50Hz-1KHz
Model 4AS3:	100A- 800A	+/-1% ACmA Out,	60' phase error	Select Window	50Hz-1KHz
Model 4AS3:	1000A- 5000A	+/-1% ACmA Out,	60' phase error	Select Window	50Hz-1KHz

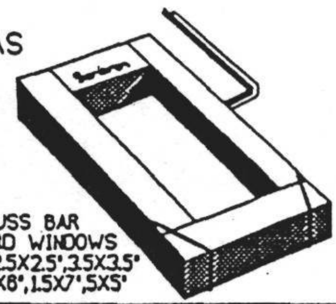
Series 1A
AC millivolt Output

Series 4LN

Model 4LN2: 0.4"
Model 4LN3: 0.75"

Series 4LS/4AS

STANDARD WINDOWS
0.75, 1.0, 1.25, 1.5"
2.0 & 2.5"

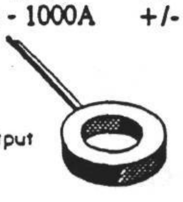


BUSS BAR
STANDARD WINDOWS
2X5",2X6",2.5X2.5",3.5X3.5"
1.5X5",1.5X6",1.5X7",5X5"

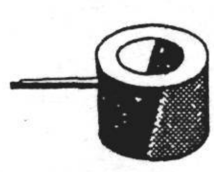
SOLID BUSHING Current Transformers/Transducers - ACmV or ACmA Per Amp Output (0.5% special order)

Model 2LF1:	5A - 50A	+/- 1% ACmV Out	15' phase error	1/2" Window	50Hz-1KHz
Model 2LF2:	100A- 200A	+/- 1% ACmV Out	30' phase error	1" Window	50Hz-1KHz
Model 2LS1:	20A - 200A	+/- 1% ACmV Out	30' phase error	1/2"- 1 1/2" Windows	50Hz-1KHz
Model 2LS2:	200A - 2000A	+/- 1% ACmV Out	30' phase error	1 1/2"- 4" Windows	50Hz-1KHz
Model 2CS1:	50A - 200A	+/- 1% ACmA Out	30' phase error	Custom Windows	50Hz-1KHz
Model 2CS2:	400A - 1000A	+/- 1% ACmA Out	30' phase error	Custom Windows	50Hz-1KHz

Series 2L
AC millivolt output



Series 2C
AC Amp Output
AC milliamp Output



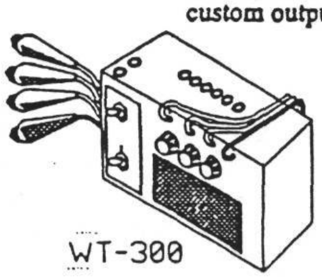
POWER TRANSDUCERS AND VOLTAGE (POTENTIAL) TRANSFORMERS

Model WT-300: Watt Transducer True Power, 3 Phase Internal VPTs 100-300VAC & 300-600VAC switch selectable, 5VDC Full Scale Out, Power Out depends on CTs, +/-1%, 4 Leads (Add 3 CTs)

Model WT-100: Watt Transducer, True Power, 1 Phase with 1 VPT 0-150 or 150-300 switch selectable, 5VDC Full Scale Out (depends on CT), +-1%, 2 Leads (Add 1 CT)

Series WT-x: Watt Transducers (Series) - True Power, 1 and 3 Phase, Exteranl CTs & VPTs, 5VDC Full Scale Out (depends on CT and VPT used), +/-1%, Terminal Connections (Add VPTs)

Series VPT-x: Voltage (Potential) Transformers (VPT-1 = 0-150Vac, VPT-2 = 0-300Vac) with 5Vac, 10Vac, 12Vac or custom output voltage



WT-300

WT-100

Series WT-x
Watt Transducers

Series VPT

SENTRAN™

Sentran Corporation

MODEL WL-3968
WATT HOUR TRANSDUCER

INPUTS:

VOLTAGE	120/208 & 277/480
PHASE	3Ø 3W OR 3Ø 4W
RANGE	+/- 15%
* CURRENT	EACH CURRENT TRANSFORMERS OUTPUT 0 TO .333V
BURDEN	NONE
POWER FACTOR	.5 LEAD TO .5 LAG
INSTRUMENT POWER	208/240/480V 50/60HZ, 2.5 WATTS

OUTPUTS:

STANDARD RELAY	DRY CONTACT, 120V, .3A 10VA MAX
CLOSURE RATE	250 MILLISECONDS
ISOLATION INPUT/OUTPUT/CASE	750V AC
ACCURACY (BASE)	+/- 0.5% RO
TEMPERATURE EFFECTS (-20 +60 DEG C)	+/-0.02% / DEG C

CALCULATING OUTPUT CLOSURE RATE

THE WL3968 WATT-HOUR TRANSDUCER WAS CALIBRATED AT THE FACTORY WITH 100 AMPERE CURRENT TRANSFORMERS. TO OBTAIN THE WH/C RATE FOR OTHER CURRENT TRANSFORMERS CONSULT THE CHART.

25 AMPS	25 WH/C
50 AMPS	50 WH/C
100 AMPS	100 WH/C
200 AMPS	200 WH/C
400 AMPS	400 WH/C

* CAUTION:
TO PREVENT DAMAGE TO POWER LINES AND THE WATT-HOUR TRANSDUCER NEVER CONNECT THE CURRENT INPUTS DIRECTLY, ALWAYS USE CURRENT TRANSFORMERS.

SIGNAL CONVERTERS

PRECISION INTEGRATOR — MODEL VFC

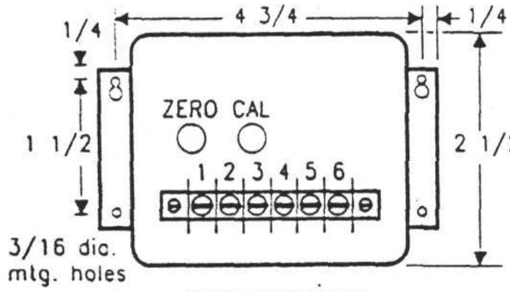
CONVERTS DC INPUT TO TIME-INTEGRATED PULSE

FEATURES
- Provides relay closure count which is proportional to the time integral of the input signal.

APPLICATIONS
- Designed for use with dc, pulsating dc, or dc with AC components.

INPUT RANGE	CLOSURE RATE (COUNTS/HR.)	PART NUMBER
0 to 50mV	0 to 10000	VFC-010
0 to 100mV	0 to 10000	VFC-020
0 to 150mV	0 to 10000	VFC-030
0 to 250mV	0 to 10000	VFC-040
0 to 1mA	0 to 10000	VFC-050
0 to 10V	0 to 10000	VFC-060
4-20mA	0 to 10000	VFC-070
0-5V	0 to 10000	VFC-080

CUSTOM COUNT RATES AVAILABLE-CONSULT FACTORY

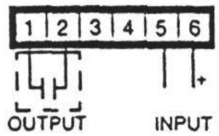


Maximum height 4 3/8

CASE DIMENSIONS (INCHES)

MODEL VFC SPECIFICATIONS

INPUT
VOLTAGE: See table
OVERLOAD: 10Vdc max.
IMPEDANCE (Ohms):
Voltage input models: Greater than 1M
Current input models: Less than 200
FREQUENCY: dc with up to 100% ripple at 120 Hz. or higher.
OUTPUT
RELAY: N/O SPST, 120V, 0.5A contact rating
RELAY CLOSURE PERIOD: 200 milliSeconds
ACCURACY +/- 0.25% F.S.
LINEARITY: +/- 0.1% F.S.
TEMPERATURE EFFECT (-10° to 60°C): +/- 0.5%
INSTRUMENT POWER (STD.): 115VAC+/- 10%, 50-400 Hz.
Optional 220VAC instrument power-Add suffix "-22"



Internal output relay connection at terminals 1, and 2.
AC instrument power-terminals 3, 4.

CONNECTION DIAGRAM

TRANSMITTER OUTPUT CONVERTER — MODEL PI

CONVERTS 4-20mA TO 0-1mA, OR 0-1V OUTPUT

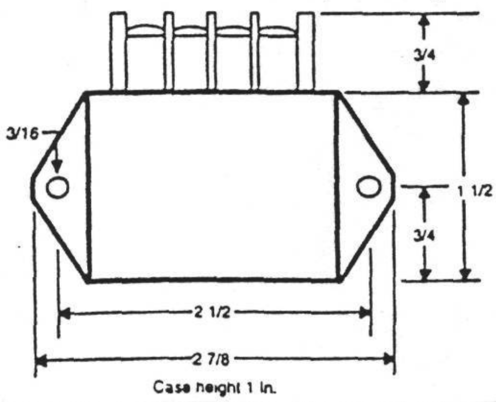
INPUT	OUTPUT	PART NUMBER
4-20mA	0 to 1mA	PI8300B
4-20mA	0 to 1Vdc	PI8300D

NO EXTERNAL POWER REQUIRED

MODEL PI SPECIFICATIONS

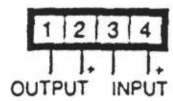
INPUT
CURRENT: See table
LOAD ON INPUT: 400 Ohms
OUTPUT
PI8300B: 0-1mA
PI8300D: 0-1Vdc
OUTPUT LOADING (Ohms):
0-1mA: 0-4K
0-1V: 100K min.
ACCURACY +/- 0.25% F.S.
Includes effects of linearity.
TEMPERATURE EFFECT (-20° to 65°C): +/- 0.005%/°C
GROUNDING: Converter is non-isolated. Ground either input or output, not both. If the 4-20mA loop is grounded, float both input and output.

CASE DIMENSIONS (INCHES)



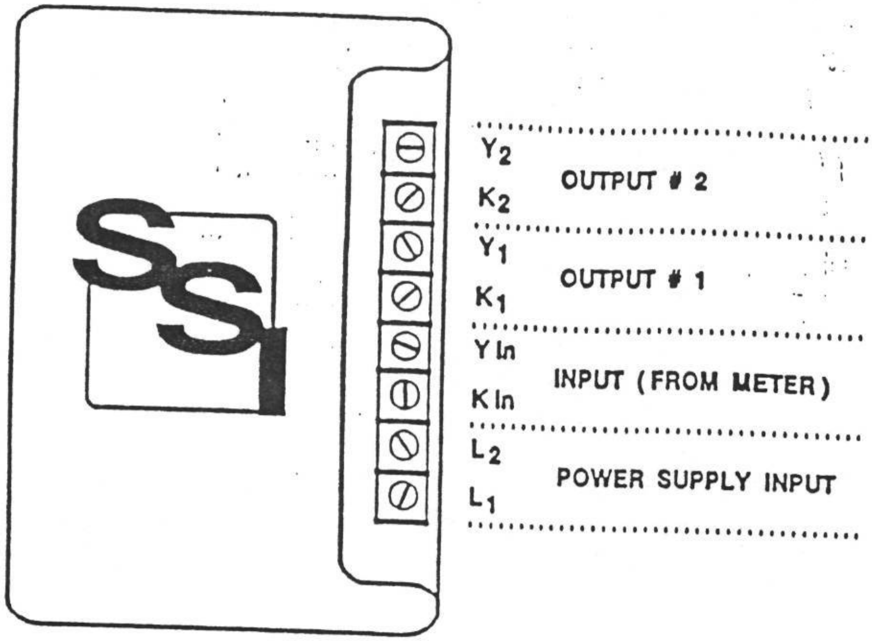
Case height 1 in.

CONNECTION DIAGRAM



OHIO SEMITRONICS, INC.
1205 CHESAPEAKE AVENUE, COLUMBUS, OHIO 43212-2287
Phone: (614) 486-9561 FAX: (614) 486-0743
TO PLACE AN ORDER: 1-800-537-6732

INSTRUCTION SHEET
P I R - 2 PULSE ISOLATION RELAY



POWER INPUT The P I R - 2 should be powered by a AC voltage of between 90 to 300 volts. The hot lead should be connected to L1 and the neutral lead to L2.

METER CONNECTIONS The P I R - 2's "KIn" & "YIn" terminals should be connecter to the meter's "K" & "Y" terminals. Terminals "KIn to K" & "YIn to Y". The P I R - 2 supplies a +13 VDC sense voltage to the meter or other contacts.

MOUNTING POSITION Because the P I R - 2 contains mercury wetted relays it must be mounted in a vertical position to operate correctly.

FUSES The fuses are type 3AG and may be up to 2 AMPS. In size. One half amp fuses are normally supplied with the unit unless otherwise specified.

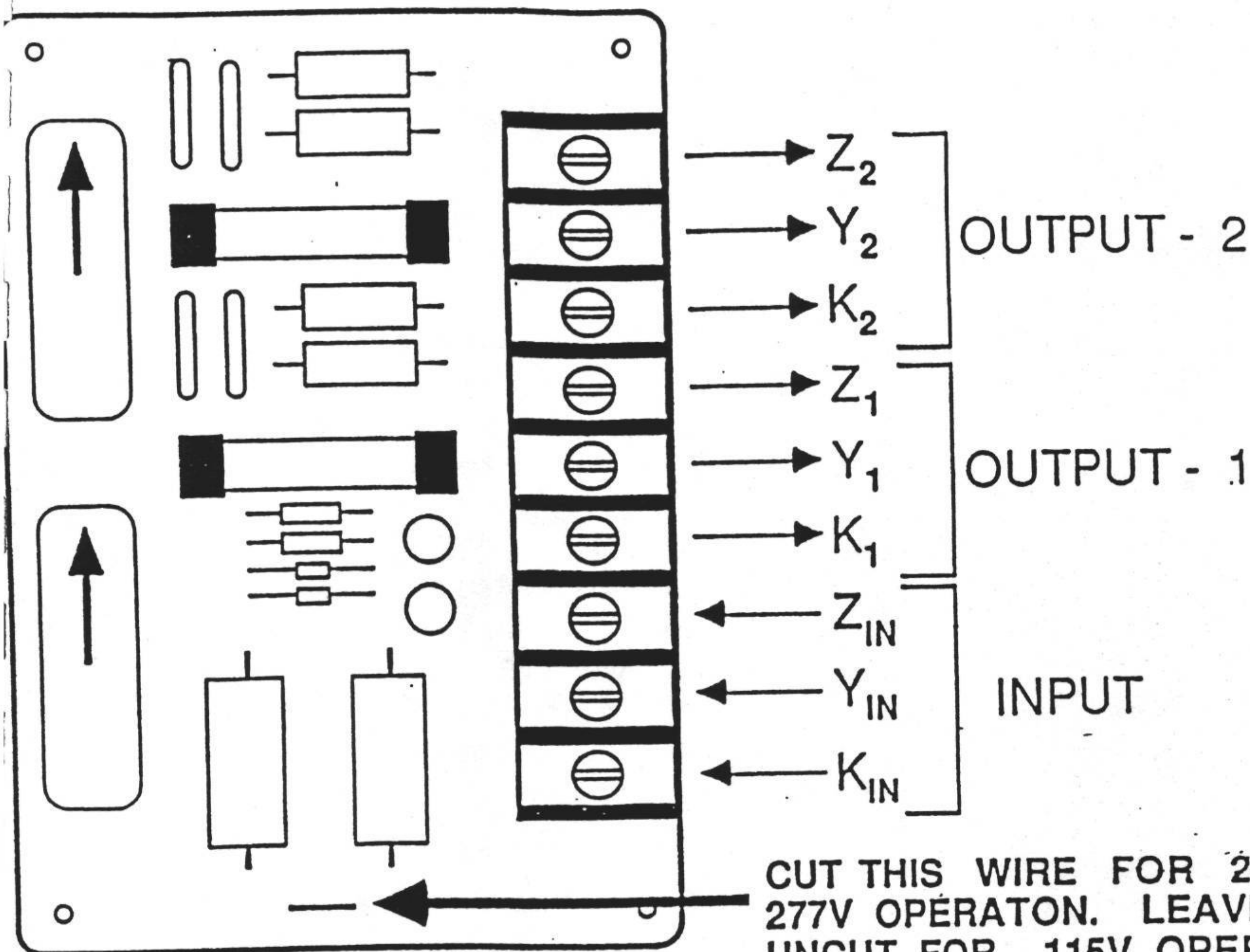
OUTPUTS Under the plastic cover and at the upper right corner of each relay there is a small jumper switch which determines the contacts output "form". Form "A" is normally used (contacts close when a pulse occurs, "B" opens when a pulse occurs). In the center of the board just above the transformer there is a similar switch marked "L" and "S" for long and short pulse outputs. Read the backside of this sheet before setting this switch. Arc suppression for the mercury wetted relays is provided internally.

SOLID STATE INSTRUMENTS, INC.

DENVER, COLORADO 80221 USA PHONE 303-452-2604 FAX 303-452-0504

RPR-2

RELAY INSTALLATION INSTRUCTIONS
PULSE ISOLATION RELAY - 2 ISOLATED OUTPUTS



INPUT

The AC line's L_1 voltage (or the DC's negative voltage) should be connected to the K_{in} terminal on the RPR-2 relay. The AC line's L_2 voltage (or the DC's positive voltage) should be connected to the K_{out} terminal on the pulse source (meter). Connect the RPR-2's Y_{in} terminal to the pulse source's Y_{out} terminal. Connect the RPR-2's Z_{in} terminal to the pulse source's Z_{out} terminal.

OUTPUT

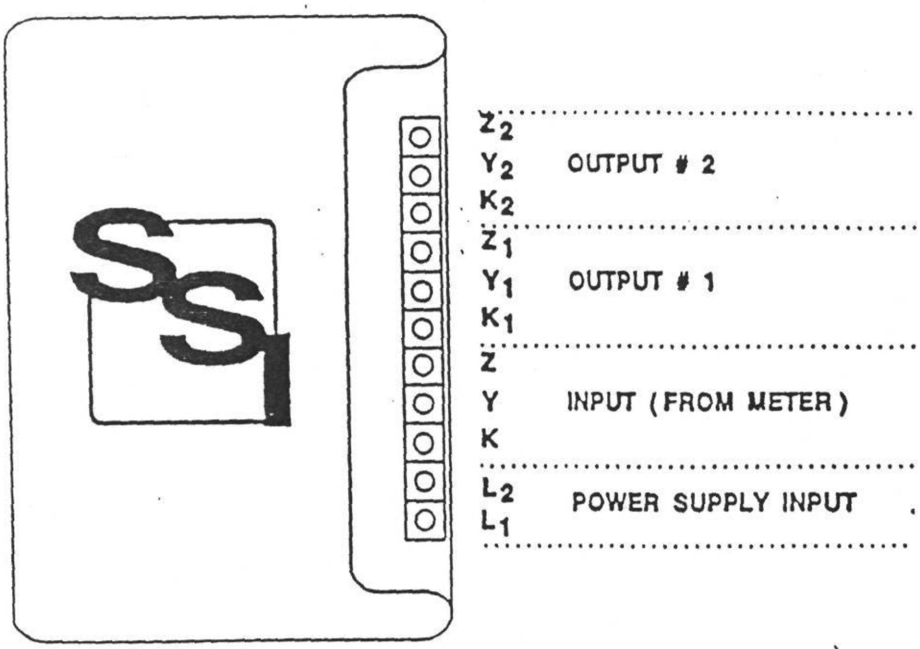
The outputs are by terminals K_1, Y_1, & Z_1, and K_2, Y_2 & Z_2. Output load currents should be limited to 1 Amp. by fuses F_1 and F_2. Output transient protection is provided.

MOUNTING

The RPR-2 relay must be mounted in a vertical position for the mercury wetted relays to operate correctly. Make sure that the arrows on the relays are pointed upward when mounted.

SOLID STATE INSTRUMENTS INC.
DENVER, COLORADO 80221 (303) 452-2604

INSTRUCTION SHEET
RPR-2P PULSE ISOLATION RELAY



POWER INPUT The RPR-2P should be powered by a AC voltage of between 90 to 300 volts. The hot lead should be connected to L1 and the neutral lead to L2.

METER CONNECTIONS The RPR-2P's "K", "Y", & "Z" terminals should be connecter to the meter's "K", "Y", & "Z" terminals. Terminals K to K, Y to Y, and Z to Z.

MOUNTING POSITION Because the RPR-2P contains a mercury wetted relay it must be mounted in a vertical position to operate correctly.

FUSES The fuses are type 3AG and may be up to 2 AMPS. in size. A one half amp fuse is normally supplied with the unit unless otherwise specified.

OUTPUTS Two three-wire isolated outputs are provided in the RPR-2P. Arc suppression for the mercury wetted switch is provided internally.

SOLID STATE INSTRUMENTS, INC.

DENVER, COLORADO 80221 USA PHONE 303-452-2604 FAX 303-452-0504

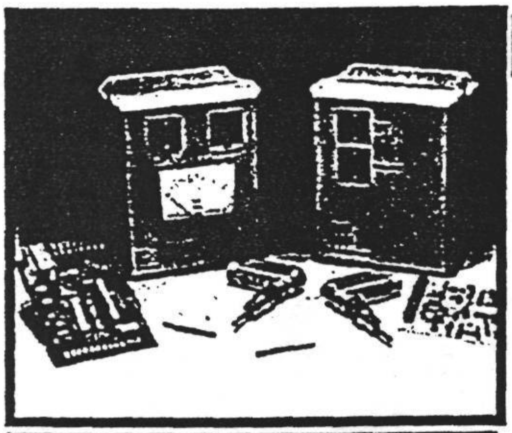
System 90
Btu Monitoring Systems

D.K. Enterprises versatile System 90 Btu Monitoring Systems are inexpensive ways to control today's expensive energy costs. They provide accurate metering of production or consumption of energy in a variety of applications such as:

- **HVAC Hydronic Heating & Cooling Systems**
- **Chilled Water Cooling Systems**
- **Heat Recovery Systems**
- **Individual tenant consumption of heating and/or cooling in Large office bldgs, Apartment bdgs., or condominiums.**
- **Co-Generation Applications**
- **Geothermal**
- **District Heating and Cooling**
- **Solar Energy**

At the center of the System 90 is a microprocessor based electronic circuit which monitors the flow rate signal from a water meter as well as the output from two temperature sensors. The temperature sensors may be located across a load or across a heat source as in a recovery system. The microprocessor based circuitry automatically measures the temperature differential between the two sensors and multiplies this by the flow rate integrated over time. The resulting BTU calculation is displayed on an electromechanical counter. The System 90 series also displays the calculation in the form of an analog current signal representing BTU/HR. The System 90 BTU Meters have many applications which our system engineers can help apply to your specific energy system.

7361 Ethel Ave #1
No. Hollywood, Ca. 91605
(818)-764-0819
(818)-764-8832 Fax



SYSTEM 90 FEATURES

The **System 90 Series BTU Meters** can be modified to work with almost any type of flow element.

The **System 90** has a "watchdog" circuit which prevents the system from "locking up" during input voltage irregularities.

The **System 90** can display BTU's and Gallons or Kilowatt Hours and Liters (x10) or Kilogram Calories and Liters (x10). **This makes it an ideal unit for overseas applications.**

The **System 90** can be programmed for special chilled water and high temperature (above 255 deg F) hot water applications.

SERIES MODELS

Model 90A2
Low cost BTU computation device designed for local display of BTU's and Gallons

Model 90B2
An industrial grade device which provides remote readout capabilities of BTU's and Gallons. Designed for applications which require remote counter display's or NEMA 4 enclosures.

Model 90D
A dual BTU computation circuit, designed to measure primary load BTU's as well as back up load BTU's. **Ideal for a Two Pipe Heating and Cooling systems.**

OPTIONAL FEATURES:

C1, C2 and C3 Adder Cards.

These are Plug-In analog output signal cards. They provide 0-1 madc and 4-20 madc analog signals representing BTU/Hr and/or GPM (C1), BTU/Hr and GPM (C2), or BTU/Hr, GPM and temperature difference (C3).

Input Power.

The standard **System 90** operates on 120 VAC. The unit can be modified to operate on 220 VAC or 24 VAC.

Data Logger or EMS Interface.

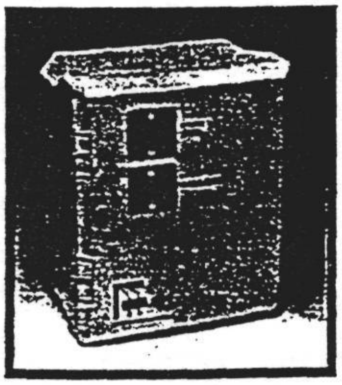
The **System 90** can be provided with S.P.D.T. relay contact closure outputs representing BTU's and Gallons to interface with Data Loggers or Energy Management Systems.

Output Displays.

The standard **System 90** is provided with 2, 6-digit electromechanical counters. **LCD and Analog Panel Meters** can be provided.

High/Low Limit Alarms.

The **System 90** can be provided with High/Low limit alarms for system applications.



Temperature vs. Resistance Chart.

This chart is used as a reference to determine the temperature reading of the sensor when disconnected from the circuit board and installed in the line.

F	C	Resist.	F	C	Resist.	F	C	Resist.	F	C	Resist.
32	0.0	32654	79	26.1	9526	126	52.2	3312	173	83.9	1110
33	0.6	31742	80	26.7	9298	127	52.8	3243	174	78.9	1303
34	1.1	30859	81	27.2	9077	128	53.3	3177	175	79.4	1280
35	1.7	30003	82	27.8	8862	129	53.9	3112	176	80.0	1257
36	2.2	29174	83	28.3	8652	130	54.4	3048	177	80.6	1235
37	2.8	28371	84	28.9	8448	131	55.0	2986	178	81.1	1213
38	3.3	27592	85	29.4	8249	132	55.6	2925	179	81.7	1191
39	3.9	26837	86	30.0	8056	133	56.1	2866	180	82.2	1170
40	4.4	26105	87	30.6	7868	134	56.7	2808	181	82.8	1150
41	5.0	25396	88	31.1	7685	135	57.2	2752	182	83.3	1120
42	5.6	24709	89	31.7	7507	136	57.8	2697	183	83.9	1110
43	6.1	24042	90	32.2	7333	137	58.3	2643	184	84.4	1090
44	6.7	23395	91	32.8	7164	138	58.9	2590	185	85.0	1071
45	7.2	22768	92	33.3	6999	139	59.4	2538	186	85.6	1053
46	7.8	22160	93	33.9	6839	140	60.0	2488	187	86.1	1035
47	8.3	21570	94	34.4	6683	141	60.6	2439	188	86.7	1017
48	8.9	20998	95	35.0	6531	142	61.1	2391	189	87.2	999
49	9.4	20442	96	35.6	6382	143	61.7	2344	190	87.8	982
50	10.0	19903	97	36.1	6238	144	62.2	2298	191	88.3	965
51	10.6	19381	98	36.7	6097	145	62.8	2253	192	88.9	949
52	11.1	18873	99	37.2	5960	146	63.3	2209	193	89.4	933
53	11.7	18381	100	37.8	5827	147	63.9	2166	194	90.0	917
54	12.2	17903	101	38.3	5697	148	64.4	2124	195	90.6	901
55	12.8	17439	102	38.9	5570	149	65.0	2083	196	91.1	886
56	13.3	16988	103	39.4	5446	150	65.6	2043	197	91.7	871
57	13.9	16551	104	40.0	5326	151	66.1	2004	198	92.2	857
58	14.4	16126	105	40.6	5208	152	66.7	1966	199	92.8	842
59	15.0	15714	106	41.1	5093	153	67.2	1928	200	93.3	828
60	15.6	15313	107	41.7	4982	154	67.8	1891	201	93.9	814
61	16.1	14924	108	42.2	4873	155	68.3	1856	202	94.4	801
62	16.7	14546	109	42.8	4767	156	68.9	1820	203	95.0	788
63	17.2	14179	110	43.3	4663	157	69.4	1786	204	95.6	775
64	17.8	13822	111	43.9	4562	158	70.0	1753	205	96.1	762
65	18.3	13475	112	44.4	4464	159	70.6	1720	206	96.7	749
66	18.9	13139	113	45.0	4368	160	71.1	1688	207	97.2	737
67	19.4	12811	114	45.6	4274	161	71.7	1656	208	97.8	725
68	20.0	12493	115	46.1	4183	162	72.2	1625	209	98.3	713
69	20.6	12184	116	46.7	4093	163	72.8	1595	210	98.9	702
70	21.1	11883	117	47.2	4006	164	73.3	1566	211	99.4	690
71	21.7	11591	118	47.8	3921	165	73.9	1537	212	100.0	679
72	22.2	11307	119	48.3	3839	166	74.4	1509			
73	22.8	11031	120	48.9	3758	167	75.0	1481	220	104.4	597
74	23.3	10762	121	49.4	3679	168	75.6	1454			
75	23.9	10501	122	50.0	3602	169	76.1	1427	250	121.1	378
76	24.4	10247	123	50.6	3527	170	76.7	1402			
77	25.0	10000	124	51.1	3453	171	77.2	1376			
78	25.6	9760	125	51.7	3382	172	77.8	1351			

* Accuracy of sensors - +/- 0.2 C from 0 C to 100 C. - Max. Temp. 350 F

* NOTE: ACCURACY OF SENSORS PURCHASED AND INSTALLED FOR THE LUANSTAR PROGRAM IS ± .1°C FROM 0° TO 100°C.

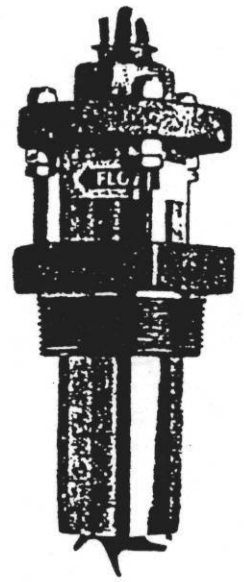
Data Industrial

Series 200 Insertion Flow Sensors

The Data Industrial flow sensor features a six-bladed impeller design with a proprietary, non-magnetic sensing mechanism. The forward-swept impeller shape provides higher, more constant torque than four-bladed impeller designs and is less prone to be fouled by water-borne debris. The forward curved shape coupled with the absence of magnetic drag provides improved operation and repeatability even at lower flow rates. This is more important where the impeller may be exposed to metallic or rust particles found in steel or iron pipes. As liquid flow turns the impeller, a low impedance 8VDC square wave signal is transmitted with a frequency proportional to the flow rate. This signal can travel up to 2,000′ between the sensor and the display unit without the need for amplification. All sensors are supplied with 20′ of Belden type 9320 (two conductor shield) cable.

Model 220B (Brass) and 220SS (Stainless Steel) Sensor

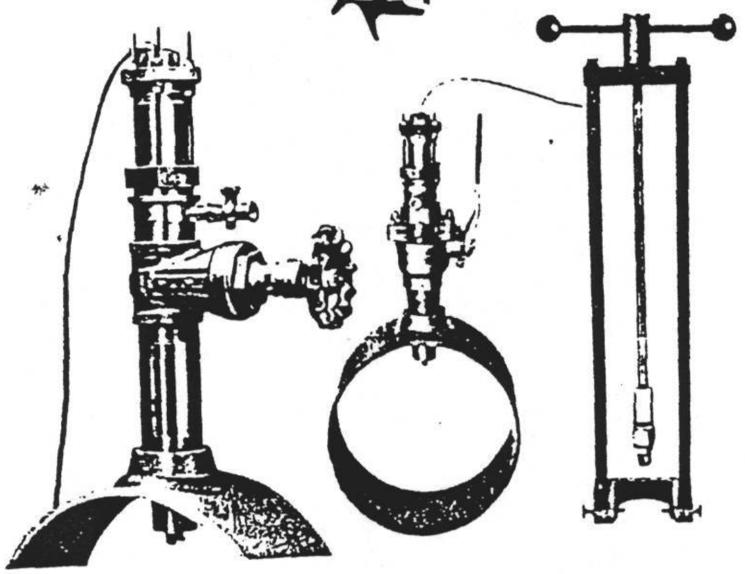
The Model 220B (Brass) and 220SS (Stainless Steel) sensors are used in most general flow measuring applications in metallic, non-metallic, or PVDF pipes. The sensor mounts in a 2" NPT pipe saddle or Threadolet® for installation in pipe sizes from 2½" to over 40". Positioning nuts on the three threaded retaining rods allow the sensor to be accurately positioned to a standard insertion depth of 1½ inches into the pipe. When this insertion depth is maintained, and there is at least 10 upstream and 5 downstream diameters of straight uninterrupted flow, an accuracy of +/-1% of full scale can be obtained between flow velocities of 1 to 30 feet/second. (Specification details are listed on reverse side.)



Hot Tap Sensors Models 225 and 226

The Hot Tap Sensor Series features an elongated sensor, special mounting adapter, pipe nipple, and isolation valve, to allow the non-magnetic impeller sensor to be installed into a pressurized pipe while the pipe is in service. This is accomplished by first attaching a saddle or Thredolet® to the pipe and screwing the nipple and isolation valve into the saddle or Thredolet fitting. A hole is then drilled through the pipe using a commercial tapping machine. When completed the tapping apparatus is removed, the isolation valve is closed, and the sensor is installed.

The Hot Tap Sensor is also recommended for any application where it would be difficult to shut down or drain the pipeline to remove the sensor for service. The overall length of the sensor tube is 18 inches (457mm). However, a clearance height of 50 inches (127cm) should be allowed for the fully extended length of the insertion tool.

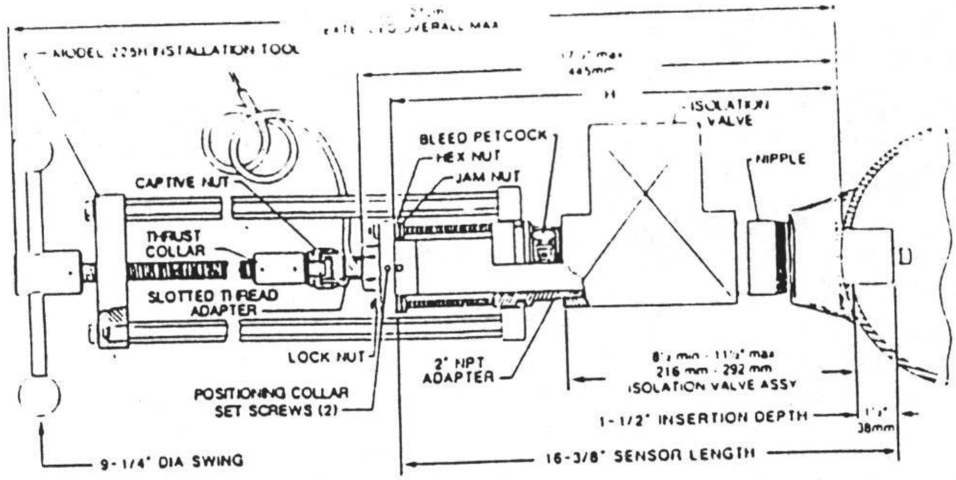


Model 225B
Brass unit with a gate-type isolation valve

Model 226B and 226SS
Brass or stainless steel sensor and ball type isolation valve.

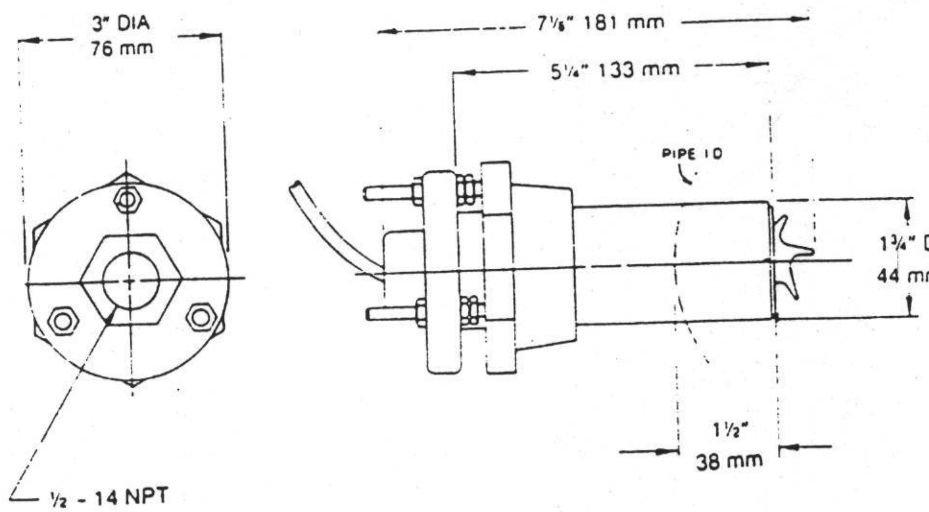
Model 225H
Insertion tool is provided seperately to insert or remove the sensor when under pressure

DIMENSIONS 225 226
with Insertion Tool in place



NOTE: ALL DIMENSIONS ARE FOR REFERENCE ONLY
CUTTING TOOL MAY REQUIRE ADDITIONAL CLEARANCE

DIMENSIONS 220B, 220SS



Specifications: 220B, 220SS, 225B, 226B, 226SS.

Accuracy: +/-1% of full scale.
Linearity: +/-1%
Repeatability +/-0.3%
Rangeability: 30:1
Flow Rate: 1-30 feet/sec.
Max Pressure: 400psi
(200psi for model 225B).
Max Temperature: 221°F (105°C).

Wetted Materials
Impeller: Glass reinforced nylon.
Bearing: Pennlon® (UHMWPE).
Ultrahigh molecular weight polyethylene.
Shaft: Tungsten Carbide.
Housing: Glass reinforced polyphenylene sulfide (PPS).
O-rings: Ethylene propylene (EPDM).

220B, 225B and 226B Sleeve
Admiralty brass UNS C44300.

Hex adapter valve bronze UNS C92200.

220SS and 226SS Sleeve
300 Series Stainless Steel and Hex adapter.

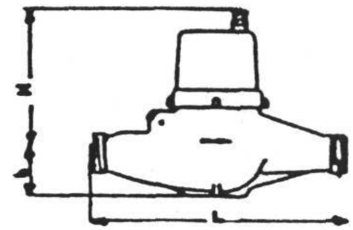
Consult Factory for other Impeller, Shaft, O-ring, Bearing Options.

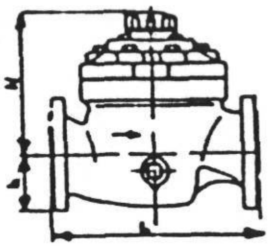
Data Industrial

Data Industrial Corporation, 11 Industrial Drive, Mattapoisett MA 02739, Telephone (508) 758-6390 FAX (508) 758-4057

Condensate Meter
SPECIFICATIONS AND DIMENSIONS

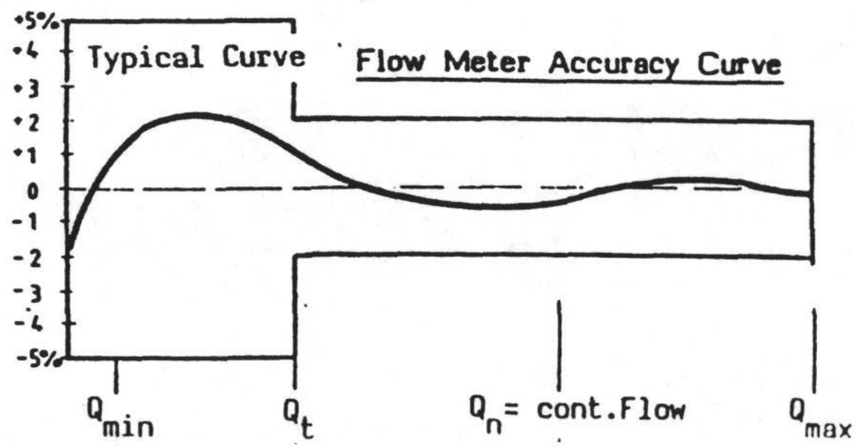
MODEL	PROD #	FLOW RANGE (GPM) MIN.	CONT.	MAX.	PIPE SIZE	INTER-CONNECTION	DIMENSIONS (INCHES) H	h	L	WIDTH	PSI PRESSURE DROP	FLOW DIRECTION	WEIGHT (LBS)	FLOWMETER REED CONTACT CLOSURE
FLOWMETER SPECIFICATIONS														
3/G	17925	.13	6.6	13.2	1/2"	C	5.25"	1.5"	6.5"	3.75"	2.9	H	4.2	1 G
7/G	17928	.29	15.4	30.7	1"	C	5.5"	1.75"	10.25"	4.00"	2.9	H	6.4	1 G
10/G	17946	.40	26.4	52.8	1"	C	5.5"	1.75"	10.25"	4.00"	2.9	H	6.4	1 G
20/G	17931	.70	43.9	87.2	1 1/2"	C	6.1"	2.0"	11.8"	5.25"	3.6	H	11.25	1 G
30/G	17934	.88	65.8	131.6	2"	F	5.75"	3.2"	10.63"	Fl	2.9	H	27.5	10 G
50/G	17935	2.63	65.8	307.0	2"	F	7.9"	3.0"	7.9"	Fl	.15	A	31.5	10 G
80/G	17936	3.51	175.4	658.0	3"	F	7.9"	3.6"	8.9"	Fl	.3	A	40.1	10 G
100/G	17937	5.26	263.2	790.0	4"	F	7.9"	4.3"	9.85"	Fl	.4	A	43.7	10 G
150/G	17938	26.32	657.9	1535	6"	F	8.5"	5.6"	11.8"	Fl	.3	A	71.6	100 G
200/G	17939	43.86	1096.5	2631	8"	F	8.5"	6.8"	13.75"	Fl	.2	A	99.2	100 G
250/G	17947	53.0	1761.0	4400	10"	F	11.0"	8.0"	19.75"	Fl	.2	A	260.0	100 G
300/G	17948	66.0	2642.0	5284	12"	F	10.25"	9.5"	19.75"	Fl	.2	A	300	100 G


Flowmeter up to 1½"


Flowmeter 2" up

Maximum Pressure = 250 psi   Maximum Temperature = 250°F

C = Water meter coupling NPT with locking nuts and gaskets
F = Flanged connections with gaskets ANSI Standard B16.1 (125 lb.)
H = Horizontal flow only
A = Any flow direction (Horizontal - up or down)
Flow range - see accuracy chart
Dimensions - see diagram
Pressure drop = Pressure change at continuous flow rate



ista
ENERGY SYSTEMS CORPORATION
407 Hope Avenue — P.O. Box 618
Roselle, New Jersey 07203

Hot Water Meters

ista

Construction materials:

ISTA INDUSTRIAL WATER METERS

1/2" TO 1 1/2" MODELS 3 TO 20

HOUSING:	BRASS

OTHER MATERIALS SAME AS LARGER SIZE METERS

2" UP MODEL 30-UP

HOUSING:	CAST IRON
STRAINER:	STAINLESS STEEL
TURBINE:	FIBERGLASS
TURBINE AXLE:	CHROME / NICKEL / STEEL
BEARING MATERIAL:	STAINLESS STEEL / SAPPHIRE
TIGHTENING SCREWS:	STAINLESS STEEL
MAGNETIC TRANSFER:	KOBALT / SAMARIUM
GEARS, AXLES, SCREWS AND ADJUSTMENT PARTS:	STAINLESS STEEL

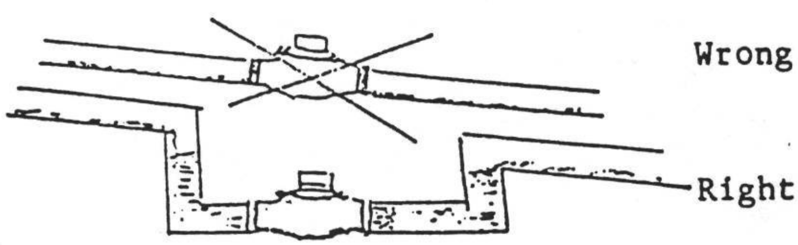
COUNTER ASSEMBLY

GEARS & AXLES:	CHROME / NICKEL / STEEL
DISPLAY & HOUSING:	PLASTIC MATERIAL

CONDENSATE METERING

TEMPERATURE RATING 250 DEGREES F

UP TO 1 1/2" ALL FLOW METERS HAVE WATER METER COUPLINGS. 2" AND UP ARE REGULAR FLANGED INTERCONNECTIONS (125 LBS.)



IT IS IMPORTANT THAT THE FLOW METER IS ALWAYS FULLY SUBMERGED INTO LIQUID, OTHERWISE SMALL AMOUNT OF CONDENSATE WATER COULD PASS THROUGH THE PIPE WITHOUT ROTATING THE TURBINE.

ista ENERGY SYSTEMS CORPORATION
407 Hope Avenue — P.O. Box 618
Roselle, New Jersey 07203

APPENDIX D

Murphy's Law

INSTRUMENTING BUILDINGS TO DETERMINE RETROFIT SAVINGS: MURPHY'S LAW REVISITED

Dennis L. O'Neal, John Bryant, Curtis Boecker, and Chuck Bohmer
Department of Mechanical Engineering, Texas A&M University, College Station, TX

ABSTRACT

Experiences with instrumentation, installation and maintenance of building energy metering systems are presented. The building energy metering is installed to support the Texas LoanSTAR program in sites throughout the State of Texas. Metering typically includes monitoring the whole building electric load, building thermal loads and selected submetered loads. The emphasis of the lessons learned is on the instrumentation used and installation problems encountered during this project.

INTRODUCTION

During the past three and one-half years, the Energy Systems Laboratory has been under contract to the Texas Governor's Energy Office to install building energy monitoring systems in over sixty buildings throughout the state of Texas. The monitoring equipment provides data to support building energy analysis and energy savings due to energy conservation measures to be implemented in the candidate building(s). The installed equipment has typically included thermal metering (chilled and hot water Btu), electrical load metering (kW), psychrometric data (cooling and heating coil temperatures and relative humidity), and weather monitoring (solar radiation, wind speed, ambient air relative humidity, and ambient air dry bulb temperature). During this time, valuable "on-the-job" experience has been gained relating to building energy metering instrumentation and installation.

This paper summarizes the experiences related to building energy metering instrumentation and installation thus far during the LoanSTAR program. There have been many other building energy monitoring projects, notably the ELCAP study in the Pacific Northwest and utility studies in the Northeast, involving millions of dollars for metering instrumentation and installation. Prior to this project, there seemed to be little published information available to the engineer to aid in the planning or direction of a building metering project. There also was very little published information on the type of instrumentation recommended or problems that had been identified concerning different types of metering equipment. Therefore, it is important that valuable lessons learned on one project be noted and shared with others who endeavor to undertake such a project. The knowledge shared could potentially allow major savings in manpower and costs in future projects..

If energy monitoring is being conducted to evaluate the potential savings due to a planned energy conservation retrofit measure (ECRM), then prompt installation of energy metering equipment can provide the analyst with a wealth of pre-retrofit data. Many of the lessons described can provide the reader with information that should help speed the installation of a metering project. Some of the identified problems may seem so obvious that "anyone who is careful" should be able to avoid them. However, even experienced installers of building energy metering systems seem to struggle with some of these "obvious" problems and if a solution is developed, often there is no written record left for future reference.

This paper is not meant to be only a discussion of instrumentation failures or problems. There are a number of "real world" problems that involve the installation of the instrumentation and maintenance. Other problems focus on proper communication between the installer and instrumentation manufacturer or between the installer and those who have to analyze the data. The presentation of the material is divided into three categories: (1) Equipment, (2) Installation, and (3) Maintenance.

EQUIPMENT

To have a meaningful analysis of energy use data on buildings, it is critical that the instrumentation be reliable and provide accurate information on what is being measured. Unfortunately, instrumentation can provide a stream of numbers that may not reflect what is actually being measured. Equipment problems encountered in the first two years of this project have included instrumentation used in thermal metering, electrical measurement, and psychrometric measurements.

Thermal Metering

Thermal metering is important for large commercial building applications where the building is purchasing chilled water, hot water, or steam. In addition, thermal metering may be applied where the user wants to track the efficiency of a chiller. Thermal metering typically involves monitoring entering and leaving temperatures of the water and the water flow rate. For the majority of the sites on this project, it has been necessary to install the required transducers (typically thermistors and insertion flow meters) into piping while the systems are operating. This requirement has made the thermal metering effort difficult and introduces room for more installation errors. These data points typically feed into a thermal energy ("BTU") meter which processes the temperatures and flow rates to calculate the energy use. Some problems with thermal metering have included:

1. A thermal energy meter will pick up 60 Hz noise from its electrically noisy surroundings. In many building energy applications, a thermal energy meter and the instrumentation associated with it are located in an equipment room which is an electrically "noisy" environment because of large pump and fan motors and chillers. If a turbine flow meter is connected to the thermal energy meter, the thermal energy meter will be expecting a signal from the flow meter which has a frequency component. There have been instances where, with improper shielding, the only signal the thermal energy meter gets from the flow meter is a 60 Hz noise signal. The analyst may not even realize that there is a problem because the total thermal energy may show a change from hour-to-hour because of fluctuations in the entering and leaving temperatures of the water. However, the actual thermal energy may be quite different than what is being measured. this problem has been investigated at the Texas A&M Energy Systems Laboratory (ESL) calibration facility (O'Neal, et al., 1990). It was found that the internal amplifiers in the thermal energy meter would continually increase their gain as the signal from the magnetic impeller type flow meter decreased. At a level of approximately 15 mv ac (<2 fps) the gain would be sufficient to capture "stray" 60 Hz noise. An add-on computer was installed which helped to acquire the signal from the flow meter, but the flow meter itself had operational problems at velocities less than two feet per second. The solution has been to replace any flow meters that fall into this category with a non-magnetic impeller type insertion flow meter.

2. Two different brands of thermal energy meters will produce outputs different from each other. On one site, one brand of thermal energy meter that was installed according to the manufacturer's recommendations was replaced by a second brand of thermal energy meter installed according to its manufacturer's recommendation. The net result was that the "measured" thermal energy increased by a factor of two. This problem was studied at the ESL and the primary cause for the measured differences due to the low flow problems associated with the magnetic impeller flow meter with the low flow problem corrected. Both energy meters measured energy rates within five per cent of the ESL reference.

3. A thermal energy meter that is not field scaleable will be set wrong at the factory. The initial brands of thermal energy meters utilized had to be set for a specific application at the factory. Information was provided to the factory on the type of flow meter, anticipated temperature difference, pipe size, maximum estimated energy, etc. The factory would then "burn in" a ROM for that particular application or install other hardware for that specific application. Often the estimate provided by the facilities personnel at a given site for the energy rate of the chilled or hot water line was off by an order of magnitude. Likewise, these personnel had only estimates of the pipe sizes and these were often wrong. There also were several meters delivered from the factory that had been incorrectly programmed. The net result was that the meters provided were not appropriate for the particular application. It was not unusual for the manufacturer of the thermal energy meter to estimate that it would take four to six weeks to reprogram the meter.

Electrical Metering

For many building energy metering applications, electrical measurements are the only measurements made. For this project, the decision is often based on funds available for the metering installation and on the retrofits being installed in the building. Typically, these measurements include whole building feeds, motor control center feeds, individual motor loads, chiller feeds, and lighting loads. Experiences with electrical measurements have included:

1. The marked polarity of current transformers (CTs) will be opposite of its actual polarity. The polarity of CTs should be checked before installation. On a single phase application a CT with a reverse polarity may be a nuisance (you'll get a negative power). However, on a three phase application, one CT with reverse polarity will cause major errors in the measured total power of the equipment. For instance, in a recent application, a CT with reversed polarity was

found on a 30 kW three phase variable speed motor. The CTs had been installed according to the manufacturer's instructions (i.e., with the arrow pointing toward the line source). The indicated power of the motor was 1.5 kW, which did not make sense because of the size of the motor and the fact that it was running at 82% of it's maximum speed. A close check of one of the CTs used to monitor the equipment revealed that the polarity was marked incorrectly. Switching the leads to the CT corrected the problem. This happened to approximately 2% of the CTs.

2. The size of the shunt resistor will be different than what the manufacturer specified. Another problem with the CTs was that the manufacturer put the wrong shunt resistor in the CT, which effectively changed the primary rating of the CT. This happened about 12 times. The CTs were sent back for correction.

3. The output of a current transformer will be far different from it's rating. Much of the data acquisition equipment used in the monitoring studies utilizes a current transformer that produces a 333 mVac output at rated full load. Voltages of 3 and 10 Volts from some CTs that were clearly marked 333 mv output have been observed. Inputting 10 Vac instead of 333 mVac to the data logging equipment has produced some unusual readings from the power channels in the data logger. One symptom was that the power signals for a fan load slowly decayed over time. The net result was that the bad CT not only affected the channel to which it was connected, but all power readings from that particular logger. These problems have led to the development of procedures to pre-check the polarity and output of CTs before being installed.

4. If there is only one manufacturer of some of your electrical instrumentation, that manufacturer will go out of business midway through your project. the primary supplier for the CTs used in the LoanSTAR project recently went out of business. This caused the interruption of two major metering installations and several months' delay in completing the sites. A search was initiated to identify a replacement CT manufacturer who would be able to meet the CT specifications for the LoanSTAR project. Two manufacturers were selected, but neither could meet the delivery date of less than eight weeks, and for some CT sizes, 10 to 14 weeks. Our previous manufacturer was delivering CTs in four or fewer weeks. In addition, the new manufacturer's CTs did not have the U.L. listing and this caused added delays. Such delays have a significant impact on the amount of pre-retrofit energy data available to the analysts. Therefore, it is important to determine the CT requirements for a given project as early as possible to allow for significant delivery time delays.

5. Metering with an existing Energy Management and Control System appears attractive, but bottom line costs and performance will typically be prohibitive. Much of the instrumentation required to monitor energy use in building systems may already be present as part of the EMCS. Sometimes the signals from this equipment can be shared by both the EMCS system and a separate dedicated logger for recording energy use. Another option that may be used, is to use the EMCS data trending features to record the data. The approach generally taken by the LoanSTAR program is to share signals when possible and route them into our own data logger. The advantage to this approach is reduced installation costs, and isolation from the EMCS. EMCS shutdowns due to maintenance, reprogramming, and unknowledgeable operators usually do not affect the signal to our data logger. The main disadvantages to sharing signals are 1) poor documentation of the existing EMCS,
2) difficulty of tracing wires (usually in conduit) and
3) determining responsibility for repairs and calibration.

Most EMCS signals consist of 4 to 20 ma current loops. These signals can be split in either of two ways: a voltage can be taken across the EMCS dropping resistor, resulting in a signal of 1-5 volts; or the current loop can be interrupted with a series connection providing a 4-20 ma signal for the data logger. A signal isolation device is required in either case to prevent equipment failures from either piece of equipment from affecting system operations. The voltage sharing method is inherently safer because a failure while splitting a current loop results in an open circuit, thus causing a complete loss of signal.

The responsibility for repairs and calibration is another issue of great importance. Equipment failures typically take much longer to repair when the sensor is owned by the facility. At one site we lost the signal for three months. Several phone calls had to be made to the facilities personnel to resolve the problem.

Other Instrumentation

Other types of metering are also used to quantify energy use in buildings in the LoanSTAR project. These include air-side instrumentation and local weather measurements.

1. <u>The manufacturers of the relative humidity (RH) instrumentation will not inform you of the temperature dependence of his instrumentation.</u> While relative humidity instrumentation is not supposed to have any dependency with temperature, experience has shown that specific brands of RH equipment do show a dependency on temperature. If the RH sensor outputs a 0 to 5 Vdc signal, one would expect that it would generate a signal of 2.5 Vdc for 50% RH whether the temperature is 10° C or 30° C. Some RH sensors have indicated that moisture was being added to the air across a heating coil (when, in fact, only sensible heat was being added). While a small error is acceptable, errors that far exceed the stated measurement uncertainty of the transducer (typically ± 3%) are common. Close inspection of the data has shown that as the air temperature increases, deviation from the actual RH increases.

2. <u>Relative humidity instrumentation will fail to perform adequately after only a few months operation</u>. Many of the RH sensors use a bulk polymer element. If the humidity instrumentation becomes saturated (100% RH) for any length of time, this type of element does not seem to perform reliably afterwards. Particular applications where this will occur include placement of a RH sensor on the downstream side of a chilled water coil and in weather stations at locations where there are considerable times (usually at night) when the ambient air is saturated. Relative humidity continues to be a problem. One solution has been to purchase enough RH sensors that each sensor in the field can be exchanged approximately once every six months (or more often if needed) with a sensor that has been re-calibrated.

3. <u>The data logger manufacturer will not inform you about an undocumented calibration procedure for their data logger until asked</u>. In one application, it was noted that all of the analog temperature (1000 ohm RTD) channels were not producing readings that were believable. For instance, the entering chilled water temperature was -7° C. All instrumentation was checked closely for any possibility of a stray voltage being fed into one of the channels. Finally, out of frustration, a call was made to the data logger manufacturer. The applications engineer diagnosed the problem as an analog board that had not been properly calibrated. He provided a step-by-step calibration procedure that was not documented anywhere in the technical specifications or user manual for the data logger. However, not having the board calibrated earlier probably cost about four weeks worth of usable data from that data logger. It has now become one of the regular checks made at each logger equipped with the analog option.

EQUIPMENT INSTALLATION

While the above section dealt more on characteristics of the instrumentation out of the box, many problems associated with instrumentation focus on their application (or misapplication). Some problems discovered during the installation of instrumentation are listed below. The same order is followed as before. Thermal metering is discussed first, followed by electrical instrumentation and psychrometric instrumentation.

Thermal Metering

Problems with the installation of thermal metering includes the temperature and flow inputs to the thermal energy meter as well as the thermal energy meter itself.

1. <u>The flow velocity will be outside the useful range of the flow meter</u>. With some buildings, there is already flow instrumentation in place such as a venturi, orifice plate, or turbine meter. It can be very cost-effective to utilize this instrumentation. However, for buildings designed before the early 1970s when dual-duct and reheat systems were predominantly installed in buildings, the flow instrumentation was probably designed for much higher flow rates (and correspondingly higher chilled or hot water usage) than is actually occurring in the building. Venturi flowmeters operating with flows that were one-third of their minimum rating have been seen. In addition, if there is no flowmeter in the piping, then a flow meter must be installed. Typically, these flow meters are insertion turbine or paddle wheel flow meters. The linear range for several typical insertion flow meters ranges from 0.6 to 9 m/s. Chilled water design flow velocities typically range from 1.2 to 2.4 m/s. Thus, one would expect the flow velocities to be within this range. However, due to poor design or perhaps allowing for future building additions, there have been a number of installations with oversized pipe where the velocities ranged from 0.15 to 0.6 m/s. At these lower velocities, many insertion flowmeters no longer produce a signal or produce a signal that is consistent with the calibration curve above 0.6 m/s. One solution has been to develop calibration curves for flowmeters in these applications that are only valid at the lower flow range of the meter. At this time, there appear to be no reasonably priced insertion flowmeters which can read down to 0.15 m/s.

2. Asbestos insulation will be on the piping where the thermal metering instrumentation will be installed. Unfortunately, asbestos is one of the hazards encountered in thermal metering in buildings. If the building was constructed before 1970, one can almost always count on asbestos being used in the piping insulation on some of the piping. Asbestos abatement can drive the cost of thermal metering so high that it can endanger the installation. "Is there asbestos on the chilled or hot water piping?" should be one of the first questions an engineer asks of the facilities or building manager before going to the trouble of developing an instrumentation plan. The next logical question to ask is: "Who is going to pay for the abatement of the asbestos?"

3. Signal wire length affects RTD sensor readings and will not be compensated. In many installations, the entering and leaving hot or chilled water temperatures are measured. The data logger used for this project can accept a two wire 1000 ohm RTD for direct measurement of temperature. If the lead length for one RTD is 5 m and the other is 25 m, then it is possible to have several degrees of temperature difference indicated due to these differences in lead length. Ideally, a three wire RTD should be used which will allow compensation for the differences in lead length.

4. The diameter of the pipe in which the flowmeter is installed will be different from that indicated by the facility manager or shown on the building schematics. With many insertion flowmeters, the pipe size is a critical piece of information for both installing the flowmeter at the right depth in the pipe and setting the thermal meter correctly. If the pipe diameter is incorrect, then the pipe thickness is also incorrect, which means the depth of the flowmeter is also incorrect. While building operators or building schematics (which may not reflect the as-built condition) are useful, the only diameter for the pipe that should be trusted is the one which is directly measured (preferably twice). At one site, the information provided on five different pipes (out of five) was incorrect.

5. If a temperature probe can be reached by a person from the floor, the probe will be used as a chin-up bar, step ladder, or some other climbing aid. On the first major installation on this project, a number of RTD probes were mounted in a near horizontal position and within easy reach of maintenance personnel. Within six months, most of these RTDs were at 45 degree angles to the pipe where individuals had used them in ways for which they were not designed.

6. If a thermal energy meter is no longer functioning, it will be because the temperature sensor(s) no longer exists. On some early installations, the compression fitting used for the insertion of RTDs into a pipe allowed the RTD probes to vibrate within the pipe. The vibrations eventually produced a failure of the probe where it protruded from the compression fitting into the flow stream. The probes broke off and disappeared into the pipe. While thermowells would be one solution to a temperature probe, the cost for "hot tapping" a thermowell is much higher than that for a probe. On other installations, the retrofit contractor removed sections of pipe containing the flow meter and temperature sensors that were a part of the thermal metering. While it may not be possible to completely eliminate this problem, careful coordination and placement of the metering equipment can minimize its occurrence.

7. The boiler feedwater temperature will exceed the temperature rating of the flow meter. The meter typically used to measure condensate return and boiler feedwater has an upper temperature limit of 250°F. This meter has worked satisfactorily at several sites at other locations. However, one particular site passed steam through the meter and melted the internal parts. A significantly more expensive meter with stainless steel parts has been used to replace this meter.

Electrical Metering

There have been several problems with the installation of electrical metering equipment. In many cases, the problems could have been avoided if the installing electrician had been properly supervised.

1. If multiple transformer feeds are available in the building, then the potential transducer will be connected to the wrong reference voltage. The data logger used for this project has the ability to accept two different potential transducer (PT) references which are used for CT reference and the proper internal calculation of active power. A common field error is referencing CTs to the wrong PT or referencing all CTs in a building to a single PT when there are several transformers (requiring several PTs) in the building. The most extreme case involved a large 12 story office building which had 4 different transformers in the building. Only one PT was installed and used as a reference for all the CTs in the building. Several costly fixes have been necessary to correct the problem and several months worth of pre-retrofit data have been lost.

2. If current transformers are installed on an existing CT secondary, they will not be scaled properly. On large electrical loads (i.e. main building feed, centrifugal chiller feed) there often are existing current transformers available. These existing CTs are used by building operations personnel to monitor the electrical loads at these devices. For example, a large centrifugal chiller might have CTs with 1000 to 5 ratios on each of the 3 phases to the chiller motor. The ratio indicates that the CT will output 5 amps if the motor is loaded at 1000 amps. The monitoring technique consists of installing a second 5 amp CT on the existing CT secondary wire. The CT ratio of the primary and the secondary CT is then necessary to calculate what the final CT ratio actually is. This is the ratio used to properly scale (through the data logger software) the signal received at the data logger. In some installations, the primary CT ratio was not determined and the ratio was guessed. Only after the existing CT ratio is properly determined and field verified, can the signal be trusted.

3. The standard convention of phasing of power in electrical cabinets will not be followed. Electricians often use a standard set of rules for installing the A, B, and C phases of three phase equipment. These three phases should go (as you face the electrical connection) left-to-right (A, B, C), up-to-down (A, B, C), or front-to-back (A, B, C), depending on the style of the cabinet. One subcontractor installed all the three phase current transformers with the above assumptions without checking to see that the electricians who installed the original equipment in the cabinets were consistent. Another subcontractor was brought in to this site and was able to sort out the phasing problems and resolve the current transformer referencing confusion.

Other Instrumentation

1. Data acquisition boards on the data logger can substitute as expensive fuses. With the particular data logger used, it has been seen that when a 4 to 20 milliamp transducer is installed into a channel that was expecting a 0 to 5 Volt dc input, the analog board on the logger becomes an expensive fuse that protects that rest of the data logger from damage. The only problem is that the analog board must be replaced after each mistake.

2. The data logger will probably be programmed incorrectly when data collection starts. The data loggers used can have from 4 to 47 data channels connected. While care is taken to program the data loggers correctly when the site is first brought on line, the loggers on every site have had to be carefully checked channel by channel to ensure that what is given in the documentation is in fact what was programmed into the logger.

3. You can never schedule enough lead time for coordinating the installation of pulse initiators with the local utility company. Coordination efforts with local electrical (or gas) utilities can vary. In most cases, the local utility is knowledgeable and responsive to requests for installation of pulse initiating equipment or splitting signals from existing equipment. It is best to allow or accept 3 months lead time, know what equipment is necessary, know exactly where and when you need it, and to verify that the scales given by the utility are correct. Also, in some cases, electrical metering pulse initiators have an electronic relay which by itself may not be compatible with data acquisition systems. In those cases, an additional isolation relay is necessary to eliminate the resistance when the relay closes.

EQUIPMENT MAINTENANCE

Once the instrumentation is in place, it must be maintained. The maintenance may be more difficult to handle than the original installation. If an instrument fails, it requires a trip to the site to diagnose the problem and at least one more subsequent trip to the site to fix the problem. The cost of maintenance will probably exceed the initial expectations of personnel on the project. The types of failures seen in the field will depend on the type of instrumentation used. The rule of thumb is to expect all instrumentation to fail at some point in the program. In two years, the types of maintenance problems and failures seen thus far include:

1. Modem failure - While the number of modem failures in the past two years has been fewer than ten, the failure of one modem can potentially disrupt the data collection for two to three buildings when the buildings are tied to the same data logger. One particularly annoying failure of the modem occurs after a short power outage. The modem will not properly reset, and when calls are placed to the data logger, the modem does answer. Thus, the logger cannot be reached remotely via the phone. The datalogger has to be physically turned off and then back on to properly reset the modem. Because there are buildings hundreds of kilometers from each other on this project, doing this more than once can be very time consuming and costly.

2. Dewpoint sensor getting dirty - After the temperature dependence and saturation problems were identified with some RH instrumentation, chilled mirror dewpoint sensors rated for outdoor use were specified for several weather stations at high humidity locations. While more accurate these sensors require at least bi-monthly maintenance to clean the mirror surface and they need to be completely re-calibrated every six months.

3. Equipment disconnected or damaged - As some sites start to have their energy conservation retrofits installed under the LoanSTAR program (Nutter, et al., 1990), some of the energy metering equipment that has been installed at that site has been damaged by the retrofit contractor. This damage is not evident until the data logger has been polled. The cause of the problems cannot be diagnosed without a visit to the site. At one site, it was found that an electrical subcontractor had disconnected the wiring for both reference volts and CT inputs to the datalogger. At another site, an asbestos abatement contractor tore the wire from a steam pressure transducer and caused a short to the datalogger. The problem caused the loss of several weeks building energy data. Measures are being attempted to ensure that the building operations people as well as the designers for the energy retrofits are made aware that there is metering instrumentation installed in their buildings.

4. Aspirating fan failure on weather station - The weather stations are equipped with aspirating fans which ensure that an adequate fresh air sample crosses the relative humidity (or dewpoint) sensor and the dry bulb temperature sensor. When measured air temperatures approached 50° C at one site, it became obvious that there was a problem. During a visit to the site, it was found that the aspirating fan had become "stuck" and after being given a helping twirl, it started again. Subsequent data showed marked improvement and the fan has continued to operate normally.

5. Current transformer failure - There have been several instances of the shunt resistor failing in the CT. This allows the CT to output a voltage far higher than the 333 mVac at rated load. In one case the CT was outputting 10 Vac which caused the logger to record false power readings for the affected channel as well as other channels. One other site had a similar problem and provided over 50 volts to the logger.

6. Weather station data does not match National Weather Service (NWS) data - The weather station is cross-plotted with data obtained from the NWS to help identify any problems. Some problems have been noticed and they usually have to do with local climate effects. However, the cross-plots have helped us to identify problems with two outside air temperature sensors and one relative humidity sensor. At one site, it was found that the NWS relative humidity sensor was located in a drainage area at the local airport and was consistently reading higher than our instrument.

7. DAS Main Processor Boards - These boards contain a significant number of electronic components and many can fail. Although these component failures (such as capacitor, internal power supply, diode, and CPU, etc.) were relatively few during the first 18 months of the project, the number has significantly increased during the subsequent 18 months. the DAS equipment still seems to be acceptable in terms of dependence and the manufacturer has been reasonable, fair and prompt in completing the repairs. The reason for the number of failures may be due to the typically harsh conditions in which the DAS is used. To minimize field trips to diagnose and repair DAS failures, it is recommended that a spare main processor board be taken to a site whenever a failure is suspected. Because the type of equipment used in this project is very interchangeable, as few as 2 or 3 spare processor boards has been adequate and has saved many distant trips.

8. Flow meter components - For the most part, the flow meter electronic and mechanical components in the CHW and HW used in this project have been very dependable. One brand which was used early in the project had an electronics package in the flow meter which failed several times. Another problem was the existence of metallic trash within the pipe. this became apparent during the installation of another type of insertion flow meter. The trash struck the impeller of the flow meter, causing it the impeller to be destroyed. In one case, a flow meter which had been installed near the bottom of a pipe was being replaced for regular service and miscellaneous trash had accumulated in the plumbing fittings because the gate valve could not be closed.

9. Power supplies - A 24VAC power supply (i.e., 110 volt to 24 volt a. c. transformers) is used to power every DAS and many other types of metering equipment. These are inexpensive component s and easily replaced when they fail. Although the number of failures has been few in the past two years, the cost to replace the components includes diagnoses and travel costs. The transformers contain an internal fuse

which is non-replaceable. Early problems with the transformers ailing was alleviated by installation of a fast-acting 1 amp fuse on the secondary side of the transformer. This saves the powered up transformer when the secondary leads are shorted, which can easily happen during the installation process.

10. Interruption of gas metering - Certain types of electronic gas metering equipment require a battery to power the electronics in the meter. When the battery goes dead, the meter loses its memory and halts recording consumption data. If the utility company and/or facility does not share the signal, they probably will not notice the problem and will not make an effort to replace the battery until you call them. The meter will need to be reprogrammed as well when the battery is replaced. This sounds simple, but be prepared for numerous telephone conversations with the utility company as well as the facility.

11. Phone system problems - Discontinuation of service, reprogramming of the campus network, and wiring failure were a few of the problems with phone service that occurred. Sometimes the facility forgets why there is a phone line connected to the data acquisition system. In these instances, they have eliminated the phone line without contacting us. These problems have happened on a regular basis (approximately 6 to 8 times to date). When a communications line failure happens, the natural cause is to thought to be a modem failure. Typically, an engineer makes a trip to the site prepared to replace the modem or main processor board, only to find that there is no longer 50VDC on the phone line at the DAS. The loss of the communication line is reported to the appropriate facility contact and then the wait begins. It has taken as long as three months to restore service. This amount of waiting time is not unusual for the original installation of service, either. However, polling must be accomplished on site when the phone is dead. In some instances this requires a field trip every few weeks to avoid loss of data. Wiring failures usually occur due to the use of 24 gauge solid copper wire which is somewhat brittle and can be damaged in long runs or at termination points and therefore can break easily.

12. Signal cable brands - There is a nearly infinite number of brands of signal cable, so for continuity in a project, try to stay with one brand. The basic specification for the signal cable use was "x" pair(s) 22 gauge, twisted pairs, stranded wire, shielded (overall), with drain, and plenum-rated for all signals. However, for digital channels with relatively short cable runs in normal environments, 2 pair, 22 gauge, twisted pairs, solid wire, plenum-rated cable was used. The solid wire was less expensive and if 22 gauge was specified, it had adequate strength for all but the longest pulls in a normal environment. The use of one brand allowed familiarity with characteristics such as strength, stripability, color code assignment, and product quality. Multiple pairs were used whenever possible. The use of 22 gauge was adequate for nearly all applications and the plenum rating allowed cable runs to be placed in or through all areas without code or facility code violations.

SUMMARY AND CONCLUSIONS

There are two things which have helped to ensure that the data which is collected is of good and consistent quality; 1) The number of contractors active on the project has been reduced to one, and 2) The experience has been gained "in-house" to perform basic trouble-shooting diagnostics and take corrective actions. Another helpful development has been provided by the programming and analysis group. After the data has been downloaded from the data loggers, it is sent through a number of data reduction routines and checked for missing data, outlets, or other data stream problems (Haberl, et al., 1990). After this process, the data is graphed and the finished graphs inserted in a project binder which contains approximately six weeks of graphed data. This binder is circulated to several of the principal engineers and analysts involved in installation and analysis on the LoanSTAR program. If there are instrumentation problems in the field, they are most often identified through the inspection of these weekly graphs. If a plot of a particular data channel has some questionable trends, the problem is cited and passed on for investigation. A formal procedure has been developed to track any data related problem from identification through corrective action taken. As the project continues, this problem database will become a valuable source for future metering projects. Though it sounds as though there has been nothing but problems on this project, it is felt that the majority of the installations have gone in with little or no trouble. The "war stories" cited in this paper are examples of the types of problems which have been encountered. The intent has been to present them openly so that others involved in building energy metering projects may benefit from our experience and avoid similar pitfalls.

REFERENCES

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2. Nutter, D., Britton, A., Muraya, N., Heffington, W. 1990. "LoanSTAR Energy Conservation Audits: January 1989 - August 1990", Proceeding of the Seventh Annual Symposium on Improving Building Systems in Hot and Humid Climates, Texas A&M University, College Station, Texas, October.

3. O'Neal, D., Bryant, J., Turner, D., Glass, M. 1990. "Metering and Calibration in LoanSTAR Buildings", Proceeding of the Seventh Annual Symposium on Improving Building Systems in Hot and Humid Climates, Texas A&M University, College Station, Texas, October.

4. Verdict, M., Haberl, J., Claridge, D., O'Neal, D., Heffington, W., Turner, D. 1990. "Monitoring $98 Million in Energy Efficiency Retrofits: The Texas LoanSTAR Program", Proceedings of the ACEEE 1990 Summer Study on Energy Efficiency in Buildings, ACEEE Washington, D.C., August.

5. O'Neal, D., Bryant, and Boles, K., "Building Energy Instrumentation for Determining Retrofit Savings: Murphy's Law Revisited," <u>Solar Engineering 1992</u>, Proceedings of the ASME/JSES/KSES International Solar Energy Conference, Maui, Hawaii, April.

APPENDIX E

Completed Documentation Forms
(Sample Workbook)

FORM #: PREMAP1; REV 5/30/90

PRE-MAP CHECKSHEET

Site ID 135N 006 | Building ID TAMU GALVESTON | Date 10-30-91

1. PREMAP Checksheet ✓
2. General Site Information ✓
3. General Building Information ✓
4. Building Tour Information ✓
5. Operational/Installation Constraints ✓
6. Riser Diagram ✓
7. Riser Information Form ✓
8. Service Entrance Information -- 1 ✓
9. Service Entrance Information -- 2 ✓
10. Service Entrance Information -- 3 ✓
11. Building Equipment List ✓
12. Panel Documentation ✓
13. Switchgear Documentation ✓
14. Wattmeter Channel Requirements Summary ✓
15. Flow Sensor Requirements Sitesheet ✓
16. Phone Line Order Form ✓
17. Special Equipment Requirements ✓
18. EQUIP LOCATIONS & ASBESTOS TEST RESULTS ✓
19. PREMAP Checksheet Complete [initials]

Initials

INSTALLATION DATE OF
ALL EQUIPMENT OCTOBER, 1991

GENERAL SITE INFORMATION FORM

Site ID: 135 N 006 Date: 10-30-91 Initials: CB

SITE NAME: TAMU - GALVESTON
Address: MITCHELL CAMPUS @ PELICAN ISLAND
PO BOX 1675
City GALVESTON, TX 77553

SITE CONTACTS:

Name: N.J. NICK SUNSERI
Title: ASST DIR. PHY. PLANT
Address: MITCHELL CAMPUS · TAMU
PO BOX 1675
GALVESTON, TX 77553
Phone: 409-740-4544

Name: FRED BREWER (ALSO BOBBY, ASST.)
Title: MAINT CHIEF
Address: SAME AS ABOVE
Phone: 409-740-4553

Name: BILL MATEF
Title: DIRECTOR PHY PLANT
Address: SAME AS ABOVE
Phone: 409-740-4544

Name: VICKI BARKER (PHONE PERSON)
Title: PHONE COMMUNICATIONS SPEC
Address: FACILITIES COMM. DIRECTOR
SAME AS ABOVE
Phone: 409-740-4404

UTILITY CONTACTS:

Utility: (electric) HL&P HOUSTON LIGHTING AND POWER
Name: TED ARMSTRONG
Title: COMMERCIAL SPEC.
Address: PO BOX 718
GALVESTON, TX 77553
Phone: 409-763-1111
OR 713-388-3631
FOR METERING DEPT

Utility: (gas) S.U.G. SOUTHERN UNION GAS
Name: DON DEFORE
Title: METERING SUPERVISOR
Address: P.O. BOX 238
GALVESTON, TX 77553
Phone: 409-763-8551

Utility:
Name:
Title:
Address:
Phone:

Utility: MERCURY INSTRUMENTS GAS PULSE INITIATORS
Name: JOHNNY MCDONALD
* GARY MILLER
Title: WAYNE BURRELL
Address:
Phone: 713-890-3231

Number of Monitored Buildings at site: CUP & CAMPUS GAS-ELECTRIC

(Make one copy for each building notebook.)

FORM #: PREMAP5; REV 5/30/90

OPERATIONAL/INSTALLATION CONSTRAINTS

Site ID 135N / 006 Building ID TAMU / GALV Date 9-30-91 Initials [illegible]

Schedule limitations: 730A → 500 P EXCEPT FOR PREARRANGED OUTAGES

Loads affected by power interruption:

COMPUTERS ~~ALARMS~~ TELEPHONE TIMERS (HVAC) (OTHER) NONE

NO FIRE ALARMS

ALL CUP EQUIP AFFECTED BY XFMR'S OUTAGE.

Special restart procedures: FACILITY STAFF TO RESTART ALL ELEC EQUIP WITH JOURNEYMAN ELECTRICIAN ON HAND

Limited access areas: KEYS NECESSARY TO ACCESS ALL MECH/ELECT ROOMS OTHER THAN CUP.

Aesthetic sensitivities: TYPICAL

Other Factors: DRAW BRIDGE DELAYS ON ENTRANCE.

FORM #: PREMAP6; REV 5/30/90

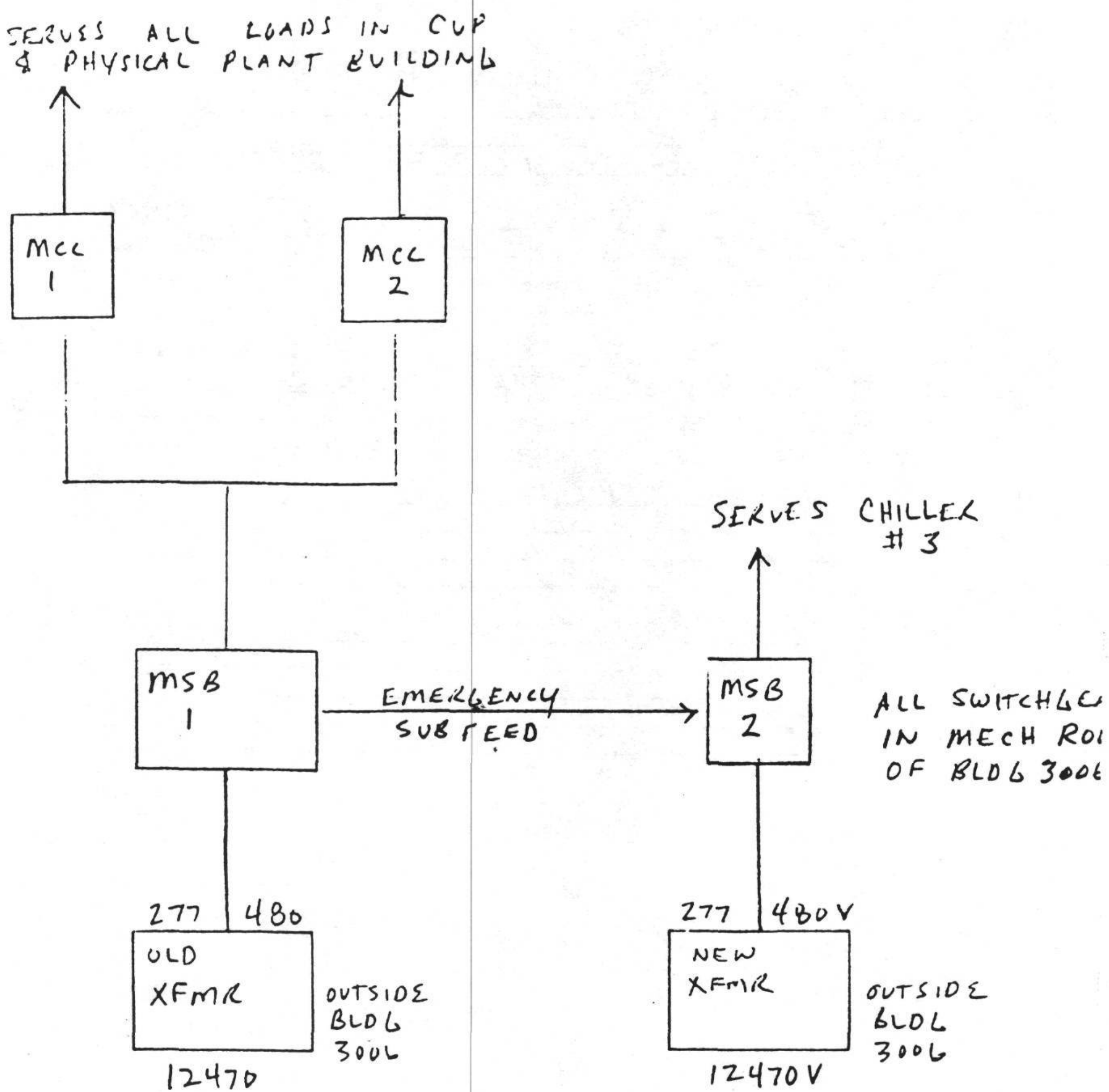
Page 1 of 1

RISER DIAGRAM

Electric ✓ Gas ____

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

(Include transformers with voltages above and below.)



FORM #: PREMAP3; REV 5/30/90

GENERAL BUILDING INFORMATION FORM

Site ID 135N Building ID TAMU GALVESTON Date 10-30-91 Initials OB

Building name: TAMU-GALVESTON @ MITCHELL CAMPUS PELICAN ISLAND

Address: P.O. BOX 1675

City: GALVESTON, TX Zip: 77553

BUILDING CONTACTS:

Name:	NICK SUNSERI	Name:	FRED BREWER
Title:	DIRECTOR, ASST: PHY PLANT	Title:	MAINT. CHIEF
Address:	SAME AS ABOVE	Address:	SAME AS ABOVE
Phone:	409-740-4544	Phone:	409-740-4553

Level of monitoring:

__ 0 (Pulse output electric meter, no DAS)
__ 1 (Meter plus 1-5 channels)
✓ 2 (Meter plus 5-20 channels) (PREMAP/SITEMAP budget limit = $1500 without prior written approval.)
__ 3 (Meter plus 20 or more channels) (PREMAP/SITEMAP budget limit = $3000 without prior written approval.)

Thermal energies monitored:

(Y) N N/A Chilled water

Y N (N/A) Steam condensate

Fuels monitored:

(Y) N N/A Gas

Y N (N/A) Oil

FORM #: PREMAP4; REV 5/30/90

BUILDING TOUR INFORMATION FORM

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

ELECTRICAL METERING and DISTRIBUTION

Date MISC Time: ______ Tour guide: FRED BREWER

ELECTRICAL SYSTEMS in BUILDING

Date MISC Time: ______ Tour guide: ______

STEAM/CONDENSATE

Date N/A Time: ______ Tour guide: ______

CHILLED WATER

Date MISC Time: ______ Tour guide: ______

TELEPHONES

Date ______ Time: ______ Tour guide: VICKI BARKER

MECHANICAL EQUIPMENT LOCATIONS

Date MISC Time: ______ Tour guide: FRED BREWER

ASBESTOS INSPECTION:

Date MISC Time: ______ Tour guide: NICK SUNSERI

FORM #: PREMAP7; REV 5/30/90

RISER INFORMATION FORM

Site ID 135N 006 Building ID TAMU GALV Date 10-30-91 Initials [illegible]

MONITORED NODES

Node Type	Node Name	Location	Voltage Config.	Volts	Current Rating	Served From		

SEE RISER DIAGRAM
AND SWITCHGEAR/PANEL DOCUMENTS.

FORM #: PREMAP8: REV 5/30/90

SERVICE ENTRANCE INFORMATION -- 1

Site ID 135N UCU Building ID TAMU GALVESTON Date 10-30-91 Initials CB

ELECTRIC METERS and FEEDS WHOLE CAMPUS ELEC METER N/A

METER ID #1 METER # 82204938 (6532)
Location NORTHSIDE OF CAMPUS
If paired, Left N/A Right ____ R/I = 25/72
Mfg. ? Model ?
Year mfg. ?
KYZ? Y (N) Available? (Y) (N) PURCHASE
Multiplier or "k" ?
K_h 1.8 ; CT: 80 ; PT: 60
Measured time for 5 rev.: 26.69 seconds
Measured kW: ____
Secondaries:
Rated bus or disconnect amps ____ volts ____
Type ____ ALL BLDGS
Sub-feeds to outdoor/other bldgs? (Y) N
Monitoring point location: @ METER ON POLE INTO ELECT. VAULT BLDG

METER ID ___ METER # ____
Location ____
If paired, Left ____ Right ____
Mfg. ____ Model ____
Year mfg. ____
KYZ? Y N Available? Y N
Multiplier or "k" ____
K_h ____; CT: ____; PT ____
Measured time for __ rev.: __ seconds
Measured kW: ____
Secondaries:
Rated bus or disconnect amps ____ volts ____
Type ____
Sub-feeds to outdoor/other bldgs? Y N
Monitoring point location: ____

Comments: COULD NOT GET CT OR PT RATIO FROM UTILITY / I GOT THEM, SHOWN ABOVE
KWh / PULSE = .75 OR 1.5 / COUNT

N/A
METER ID ___ METER # ____
Location ____
If paired, Left ____ Right ____
Mfg. ____ Model ____
Year mfg. ____
KYZ? Y N Available? Y N
Multiplier or "k" ____
K_h ____; CT: ____; PT: ____
Measured time for __ rev.: __ seconds
Measured kW: ____
Secondaries:
Rated bus or disconnect amps ____ volts ____
Type ____
Sub-feeds to outdoor/other bldgs? Y N
Monitoring point location: ____

CUP OLD SUC
METER ID 2 METER # ____
Location OUTSIDE-BEHIND C.U.P.
If paired, Left N/A Right ____
Mfg. ____ Model ____
Year mfg. ____
KYZ? Y (N) Available? Y (N)
Multiplier or "k" ____
K_h 3.6 ; CT: 300 ; PT: 2.4
Measured time for __ rev.: __ seconds
Measured kW: ____
Secondaries:
Rated bus or disconnect amps ____ volts ____
Type ____
Sub-feeds to outdoor/other bldgs? Y (N)
Monitoring point location: N/A

Comments: METER #2 @ OLD SUC @ CUP - METER NOT CALIBRATED CANNOT USE TO VERIFY KWh WATT XDUCER ON OLD SUC

GAS METERS

EXISTING

METER ID	METER #	MFG. & MODEL	LOCATION	PULSE INIT.?	TYPE OF GAS	STORAGE CAPACITY	MEASURE CU.FT/SEC
CAMPUS METER-		MERCURY INSTR MODEL - MERCUR E.C.	(WEST SIDE OF CAMPUS)	(Y) - (N)	NAT	N/A	N/A / SEE SE... & NE...
				Y N			
				Y N			/

New meter location: SAME AS OLD METER

1P = 1MCF

FORM #: PREMAP9; REV 6/1/90

SERVICE ENTRANCE INFORMATION -- 2

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [signature]

STEAM NOT METERED @ THIS SITE

Number of feeds, building total ______

Feed ID _______ Location ____________________________
High pressure: Pipe size _____ Pressure _________ Temp. ______
Low pressure: Pipe size _____ Pressure _________ Temp. ______
Reducing valve: Mfg. ___________ Model ________ Capacity __________
Existing flow meter? Y N Calibration ________ Measured __________

New meter location:

Feed ID _______ Location ____________________________
High pressure: Pipe size _____ Pressure _________ Temp. ______
Low pressure: Pipe size _____ Pressure _________ Temp. ______
Reducing valve: Mfg. ___________ Model ________ Capacity __________
Existing flow meter? Y N Calibration ________ Measured __________

New meter location:

CONDENSATE RETURN NOT METERED @ THIS SITE.

Number of condensate lines from building, total ______

Line ID _______ Location ____________________________
Pump HP ____ Measured amps ______ Label flow _______ Pump outlet diameter ______
Return line diameter ______ Receiver capacity, gallons _______ Gravity return? Y N
Existing flow meter? Y N Calibration ________ Measured __________
Measured pump output: _________/_______ = __________gpm.
quantity / time
New meter location: ____________________

Line ID _______ Location ____________________________
Pump HP ____ Measured amps ______ Label flow _______ Pump outlet diameter ______
Return line diameter ______ Receiver capacity, gallons _______ Gravity return? Y N
Existing flow meter? Y N Calibration ________ Measured __________
Measured pump output: _________/_______ = __________gpm.
quantity / time

New meter location:

FORM #: PREMAPIO; REV 6/1/90

SERVICE ENTRANCE INFORMATION -- 3

Site ID 135N C06 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

CHILLED WATER CAMPUS FEED

Number of feeds, building total 1

Feed ID 16" Location CENTRAL UTIL
Pipe sizes: Supply 16" Return 16"
Existing flow meter type NONE Calibration N/A
Measured: Flow rate 1258 Supply temp 41-41 Return temp 48-49
CHW pumps, label data HP: 1. 20 2. 20 3. 30
CUP ~~CHW~~ pumps, label data gpm: 1. 20 2. 40 3. 40
CHW pumps, measured inlet pressure: 1. ____ 2. ____ 3. ____
CHW pumps, measured outlet pressure: 1. ____ 2. ____ 3. ____
New flow meter location: CUP MAIN LOOP CHWR @ 20-FT HEIGHT.
CHW supply temp sensor location: CUP SAME
CHW return temp sensor location: CUP SAME

MSMT'S WITH INSTALLED DK, FR. EQUIP & EXISTING TEMP SENSORS

Feed ID N/A Location ____
Pipe sizes: Supply ____ Return ____
Existing flow meter type ____ Calibration ____
Measured: Flow rate ____ Supply temp ____ Return temp ____
CHW pumps, label data HP: 1. ____ 2. ____ 3. ____
CHW pumps, label data gpm: 1. ____ 2. ____ 3. ____
CHW pumps, measured inlet pressure: 1. ____ 2. ____ 3. ____
CHW pumps, measured outlet pressure: 1. ____ 2. ____ 3. ____
New flow meter location: ____
CHW supply temp sensor location: ____
CHW return temp sensor location: ____

OIL N/A

Number of feeds, building total ____

Feed ID ____ Location ____
Pipe size ____ Pump HP ____ Label flow ____ Tank capacity ____
Burner input capacity ____

Feed ID ____ Location ____
Pipe size ____ Pump HP ____ Label flow ____ Tank capacity ____
Burner input capacity ____

1 #: PREMAP11; REV 5/30/90

BUILDING EQUIPMENT LIST

e ID 135 N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

From: __Drawing __Audit ✓ Site visit

t. ID	Description	Area Served	Electric Inputs Volts	Amps	No. of Phases	Capa-city	Units	Other Inputs Fuel Type	Rate	Output Rate	Units	Measured data	Comments	Node name	Breaker Numbers
#1	250 TON	CAMPUS	480												
#2	250 TON	↓	↓												
#3	500 TON	↓	↓												
WP#1	20 HP	↓	↓												
WP#2	20 HP	↓	↓												
WP#3	30 HP	↓	↓												
P#1	20 HP	↓	↓												
P#2	40 HP	↓	↓												
P#3	40 HP	↓	↓												
WP#1	15 HP	↓	↓												
WP#2	15 HP	↓	↓												
OILER #1															
ILER #2															
2 COMP #1	PNEUMATIC HVAC	5HP	480												
C COMP #2	" "	5HP	↓												

SEE SWITCHGEAR DOCUMENTS FOR MORE DETAILED INFO.

FORM #: PREMAP12; REV 6/25/90

PANEL DOCUMENTATION FORM

Site ID 135 N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

PANEL ID: PNL LS ✓ Left ✓ Right

Location: Floor 1 Room ELEC XFMR VAULT BLDG ON WEST SIDE OF CAMPUS.

From: __ Drawing __ Audit ✓ Site visit

Onto floor plan? ✓

Fed from: SMALL XFMR

Phase	A	B	C
Line Volts	120	120	120
Rated Amps	100		
Meas Amps			
Wire size			
CT Quantity			
CT Type			
Logger ID			
Channel No.			

Breaker Capacity A	B	C	No.	Circuit Description	Meas Amps	Wires/ phase	Wire diam	End use	Logger ID	Chan-nel	CT type	Remarks
		20	6	SPARE -	Ø	1	1/0	24 VAC				POWER FOR 24 V.
												XFMR FOR PU
												INITIATOR/SPLIT
												IN ELEC XFMR
												VAULT BLDG -
												ALSO, XFMR &
												RPR-2 SPLITTER
												& (1) 2 AMP IN
												LINE FUSE LOC
												IN 10 × 10 × 4
												NEXT TO PNL

SWITCHGEAR DOCUMENTATION FORM

Site ID 135 Building ID TAMU Date 10-30-91 Initials CB

SWITCHGEAR ID: MSB-2

Location: Floor 1 Room BLDG 3006 MAIN MECH RM C.U.P.

From: ___Drawing ___Audit ✓ Site visit

Onto floor plan? ✓

Fed from: NEW XFMR OUTSIDE ON NORTH SIDE OF C.U.P.

Phase	A	B	C
Line Volts	277	277	277
Rated Amps	800	800	800
Meas Amps	210	205	200
Wire size	1" 2/Ø	→	→
CT Quantity	2	2	2
CT Type	301	301	301
Logger ID	N	N	N
Channel No.	D3	D3	D3

SW. #	Switch ID	Description	H.P.	PH.	Fuse amps	Meas amps	Wires/ phase	Wire diam	End use	Logger ID	Chan- nel	CT Type	Remarks	
1	VOLT-	EXISTING		A	N/A								CT CODE	
	AMP	V/A		B										
	METER	METER		C										
2	BLANK			A										
				B										
				C										
3a	MAIN	FEEDS	500	A	800	210	2	1	MTRC	N	D3	300	61/71	(2) 300 A CT's
		CHILLER	TON	B	800	205	2	1	MTRC	N	D3	300	62/72	PER Ø, MOUNTED
		#3		C	800	200	2	1	MTRC	N	D3	300	63/73	BEHIND VOLT/
3b	TIE-	ALLOWS		A	800	Ø	2	1						AMP METER @
	BKR	MSB 1 TO		B	800	Ø	2	1						TOP OF MSB2
		FEED MSB-2		C	800	Ø	2	1						REF VOLTS FOR
-	BLANK			A										WL3968 @
				B										FUSES INSIDE
				C										TOP SECTION BEHIN.
				A										VOLT/AMP METER.
				B										(3) 2AMP IN-LINE
				C										FUSES IN 6x6x4
				A										JB ON TOP OF
				B										MSB-2, WL3968
				C										KWh XDUCER
				A										IN 10X10X4
				B										JB ON TOP
				C										OF MSB-2
				A										
				B										
				C										

(6) 300 A CT'S 1.25" ID 333 mV OUTPUT

FORM #: PREMAP13; REV 6/25/90

SWITCHGEAR DOCUMENTATION FORM

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CX

SWITCHGEAR ID: MSB 1

Location: Floor 1 Room BLDG 3006 MAIN MECH

From: ___Drawing ___Audit ✓ Site visit

Onto floor plan? ✓

Fed from: OLD XFMR

Phase	A	B	C
Line Volts	277	277	277
Rated Amps	1600	1600	1600 @ MAIN
Meas Amps	710	700	715
~~Wire~~ Bus size	½ x 3	→	
CT Quantity	1	1	1
CT Type (CT COPC &)	1200	1200	1200
Logger ID	51, N	52, N	53, N
Channel No.	D2	D2	D2

SW. #	Switch ID	Description	H.P.	PH.	Fuse amps	Meas amps	Wires/phase	Wire diam	End use	Logger ID	Channel	CT Type	Remarks
1	LIGHT-	LTG		A	100	1	1						CT'S ON MAIN
	ING	XFMR		B		1	1						BUS FEED TO
				C		1	1						MSB-1, ON
2	PNL			A	2600	11.2							PRIMARY SIDE
	HB			B									OF MAIN
				C	1								BREAKER
3	NO			A	150	12.8							(3) 1200 AMP
	NAME			B									1 3/8 x 5" w/
				C									333 mV OUTPUT.
4	PNL			A	150	50							MOUNTED IN
	HA			B									RIGHT SIDE
				C									ABOVE MAIN.
5	MAIN			A	1600								REF VOLTS @
				B									MCC-1 @
				C									DISC # 12 for
6	MCC			A	600	220							CONT. AIR COMP
	MAIN			B									ON LOAD SIDE
				C									OF DISCONNECT,
7	CHILLER			A	300	208							(3) 2 AMP INLINE
	#1			B									FUSES IN 6x6x4
				C									JB ABOVE/ONTOP
8	CHILLER			A	300	177							OF MCC1, WL3968
	#2			B									WATTHOUR XDUCER
				C									IN 10X10X4
9	NO			A									BESIDE 6x6x4.
	NAME			B									
				C									

☆ ALSO SEE SWITCHGEAR DOCUMENT FOR MCC-1; (1) WL 3968 / (3) 1200A BUS BAR C

FORM #: PREMAP14; REV 6/1/90

DIGITAL WATTMETER CHANNEL REQUIREMENTS SUMMARY

SiteID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

DIGITAL

NODE NAME	LITE	SUPP fan	RA Fan	AH Unit	HVAC unit	CHW Pump	COND pump	DHW Circ	SUMP pump	EXTL lite	CUP CHILLER	CUP *1 ALL LOADS	WHOLE CAMPUS		TOTAL ON NODE
MSB-2											1,D3				1
CAMPUS ELEC METER													1,DØ		1
MSB-1											1,D2				1

TOTAL 3

COMMENTS: DATA MATE # 20, DIGITAL ONLY CHNLS

* CUP ALL LOADS EXCEPT CHILLER # 3 ON MSB-2, INCLUDES ALL CHW PLANT [illegible]

FORM #: PREMAP15; REV 5/30/90

FLOW SENSOR REQUIREMENTS SITESHEET

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

Location	Chilled water BTU meters	Condensate Flow meters
I.	DK SYS 90	N/A
C.U.P.	CHW BTU METER	
PHYSICAL	WITH (2) TEMP	
PLANT,	SENSORS AND	
BLDG #	DATA INDUSTRIAL	
3006	FLOW METER.	
	C.U.P. CAMPUS	
	CHW LOOP,	
	16" CHWS &	
	CHWR.	

TOTALS: (1) DATA INDUSTRIAL 225 B CHW FLOW METER
(1) BTU MTR - SYS 90 DK
(2) DK TEMP SENSORS.

NOTE F.M. IN 16" CHWR ABOVE CHILLERS # 1 & 2 @ 20 FT ABOVE FLOOR.

DI FM M# FM0015 (M# 225 B)
TAMU TAG # 027914
TEES TAG # 0295406

TAMU - GALVEST[illegible] 006

BTU METER INFORMATION

GENERAL

BLDG #

Site: 006 Location: 3006 Measurement:

Logger #: Channel BTU: D4 Channel, Gal.: D5

Pipe & insul. circumference: 63.5" Insulation thickness: 2"

Pipe diameter=(OD/pi)-2*)insul. thick.)= 20.22 - 4 = 16.22

Nominal pipe diameter= 16 Actual OD= 16

t= pipe wall thickness= .375 Actual ID=OD-2*t= 15.25

INSERTION

d= insertion depth= nominal pipe dia./8= 1 1/2 FOR DI FLOW METER

h= measured height to top of meter adapter hex= 11 3/4

L= top hex to top collar=16.375"-(h+t+d)= $16\frac{3}{8} - \left(11\frac{3}{4} + \frac{3}{8} + 1\frac{1}{2}\right)$

$= 16\frac{3}{8} - 13\frac{5}{8} = 2\frac{3}{4}$

CALIBRATION

Mfg. data calibration:

* Flow Research eqn.:pulses/gallon=.727*7.64*60/((ID^2*2.446))=
SEE BELOW

BTU METER SWITCH SETTINGS

S1 setting= N/A

S4 setting= .38 x 100 = 38 = 100 gal/PULSE & 100 k BTU/PULSE

BTU METER INFORMATION

GENERAL

Site: Location: Measurement:

Logger #: Channel BTU: Channel, Gal.:

Pipe & insul. circumference: Insulation thickness:

Pipe diameter=(OD/pi)-2*)insul. thick.)=

Nominal pipe diameter= Actual OD=

t= pipe wall thickness= Actual ID=OD-2*t=

INSERTION

d= insertion depth= nominal pipe dia./8=

h= measured height to top of meter adapter hex=

L= top hex to top collar=15.375"-(h+t+d)=

CALIBRATION

Mfg. data calibration:

Flow Research eqn.:pulses/gallon=.727*7.64*60/((ID^2*2.446))=

BTU METER SWITCH SETTINGS

S1 setting=

S4 setting=

* DATA INDUSTRIAL EQN = Pulses/gallon = $\left[\left(\frac{Flow}{k}\right) - offset\right] 60 \div \left(\frac{Flow}{\cdot}\right)$

from TAMU CHART .36 @ 1 fps to .39 @ 2200 gal = 3.9 fps

@ 2200 gpm

$$\left[\left(\frac{2200}{154.257}\right) - .433\right] 60 \div 2200 = .38$$

8VDC POWER TO FM FROM DK w/ 1kΩ [illegible]
ACROSS 12V TO FLOW IN TERMINALS.

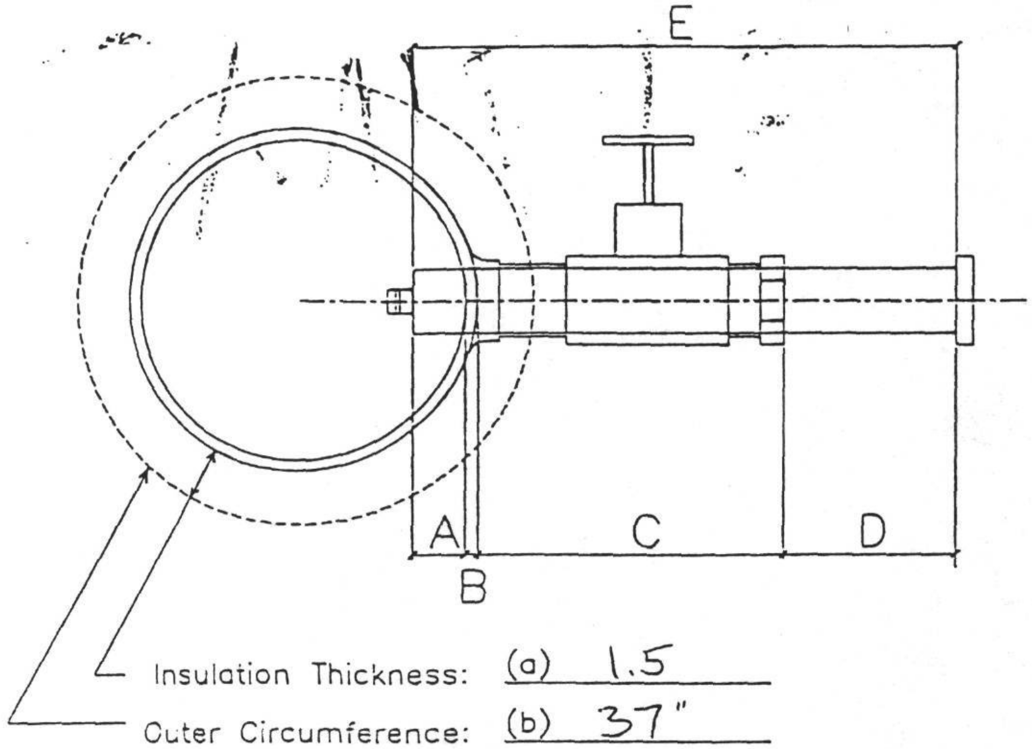
AGGIE FLOWMETER INSERTION DEPTH TABULATOR

Site ID: 403 Building Name: UTMB Moody Library

Installation Date: 8/25/93 DK S4 Switch Setting: 148

Flowmeter Description: DT Line Description: CHW

Serial # Installed: 034492 Serial # Removed: 029365



Insulation Thickness: (a) 1.5

Outer Circumference: (b) 37"

Calculated Pipe O.D.: (c) 8.78 c=b/3.141−2*a

Nominal Pipe Size: 8"

A) Insertion Depth 1.5

B) Pipe Thickness 0.322

C) Pipe to Hex Fitting 11 11/16

D) Hex Fitting to Inside of FM 2.866 D=E−(A+B+C)

E) Flow Sensor Length 16.375 Data Industrial=16.375
Flow Research=14.625

Note: Remember to Verify Orientation of Flow Meter Body with Pipe

VERIFICATION

	Time (seconds)	Counts	Parameter Set Scale	Rate		
Flow	(a) 356	(b) 24	(c) 100	(d) 404	(gpm)	d=60*b*c/a
Btu	(e) 356	(f) 2	(g) 100	(h) 2022	(kbtu/hr)	h=3600*f*g/e
ΔT	10.01	ΔT=2*h/d	(normally between 2 and 20 degrees F)			

TEXAS LOANSTAR PROGRAM

Metering Installation and DASS Management

Energy Systems Laboratory
Department of Mechanical Engineering
Texas A&M University

MEMORANDUM

TO: Flow/Btu Meter Installers
FROM: Task A - Curtis Boecker

DATE: 3/31/94

Listed below are the S4 scaling switch settings to be used with the DK Enterprises btu meters when installed with Data Industrial or Flow Research flow sensors. Also shown are the manufacturer's recommended insertion depths, pulses per gallon factors, and the resulting parameter set scales to be programmed into the loggers. All new btu meter installations should use these settings.

Data Industrial Flow Sensor

Nominal Pipe Size (inches)	DK Btu Meter S4 Switch (S1 = 0)	Insertion Depth (inches)	Meter PPG[1]	Parameter Set Scale (gallons & kbtu)
3	137	1.5	13.714	9.99
4	71	1.5	7.108	9.99
5	40	1.5	4.029	9.93
6	27	1.5	2.738	9.86
8	147	1.5	1.470	100
10	91	1.5	0.911	99.89
12	60	1.5	0.600	100
14	49	1.5	0.494	99.19
16	38	1.5	0.378	100.53
18	29	1.5	0.295	98.31
24	157	1.5	0.157	1000.00
30	96	1.5	0.096	1000.00

[1] PPG values calculated at flow rate of 4.0 feet/second.

Flow Research Flow Sensor

Nominal Pipe Size	DK Btu Meter S4 Switch (S1 = 0)	Insertion Depth (inches)	Meter PPG[1]	Parameter Set Scale
3	132	**1.0	13.248	9.96
4	102	1.5	10.232	9.97
5	59	0.63	5.942	9.93
6	40	.76	4.001	10.00
8	22	1.00	2.217	9.92
10	136	1.25	1.358	100.15
12	92	1.50	0.924	99.57
14	75	1.66	0.748	100.27
16	55	1.91	0.551	99.82
18	43	2.16	0.426	100.94
24	217	2.91	0.217	1000.00
30	154	3.66	0.154	1000.00

[1] PPG values calculated at flow rate of 4.0 feet/second.

DATA INDUSTRIAL SENSOR

C. Boecker -- 3/31/1994

PIPE DESCRIPTION ==>	3 inch Schedule 40 Steel STD Weight			4 inch Schedule 40 Steel STD Weight			5 inch Schedule 40 Steel STD Weight			6 inch Schedule 40 Steel STD Weight		
ID ==>	3.068			4.026			5.047			6.065		
Pipe Thickness ==>	0.216			0.237			0.258			0.280		
K ==>	4.36197			8.33975			14.67442			21.57376		
OFFSET ==>	0.06			0.23			0.25			0.26		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	23.06	5.22	13.592	39.71	4.53	6.849	62.41	4.01	3.851	90.12	3.92	2.610
2	46.12	10.51	13.673	79.42	9.29	7.022	124.81	8.26	3.970	180.24	8.10	2.696
3	69.18	15.80	13.701	119.13	14.06	7.079	187.22	12.51	4.009	270.36	12.28	2.724
4	92.24	21.08	13.714	158.85	18.82	7.108	249.63	16.76	4.029	360.49	16.45	2.738
5	115.30	26.37	13.723	198.56	23.58	7.125	312.03	21.02	4.041	450.61	20.63	2.747
6	138.37	31.66	13.728	238.27	28.34	7.137	374.44	25.27	4.049	540.73	24.81	2.753
7	161.43	36.94	13.732	277.98	33.10	7.145	436.85	29.52	4.055	630.85	28.98	2.757
10	230.61	52.81	13.739	397.11	47.39	7.160	624.07	42.28	4.065	901.21	41.52	2.764
15	345.91	79.24	13.744	595.67	71.20	7.171	936.10	63.54	4.073	1351.82	62.40	2.770

PIPE DESCRIPTION ==>	8 inch Schedule 40 Steel STD Weight			10 inch Schedule 40 Steel STD Weight			12 inch Steel STD Weight			14 inch Steel Schedule 30 STD Weight		
ID ==>	7.981			10.020			12.000			13.250		
Pipe Thickness ==>	0.322			0.365			0.375			0.375		
K ==>	40.08561			64.53237			97.57600			118.15125		
OFFSET ==>	0.28			0.31			0.36			0.39		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	156.06	3.61	1.389	245.98	3.50	0.853	352.80	3.26	0.554	430.13	3.26	0.454
2	312.11	7.50	1.443	491.96	7.31	0.891	705.60	6.87	0.584	860.26	6.90	0.481
3	468.17	11.40	1.461	737.94	11.12	0.904	1058.40	10.49	0.595	1290.38	10.54	0.490
4	624.22	15.29	1.470	983.92	14.93	0.911	1411.20	14.10	0.600	1720.51	14.18	0.494
5	780.28	19.18	1.475	1229.90	18.74	0.914	1764.00	17.72	0.603	2150.64	17.82	0.497
6	936.34	23.08	1.479	1475.89	22.56	0.917	2116.80	21.34	0.605	2580.77	21.46	0.499
7	1092.39	26.97	1.481	1721.87	26.37	0.919	2469.60	24.95	0.606	3010.90	25.10	0.500
10	1560.56	38.65	1.486	2459.81	37.80	0.922	3528.00	35.80	0.609	4301.28	36.02	0.502
15	2340.84	58.11	1.490	3689.71	56.86	0.925	5292.00	53.88	0.611	6451.92	54.22	0.504

PIPE DESCRIPTION ==>	16 inch Schedule 30 Steel STD Weight			18 inch Steel STD Weight			24 inch Steel Schedule 20 STD Weight			30 inch Steel STD Weight		
ID ==>	15.250			17.250			23.250			29.250		
Pipe Thickness ==>	0.375			0.375			0.375			0.375		
K ==>	154.26725			196.94325			364.33125			590.75925		
OFFSET ==>	0.43			0.49			0.67			0.83		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	569.78	3.26	0.343	729.03	3.21	0.264	1324.38	2.97	0.134	2096.13	2.72	[illegible]
2	1139.56	6.95	0.366	1458.06	6.91	0.284	2648.76	6.60	0.150	4192.26	6.27	[illegible]
3	1709.33	10.65	0.374	2187.08	10.62	0.291	3973.13	10.24	0.155	6288.38	9.82	[illegible]
4	2279.11	14.34	0.378	2916.11	14.32	0.295	5297.51	13.87	0.157	8384.51	13.36	[illegible]
5	2848.89	18.03	0.380	3645.14	18.02	0.297	6621.89	17.51	0.159	10480.64	16.91	[illegible]
6	3418.67	21.73	0.381	4374.17	21.72	0.298	7946.27	21.14	0.160	12576.77	20.46	[illegible]
7	3988.45	25.42	0.382	5103.20	25.42	0.299	9270.65	24.78	0.160	14672.90	24.01	[illegible]
10	5697.78	36.50	0.384	7290.28	36.53	0.301	13243.78	35.68	0.162	20961.28	34.65	[illegible]
15	8546.67	54.97	0.386	10935.42	55.04	0.302	19865.67	53.86	0.163	31441.92	52.39	[illegible]

FLOW RESEARCH SENSOR

C. Boecker -- 3/31/1994

PIPE DESCRIPTION ==>	3 inch Schedule 40 Steel STD Weight			4 inch Schedule 40 Steel STD Weight			5 inch Schedule 40 Steel STD Weight			6 inch Schedule 40 Steel STD Weight		
ID ==>	3.068			4.026			5.047			6.065		
Pipe Thickness ==>	0.216			0.237			0.258			0.280		
K ==>	0.22460			0.17330			0.10100			0.06810		
OFFSET ==>	0.35			0.44			0.49			0.51		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	23.06	4.83	12.565	39.71	6.44	9.733	62.41	5.81	5.589	90.12	5.63	3.746
2	46.12	10.01	13.021	79.42	13.32	10.066	124.81	12.12	5.824	180.24	11.76	3.916
3	69.18	15.19	13.172	119.13	20.21	10.176	187.22	18.42	5.903	270.36	17.90	3.973
4	92.24	20.37	13.248	158.85	27.09	10.232	249.63	24.72	5.942	360.49	24.04	4.001
5	115.30	25.55	13.294	198.56	33.97	10.265	312.03	31.03	5.966	450.61	30.18	4.018
6	138.37	30.73	13.324	238.27	40.85	10.287	374.44	37.33	5.981	540.73	36.31	4.029
7	161.43	35.91	13.346	277.98	47.73	10.303	436.85	43.63	5.993	630.85	42.45	4.037
10	230.61	51.44	13.385	397.11	68.38	10.332	624.07	62.54	6.013	901.21	60.86	4.052
15	345.91	77.34	13.415	595.67	102.79	10.354	936.10	94.06	6.029	1351.82	91.55	4.063

PIPE DESCRIPTION ==>	8 inch Schedule 40 Steel STD Weight			10 inch Schedule 40 Steel STD Weight			12 inch Steel STD Weight			14 inch Steel Schedule 30 STD Weight		
ID ==>	7.981			10.020			12.000			13.250		
Pipe Thickness ==>	0.322			0.365			0.375			0.375		
K ==>	0.03780			0.02320			0.01580			0.01280		
OFFSET ==>	0.53			0.55			0.56			0.57		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	156.06	5.37	2.064	245.98	5.16	1.258	352.80	5.01	0.853	430.13	4.94	0.688
2	312.11	11.27	2.166	491.96	10.86	1.325	705.60	10.59	0.900	860.26	10.44	0.728
3	468.17	17.17	2.200	737.94	16.57	1.347	1058.40	16.16	0.916	1290.38	15.95	0.741
4	624.22	23.07	2.217	983.92	22.28	1.358	1411.20	21.74	0.924	1720.51	21.45	0.748
5	780.28	28.96	2.227	1229.90	27.98	1.365	1764.00	27.31	0.929	2150.64	26.96	0.752
6	936.34	34.86	2.234	1475.89	33.69	1.370	2116.80	32.89	0.932	2580.77	32.46	0.755
7	1092.39	40.76	2.239	1721.87	39.40	1.373	2469.60	38.46	0.934	3010.90	37.97	0.757
10	1560.56	58.46	2.248	2459.81	56.52	1.379	3528.00	55.18	0.938	4301.28	54.49	0.760
15	2340.84	87.95	2.254	3689.71	85.05	1.383	5292.00	83.05	0.942	6451.92	82.01	0.763

PIPE DESCRIPTION ==>	16 inch Schedule 30 Steel STD Weight			18 inch Steel STD Weight			24 inch Steel Schedule 20 STD Weight			30 inch Steel STD Weight		
ID ==>	15.250			17.250			23.250			29.250		
Pipe Thickness ==>	0.375			0.375			0.375			0.375		
K ==>	0.00944			0.00730			0.00374			0.00264		
OFFSET ==>	0.58			0.59			0.62			0.64		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	569.78	4.80	0.505	729.03	4.73	0.389	1324.38	4.33	0.196	2096.13	4.89	0.140
2	1139.56	10.18	0.536	1458.06	10.05	0.414	2648.76	9.29	0.210	4192.26	10.43	0.149
3	1709.33	15.56	0.546	2187.08	15.38	0.422	3973.13	14.24	0.215	6288.38	15.96	0.152
4	2279.11	20.93	0.551	2916.11	20.70	0.426	5297.51	19.19	0.217	8384.51	21.50	0.154
5	2848.89	26.31	0.554	3645.14	26.02	0.428	6621.89	24.15	0.219	10480.64	27.03	0.155
6	3418.67	31.69	0.556	4374.17	31.34	0.430	7946.27	29.10	0.220	12576.77	32.56	0.155
7	3988.45	37.07	0.558	5103.20	36.66	0.431	9270.65	34.05	0.220	14672.90	38.10	0.156
10	5697.78	53.21	0.560	7290.28	52.63	0.433	13243.78	48.91	0.222	20961.28	54.70	[illegible]
15	8546.67	80.10	0.562	10935.42	79.24	0.435	19865.67	73.68	0.223	31441.92	[illegible]	[illegible]

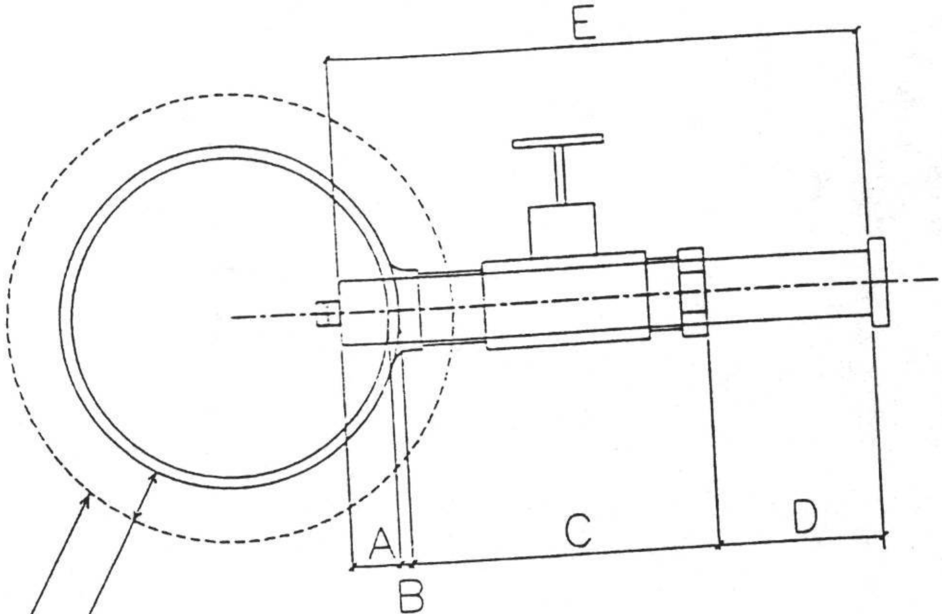
AGGIE FLOWMETER INSERTION DEPTH TABULATOR

Site ID: ________ Building Name: ______________________________

Installation Date: ______________ DK S4 Switch Setting: ______

Flowmeter Description: ______________ Line Description: ______________

Serial # Installed: ______________ Serial # Removed: ______________



Insulation Thickness: (a) ______________

Outer Circumference: (b) ______________

Calculated Pipe O.D.: (c) ______________ c=b/3.141−2*a

Nominal Pipe Size: ______________

A) Insertion Depth ______________

B) Pipe Thickness ______________

C) Pipe to Hex Fitting ______________

D) Hex Fitting to Inside of FM ______________ D=E−(A+B+C)

E) Flow Sensor Length ______________ Data Industrial=16.375
Flow Resecrch=14.625

Note: Remember to Verify Orientation of Flow Meter Body with Pipe

VERIFICATION

	Time (seconds)	Counts	Parameter Set Scale	Rate	
Flow	(a) ________	(b) ________	(c) ________	(d) ________ (gpm)	d=60*b*c/a
Btu	(e) ________	(f) ________	(g) ________	(h) ________ (kbtu/hr)	h=3600*f*g

ΔT ______________ ΔT=2*h/d (normally between 2 and 20 degrees F)

FORM #: PREMAP16; REV 5/30/90

Site ID 135N / 006 Building ID TAMU / GALV Date 10-9-91 Initials [illegible]

PHONE LINE ORDER FORM

PHONE CO. VERBIAGE = NEW SINGLE LINE, EXISTING ACCOUNT, NEW LOCATION

Site Name: TAMU @ PELICAN ISLAND / GALVESTON

New Service Address:

Phone Company Order Center (Indicate the office for the above location.)
Phone number:

Arlington
Austin
Dallas
Denton
Galveston
Houston
Lubbock
San Antonio
Other:

Existing Account Number:

Name of Business:

Send Billing To:

Service Info:
- Install single line touch tone service
- ~~Install~~ single RJ11 jack at the location specified
- Number should be UNLISTED
- NO wire warranty
- ATT long distance carrier

Location of Jack: C.U.P. @

Site Contact Name: VICKI BARKER
Phone: 409 740 4404

Alternate Name:
Phone:

---------- FILL THIS OUT WHEN ORDERING THE PHONE LINE: ----------

Installation Date and Time :

New Phone Number: 409-740-5724 Telephone Co. Order Number:

NOTE: DIAL ONLY LAST (3) DIGITS ON CAMPUS.

FLOW RESEARCH SENSOR

C. Boecker -- 3/31/1994

PIPE DESCRIPTION ==>	3 inch Schedule 40 Steel STD Weight			4 inch Schedule 40 Steel STD Weight			5 inch Schedule 40 Steel STD Weight			6 inch Schedule 40 Steel STD Weight		
ID ==>	3.068			4.026			5.047			6.065		
Pipe Thickness ==>	0.216			0.237			0.258			0.280		
K ==>	0.22460			0.17330			0.10100			0.06810		
OFFSET ==>	0.35			0.44			0.49			0.51		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	23.06	4.83	12.565	39.71	6.44	9.733	62.41	5.81	5.589	90.12	5.63	3.746
2	46.12	10.01	13.021	79.42	13.32	10.066	124.81	12.12	5.824	180.24	11.76	3.916
3	69.18	15.19	13.172	119.13	20.21	10.176	187.22	18.42	5.903	270.36	17.90	3.973
4	92.24	20.37	13.248	158.85	27.09	10.232	249.63	24.72	5.942	360.49	24.04	4.001
5	115.30	25.55	13.294	198.56	33.97	10.265	312.03	31.03	5.966	450.61	30.18	4.018
6	138.37	30.73	13.324	238.27	40.85	10.287	374.44	37.33	5.981	540.73	36.31	4.029
7	161.43	35.91	13.346	277.98	47.73	10.303	436.85	43.63	5.993	630.85	42.45	4.037
10	230.61	51.44	13.385	397.11	68.38	10.332	624.07	62.54	6.013	901.21	60.86	4.052
15	345.91	77.34	13.415	595.67	102.79	10.354	936.10	94.06	6.029	1351.82	91.55	4.063

PIPE DESCRIPTION ==>	8 inch Schedule 40 Steel STD Weight			10 inch Schedule 40 Steel STD Weight			12 inch Steel STD Weight			14 inch Steel Schedule 30 STD Weight		
ID ==>	7.981			10.020			12.000			13.250		
Pipe Thickness ==>	0.322			0.365			0.375			0.375		
K ==>	0.03780			0.02320			0.01580			0.01280		
OFFSET ==>	0.53			0.55			0.56			0.57		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	156.06	5.37	2.064	245.98	5.16	1.258	352.80	5.01	0.853	430.13	4.94	0.688
2	312.11	11.27	2.166	491.96	10.86	1.325	705.60	10.59	0.900	860.26	10.44	0.728
3	468.17	17.17	2.200	737.94	16.57	1.347	1058.40	16.16	0.916	1290.38	15.95	0.741
4	624.22	23.07	2.217	983.92	22.28	1.358	1411.20	21.74	0.924	1720.51	21.45	0.748
5	780.28	28.96	2.227	1229.90	27.98	1.365	1764.00	27.31	0.929	2150.64	26.96	0.752
6	936.34	34.86	2.234	1475.89	33.69	1.370	2116.80	32.89	0.932	2580.77	32.46	0.755
7	1092.39	40.76	2.239	1721.87	39.40	1.373	2469.60	38.46	0.934	3010.90	37.97	0.757
10	1560.56	58.46	2.248	2459.81	56.52	1.379	3528.00	55.18	0.938	4301.28	54.49	0.760
15	2340.84	87.95	2.254	3689.71	85.05	1.383	5292.00	83.05	0.942	6451.92	82.01	0.763

PIPE DESCRIPTION ==>	16 inch Schedule 30 Steel STD Weight			18 inch Steel STD Weight			24 inch Steel Schedule 20 STD Weight			30 inch Steel STD Weight		
ID ==>	15.250			17.250			23.250			29.250		
Pipe Thickness ==>	0.375			0.375			0.375			0.375		
K ==>	0.00944			0.00730			0.00374			0.00264		
OFFSET ==>	0.58			0.59			0.62			0.64		
FLOW VELOCITY (FPS)	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG	GPM	FREQ	PPG
1	569.78	4.80	0.505	729.03	4.73	0.389	1324.38	4.33	0.196	2096.13	4.89	0.140
2	1139.56	10.18	0.536	1458.06	10.05	0.414	2648.76	9.29	0.210	4192.26	10.43	0.149
3	1709.33	15.56	0.546	2187.08	15.38	0.422	3973.13	14.24	0.215	6288.38	15.96	0.152
4	2279.11	20.93	0.551	2916.11	20.70	0.426	5297.51	19.19	0.217	8384.51	21.50	0.154
5	2848.89	26.31	0.554	3645.14	26.02	0.428	6621.89	24.15	0.219	10480.64	27.03	0.155
6	3418.67	31.69	0.556	4374.17	31.34	0.430	7946.27	29.10	0.220	12576.77	32.56	0.155
7	3988.45	37.07	0.558	5103.20	36.66	0.431	9270.65	34.05	0.220	14672.90	38.10	0.156
10	5697.78	53.21	0.560	7290.28	52.63	0.433	13243.78	48.91	0.222	20961.28	54.70	[illegible]
15	8546.67	80.10	0.562	10935.42	79.24	0.435	19865.67	73.68	0.223	31441.92	[illegible]	[illegible]

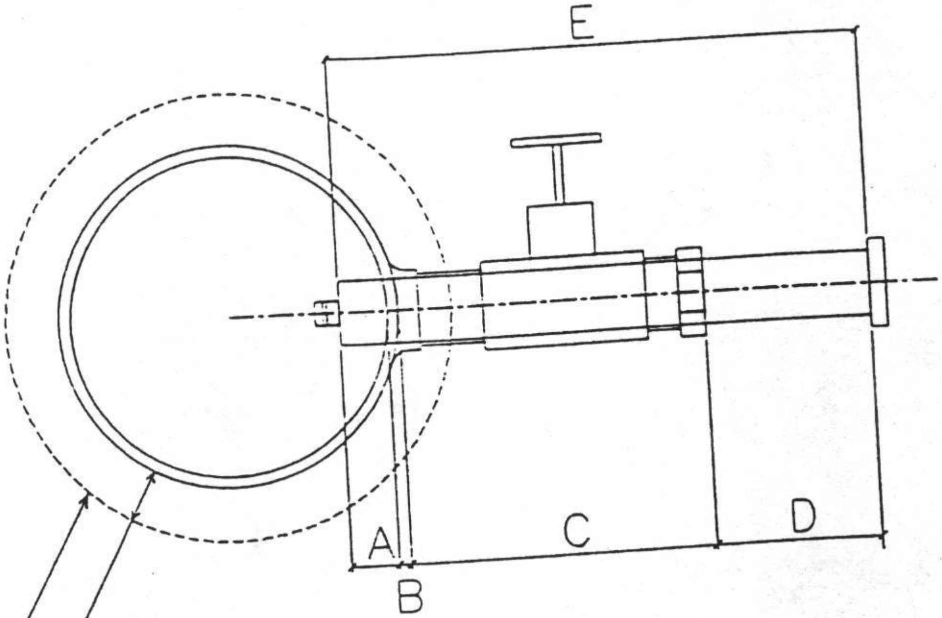
AGGIE FLOWMETER INSERTION DEPTH TABULATOR

Site ID: ________ Building Name: ______________________

Installation Date: ______________ DK S4 Switch Setting: ______

Flowmeter Description: ______________ Line Description: ______________

Serial # Installed: ______________ Serial # Removed: ______________



Insulation Thickness: (a) ______________

Outer Circumference: (b) ______________

Calculated Pipe O.D.: (c) ______________ c=b/3.141−2*a

Nominal Pipe Size: ______________

A) Insertion Depth ______________

B) Pipe Thickness ______________

C) Pipe to Hex Fitting ______________

D) Hex Fitting to Inside of FM ______________ D=E−(A+B+C)

E) Flow Sensor Length ______________ Data Industrial=16.375
Flow Research=14.625

Note: Remember to Verify Orientation of Flow Meter Body with Pipe

VERIFICATION

	Time (seconds)	Counts	Parameter Set Scale	Rate	
Flow	(a)______	(b)______	(c)______	(d)______ (gpm)	d=60*b*c/a
Btu	(e)______	(f)______	(g)______	(h)______ (kbtu/hr)	h=3600*f*g
ΔT	______	ΔT=2*h/c (normally between 2 and 20 degrees F)			

FORM #: PREMAP16; REV 5/30/90

Site ID 135N / 006 Building ID TAMU / GALV Date 10-9-91 Initials [illegible]

PHONE LINE ORDER FORM

PHONE CO. VERBIAGE = NEW SINGLE LINE, EXISTING ACCOUNT, NEW LOCATION

Site Name: TAMU @ PELICAN ISLAND / GALVESTON

New Service Address:

Phone Company Order Center (Indicate the office for the above location.)
Phone number:

Arlington
Austin
Dallas
Denton
Galveston
Houston
Lubbock
San Antonio
Other:

Existing Account Number:

Name of Business:

Send Billing To:

Service Info:
- Install single line touch tone service
- Install single RJ11 jack at the location specified
- Number should be UNLISTED
- NO wire warranty
- ATT long distance carrier

Location of Jack: C.U.P. @

Site Contact Name: VICKI BARKER
Phone: 409 740 4404

Alternate Name:
Phone:

---------- FILL THIS OUT WHEN ORDERING THE PHONE LINE: ----------

Installation Date and Time :

New Phone Number: 409-740-5724 Telephone Co. Order Number:

NOTE: DIAL ONLY LAST (3) DIGITS ON CAMPUS.

FORM #: PREMAP17; REV 5/30/90

SPECIAL EQUIPMENT REQUIREMENTS

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

ADDITIONAL BREAKERS: NONE REQUIRED

Node Name	Panel or Breaker Type	Volts	Snap or Screw?	Comments

J-BOX REQUIREMENTS: (4) 10 x 10 x 4, (2) 1900, (3) 8 x 8 x 6 PVC PLASTIC INDOOR
(2) 6 x 6 x 4

# CT Junctions	Other Components	Location
6		@ MSB 2
3		@ MSB 1

OTHER SPECIAL EQUIPMENT: SEE SITEMAP # 96 & INVENTORY XFER FORM INSTALL 6

(2) WL 3968 KWH XDUCERS

(1) DK SYS 90 W/(2) TEMP SENSORS

(1) DATA INDUSTRIAL CHW FLOW METER

(1) PULSE INITIATOR W/ KWH, KVAR & TIME PULSES

(1) CORRECTED VOLUME GAS MTR W/FORM A & FORM C OUTPUT for SAME.

(1) SSI RPR-2

(1) DM #20 W/MODEM

(3) 24VAC XFMRS.

FORM #: PREMAP18: REV 5/30/90

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

EQUIPMENT LOCATION and ASBESTOS INSPECTION DOCUMENTATION

Location #	Equipment Type	Equipment location	Test results
1	DAS, BTU MTR, 24VAC XFMR	CUP BLDG #3006 EAST WALL	N/A CONCRETE/CINDER BLOCK WALL
2	CHW FLOW MTR, HOTTAP-2"	CHWR, 16" CAMPUS LOOP MAIN ABOVE CH #1/2	SEE ATTACHED, NO ASBESTOS.
3.	CHWR TEMP SENSOR, HOTTAP 1"	SAME AS ABOVE	SAME AS ABOVE
4.	CHWS TEMP SENSOR, HOTTAP 1"	CHWS CAMPUS LOOP - SAME AS ABOVE	SAME AS ABOVE.
5.	CAMPUS ELECT. KWH PULSE SPLITTER	ELEC VAULT BLDG, WEST END OF CAMPUS	N/A FIBERGLASS ON CONCRETE WALL.
6.	WL3968 w/ 3-CT'S	MSB-1, TOP	N/A
7.	WL3965 w/ 6-CT'S	MSB-2 TOP	N/A

mastic H. B. Fuller Co. 30-35 shall be applied reinforced with white 20 x 20 glass fabric in all areas. Where urethane is used, surfaces shall be finished with two coats of Armstrong Insulcolor or approved equal.

Joints shall be sealed with mastic. Where required, oversized pipe sections or board type insulation may be used to fabricate and install insulation around pipe specialties.

Where piping is interrupted by fittings, flanges, valves or hangers, and at intervals not to exceed 21 feet on continuous runs, an insulating seal shall be formed between the vapor barrier jacket and the bare pipe by liberal applications of H. B. Fuller 30-35 flexible vapor barrier joint sealant, or approved equal, to the ends of the pipe insulation.

Longitudinal laps and 3" wide butt strips of the vapor barrier jacket shall be adhered neatly in place with Manville AP with lap secured with H. B. Fuller Co. 85-75 fire resistive vapor barrier adhesive or approved equal. Adhesive systems which employ release paper will not be acceptable.

New and existing chilled water supply and return piping in central plant shall be insulated with a nominal 2 pound per cubic foot density polyisocyanurate foam pipe insulation as manufactured by Insulex Corporation for pipe sizes up to and including 8 inch. Piping above 8 inch shall be Trymer 9501 polyurethane as manufactured by CPR division of the UpJohn Company. Thickness shall be as specified hereinbefore. This pipe insulation shall have a factory attached all service jacket (ASJ). The laps and butt strips shall be sealed in place with MON-ECO Industries 22-08 lap adhesive. At intervals not exceeding 25 lineal feet on straight runs of piping and at all fittings a vapor stop of MON-ECO Industries 55-10 vapor barrier mastic shall be applied to the butt joints.

Fittings shall be insulated with premolded and/or shop or job fabricated covers of the same type material and thickness as the adjacent piping, secured in place with filament tape, vapor sealed with MON-ECO 55-10 vapor barrier mastic and finished with Manville 25-50 rated zeston PVC covers. Zeston fitting covers shall be sealed with MON-ECO 22-08 adhesive.

The entire surface of all chilled water piping ASJ jacket in the central plant shall be coated with H. B. Fuller Co. 30-35 for additional vapor barrier protection and shall have a final finish of .020" smooth aluminum jacket with a factory applied moisture barrier. Jacket shall be secured in place with 1/2" wide x .020" thick aluminum bands on 12" centers and winged type clips. Ells will be finished with two piece covers secured in place with 1/2" aluminum bands. Valves will be finished with .020" aluminum jacket secured in place with 1/2" aluminum bands with ends finished with mastic and white fabric reinforcing.

Air Handling Condensate Drains

Factory built air handling unit condensate drains shall be insulated with 1/2" flexible, foamed elastomeric such as Armaflex II in accordance with the requirements stated in UL-883.

SwL SOUTHWESTERN LABORATORIES

Materials, environmental and geotechnical engineering, nondestructive, metallurgical and analytical services

222 Cavalcade St. • P.O. Box 8768, Houston, Texas 77249 • 713/692-9151

Client: National Center for Appropriate Technology
3408 Owen Ave
Austin, Texas 78705
Attn: Chuck Bohmer

Client No.:
Report No.: 91-09-375
Report Date: 09-26-91

Project: Bulk samples submitted for asbestos content analysis. Sampled by J. Isensee and received at SwL-Houston on 9/24/91. Analyzed on 9/25/91.

Texas A & M

RESULTS

Sample I.D.	Sample Description	SwL Lab No.	Asbestos %*	Other Fibrous Constituents %
Bldg. 3006, Chilled Water Return, Between Chillers 1 & 2	White Wrap on 24" Pipe	91-09-375-1	None Detected	Cellulose 30-40 Fiberglass 5-[illegible] Metal Foil 40-50
	Yellow Foam Insulation		None Detected	Foam 90-95
Bldg. 3006, Chilled Water Return, Above Chiller No. 2	White Wrap on 24" Pipe	91-09-375-2	None Detected	Cellulose 30-40 Fiberglass 20-30 Metal Foil 30-40
	Yellow Foam Insulation		None Detected	Foam 90-95
Bldg. 3006, Chilled Water Supply Pipe, Above E. End of Chiller No. 2	White Wrap on 24" Pipe	91-09-375-3	None Detected	Cellulose 20-30 Fiberglass 20-30 Metal Foil 30-40
	Yellow Foam Insulation		None Detected	Foam 90-95

* The percentage of asbestos is microscopically visually estimated.
** Additional material found during analysis, but not observed during field inspection.

Method of Analysis: 40 CFR 763, Appendix A to Subpart F (Polarized Light Microscopy)
SwL Houston is an accredited laboratory for bulk asbestos analysis - Laboratory I.D. No. 1502 00.
Samples will be discarded after a storage period of 60 days, unless other arrangements are specified. Results presented pertain to only actual sample analyzed.

Technician: T. Jank/J. Smeberg

Thomas Jank
Reviewed By

jfm

SOUTHWESTERN LABORATORIES, INC.

Terry Jackson
Terry J. Jackson, P.E. - Asbestos Manager
Environmental Analytical Services

FORM #: SITEMAPS; REV 5/30/90

SHUNTED CT REQUIREMENTS WORKSHEET

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

NODE	5 solid	30 solid	50 solid	50 split	100 solid	100 split	200 solid	200 split	400 solid	400 split	Other: 300 SPLIT 4LS2	1200 SPLIT (BUS BAR) 4LS3
MSB-2											6	
												3
MSB-1												
TOTALS											6	3

FORM #: SITEMAP4; REV 6/25/90

EQUATIONS

Site ID 135N CDL Building ID TAMU GALVESTON Date 10-30-91 Initials (signature)

ll referenced logger IDs in this file must be contained in
e NETWORK.DRV file in PCDAS.
Site Number (required entry)
TE = 781
Energy End-Use Equations (Units = KW) (OK to leave unused end uses blank)
Format: @AWN power channel N on logger A
@AKN apparant power channel N on logger A
@AVN line voltage channel N on logger A
@ALN line current channel N on logger A
@AAN analog channel N on logger A
@ADN digital channel N on logger A

For Measurement Numbers Format: @MN where N is the measurement number
The @ character is required for the CH2M and M2CH parsers
TE =
UPP =
FN =
UN =
HUI =
VAC =
WP =
UND =
HWC =
MP =
TL =
TRA = WHOLE CAMPUS ELECTRIC ENERGY = DØ
LS =

NOTE: FOR CAMPUS ELECTRICAL ENERGY NOT INCLUDING C.U.P. BLDG 3006; = D1 - (D2 + D3)
THIS MAY BE DESIRED TO LOOK AT ENERGY USE IN OTHER BLDGS THAN CUP BEFORE AND AFTER.

Powerfactor End-Use Equations
ITF =
PF =
FF =
HNF =
IF =
AF =
AWF =
ONF =
WF =
MF =
XTF =

OTHER!
MTRB + MTRC = CENTRAL UTILITY PLANT (BLDG 3006 ENERGY)
= D2 + D3

CHWB = CAMPUS CHW BTU (ENERGY) = D4
CHWF = CAMPUS CHW FLOW TOTAL = D5
GASF = CAMPUS GAS FLOW TOTAL = D1

NonElectric End-Use Equations
IL =
TEM =
Energy Balance Data Quality Criterion
Format: Title: Equation (in terms of loggerID/channel number)

Range check equations. Required for all temperature sensors
NGE:
Repeat check equations. Required for all temperature and GAS sensors
REPEAT:
PEAT:

FORM #: SITEMAP7; REV 5/30/90

CABLE REQUIREMENTS WORKSHEET

Site ID 135 N / 006 Building ID TAMU GALV Date 10-28-91 Initials [signature]

LOCATION	Num of channels	Dis. to logger	4-pair	8-pair (2-)	10-pair (1-)	Barrier strips (DC)	Temp wire	Phone wire
OLD SVC				100'				50
NEW ELEC SVC				100				50
GAS METER				(400) + 1400'				
ELEC Meter				(400)				
Chilled water					210 (70 x 3)			
Condensate Return	N/A							
PT	N/A							
Bell Trans	x 3							60
Comm Loop								
TOTALS:				2400'	210'			160'

FORM #: SITEMAP6; REV 5/30/90

NON-SHUNTED CT REQUIREMENTS WORKSHEET

Site ID 135N 006 Building ID TAMV GALVESTON Date 10-30-91 Initials [illegible]

NODE	KWH Transducers	5 solid	30 solid	50 solid	50 split	100 solid	100 split	200 solid	200 split	400 solid	400 split	Other:
TOTALS												

NONE REQUIRED FOR THIS SITE

FORM #: SITEMAP8; REV 6/25/90

MULTI-PAIR CABLE GUIDE

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

Logger 1651

Cable #		1 (CAMPUS LOOP →)	2	3	4	5
1 ~~2~~-pair	Node name ...	CHWS	CHWR	CHWR		
	cable ID ...	88	89	90		
	destination...	DK	DK	DK (BTU METER)		
low/high		DK	DK	DK	ALL	
black/white	1	TS	FLOW -	TR		
brown/blue	2					
red/green	3					
orange/yellow	4					

		1	2	3	4	5
4-pair	Node name ...					
	cable ID ...					
	destination...					
low/high						
black/white	1					
brown/blue	2					
red/green	3					
orange/yellow	4					

		1	2	3	4	5
PHONE WIRE ~~2-pair~~	Node name ...	DK BTU OUT	DK GAL OUT		24VAC XFMR	IN 10X10X4 BY NORTH DOOR
	cable ID ...	85	85		74	
	destination...	DL	DL		DL	
low/high						
blue/lt.blue	1 RED/GREEN...........	D4			24VAC-IN	
orange/lt. or.	2 BLACK/YELLOW		P5		⊗ (green is ground.)	

		1	2	3	4	5
Phone wire	Node name ...	KWH XDUCER MSB1R	KWH XDUCER MSB2		24VAC XFMR	IN 10X10X4 BY NORTH DOOR
	cable ID ...	83	82		75	
	destination...	DL	DL		BTUMTR	
~~green/red~~ RED/GREEN	....		D3		24VAC-IN	
black/yellow	....	D2			⊗ (green is GROUND)	

FORM #: SITEMAP8; REV 6/25/90

MULTI-PAIR CABLE GUIDE

Site ID 135N 006 | Building ID TAMU | Date 10-30-91 | Initials [illegible]

Logger 1651

4-pair

	Cable #	1	2	3	4	5
4-pair	Node name ...					
	cable ID ...					
	destination...					
low/high						
black/white	1					
brown/blue	2					
red/green	3					
orange/yellow	4					

	Cable #	1	2	3	4	5
~~4~~ pair / 2 PAIR	Node name ...	ELEC METER ✓		ELEC VAULT RPR2 ✓		
	cable ID ...	47		48		
	destination...	ELEC VAULT RPR2 IN 10X10X4		ELEC METER @ POLE TAMU EMS		
low/high						
black/white	1 BLACK/RED	N/A/24V		N/A, K		
brown/blue	2 WHITE/BLACK	Y, Z		Y, Z		
red/green	3	(+)				
orange/yellow	4					

24 VAC XFMR N/A TO K IN. RPR-2 & K out UTILITY meter

	Cable #	1	2	3	4	5
2-pair	Node name ...	GAS METER ✓	GAS METER ✓	ENG BLDG CONDUIT	XFMR VAULT 10x10 ✓	CUP CONDUIT ✓
	cable ID ...	46	49	66	65	67
	destination...	XFMR VAULT PULL BOX	XFMR VAULT 10X10	CUP CONDUIT	ENG BLDG CONDUIT	DL
low/high						
blue/lt.blue	1 BLACK/WHITE	K,Y	K,Y	B/W	B/W	DØ
orange/lt. or.	2 BLACK. RED	N/A, Z	N/A, N/A	B/R	B/R	D1

Run May Not EXIST

TO K, Y, RPR-2

TO B/R #49

	Cable #	1	2	3	4	5
Phone wire	Node name ...					
	cable ID ...					
	destination...					
green/red	....					
black/yellow	....					

FORM #: SITEMAP11; REV 6/25/90 P. 1 of

DATA LOGGER EQUIPMENT LOCATIONS

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

LOGGER ID: ______

DATA LOGGER LOCATION: Level # 1 Room # C.U.P. MAIN MECH Wall: (N) S E W

REFERENCE VOLTAGE #1: Level # 1 Room # CUP MAIN MECH ROOM
for KWH XDUCER #1
Voltage configuration: 277/480 Node name MSB-2 Breaker # FUSES FOR MSB VOLT METER IN CABINET.

Existing or (install?) New breaker description (3) 2 AMP IN LINE FUSES IN 6x6x4 JB ON TOP OF MSB-2.

REFERENCE VOLTAGE #2: Level # 1 Room # CUP MAIN MECH RM.
for KWH XDUCER
Voltage configuration: 277/480 Node name MSB-1-R Breaker # DISCONNECT #14 LOAD SIDE

Existing or (install?) New breaker description (3) 2 AMP IN LINE FUSES IN 6x6x4 JB ON TOP OF MSB-1-R

LOGGER POWER SUPPLY: Level # 1 Room # C.U.P. MAIN MECH ROOM
& BTU METER POWER SUPPLY
Voltage configuration: 120V Node name OUTLET ON NORTH WALL BY DOOR Breaker # N/A

Existing or (install?) New breaker description (1) 2 AMP IN LINE FUSE IN 10x10x4 JB WITH (2) 24 VAC XFMRS

*** *** ***

BTU METER LOCATION: Level # 1 Room # CUP MAIN MECH Wall: (N) S E W

BTU METER POWER SUPPLY: Level # 1 Room # CUP MAIN MECH ROOM.

Voltage configuration: 120 Node name OUTLET BY DOOR ON NORTH WALL Breaker # N/A

Existing or (install?) New breaker description (1) 2 AMP IN LINE FUSE IN 10x10x4 JB WITH (2) 24 VAC XFMRS

RPR-2 PULSE SPLITTER IN ELECTRIC XFMR VAULT BLDG ON WEST SIDE OF CAMPUS - SPLITS CAMPUS ELEC SIGNAL. POWER AT PNL LS BKR #6 20A VOLTAGE = 120 to 24 VAC - RPR & 24VAC XFMR IN 10x10x4 JB. W/(1) 2A IN-LINE F IN 10x10x4 JB.

KWH XDUCER #1 ; SEE REF VOLTS #1

KWH XDUCER #2 ; SEE REF VOLTS #2

PH# 409 740 5724

FORM SITE MAP #9b; INVENTORY CONTROL, HARDWAARE REQUIREMENTS
TRANSFER FORM

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-29-91 Initials CB

ITEM DESCRIPTION	QTY RECEIVED	P.O. #	QTY TRANSFR'D	QTY IN STOCK
C130-N1 DATA LOGGER				
C130-A-N1 DATA LOGGER				
C140-N1 DATA LOGGER				
C140-A-N1 DATA LOGGER				
DATA MATE M# 20		6643	1	
DATA MATE M#				
POTENTIAL TRANSDUCER				
BELL TRANS 120 to 24VAC		6643, 6803, RB80	3	
BELL TRANS 208/480-24VAC				
CT COMBINER BOARDS				
MODEM		6643	1	
kwh TRANSDUCERS; M# WL396 8		6644	2	
kwh TRANSDUCERS; M#				
___ AMP CURRENT TRANS.				
4LS3-1200-333-1 3/8x5		6641	3	
4LS2-300-333-1.25		6641	6	
OTHER; MISC				
HP&L PULSE INIT. ELEC METER		6650	1 (3)	
S.U. GAS PULSE INIT GAS METER		6651	1 (2)	
HOT TAPS		C#021	3	
& REINSULATION		C#021	AS RQED	
CHW BTU/GAL METERS DK SYS 90		6642	1	
CHW TEMP SENSORS DK		6642	2	
CHW FLOW METERS DI		6806	1	
COND RET FLOW METERS 1 1/2"				
COND RET FLOW METERS 2"				
1 PAIR CABLE		STOCK	210'	
PAIR CABLE		STOCK	2400'	
PAIR CABLE				
PAIR CABLE				
CONDUCTOR PHONE WIRE		STOCK	160'	
AMP INLINE FUSES & HOLDERS		STOCK	8	
AMP INLINE FUSES & HOLDERS		STOCK	3	
TERMINAL BLOCKS 1 CONDUCTOR		STOCK	22	
TERMINAL BLOCKS 2 CONDUCTOR		STOCK	6	
OTHER EQUIPMENT (DESC)				
SSI RPR-2 PULSE SPLITTER		6676	1	
BOX PULL STRING		6580	1	
10x10x4 JB W/SC		STOCK	4	
6x6x4 JB W/SC		STOCK	2	
1900 JB W/SC		STOCK	2	

LOGGER ID# 1651

→ TEES #0295406
TAMU #027914
FM # 0015

ALSO: MISC ELEC FTGS, CONNECTORS & TIE WRAPS FROM
a) STOCK
b) ELEC CONTRACTOR CARPENTER ELECTRIC C#022

[signature] HCAI representative Date 11-28-91

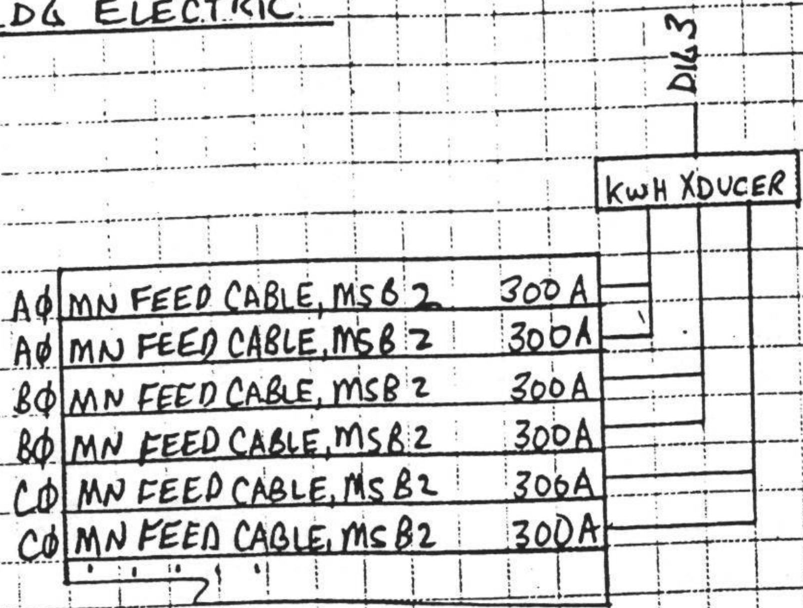
Received by: Name, title Date

SITE# 135 N
006

Ncat the National Center for Appropriate Technology
3040 Continental Dr., P.O. Box 3838, Butte, MT 59702 (406) 494-4572

JOB TAMU - GALVESTON
SHEET NO. 2 OF 2
CALCULATED BY CB DATE 10-31-91
CHECKED BY DATE
SCALE NONE

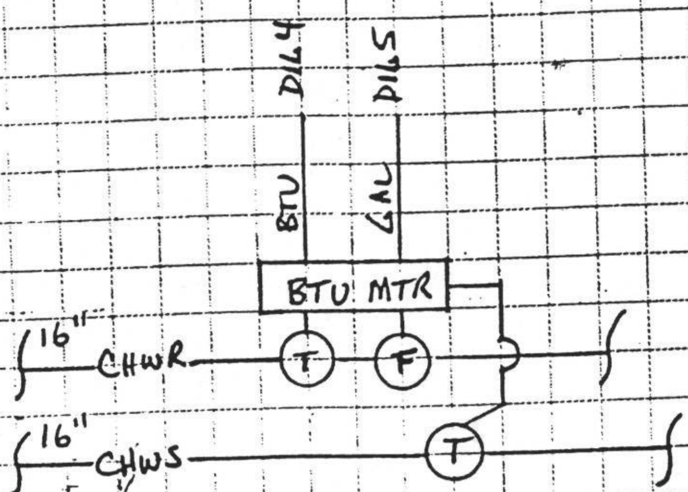
BLDG ELECTRIC



NOTE: XDUCER & (3) 2A INLINE FUSES ON TOP OF MSB-2.

NEW SERVICE - BLDG 3006 CUP, @ MSB 2.
CT'S IN TOP SECTION ON LINE SIDE OF CABLE FEED. REF VOLTS @ FUSES FOR EXISTING METER.

CAMPUS CHW



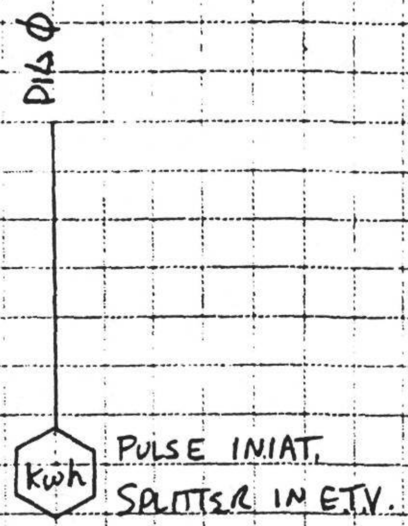
- CAMPUS CHW LOOP - BLDG 3006 CUP.
TEMP SENSORS & FLOW METER ABOVE CHILLER #1

SITE #135N 006

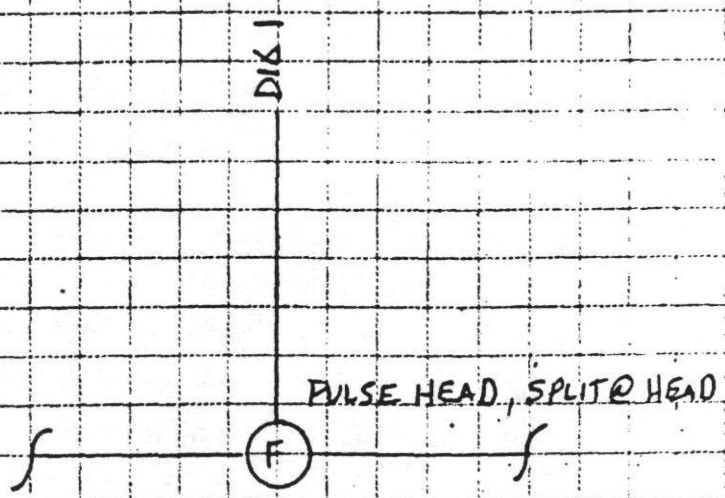
Ncat the National Center for Appropriate Technology
3040 Continental Dr., P.O. Box 3838, Butte, MT 59702 (406) 494-4572

JOB TAMU-GALVESTON
SHEET NO. 1 OF 2
CALCULATED BY CB DATE 10-31-91
CHECKED BY ______ DATE ______
SCALE NONE

CAMPUS ELECTRIC



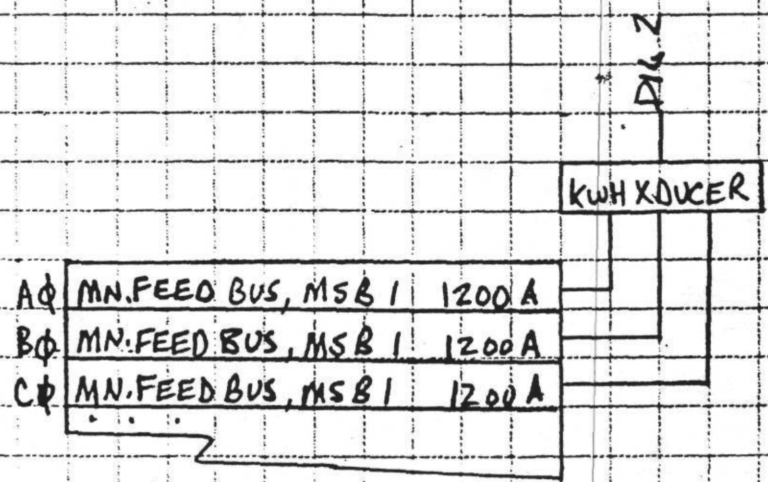
CAMPUS GAS



HL&P CAMPUS ELECTRIC UTILITY METER @ WEST SIDE BY XFMR VAULT BLDG.

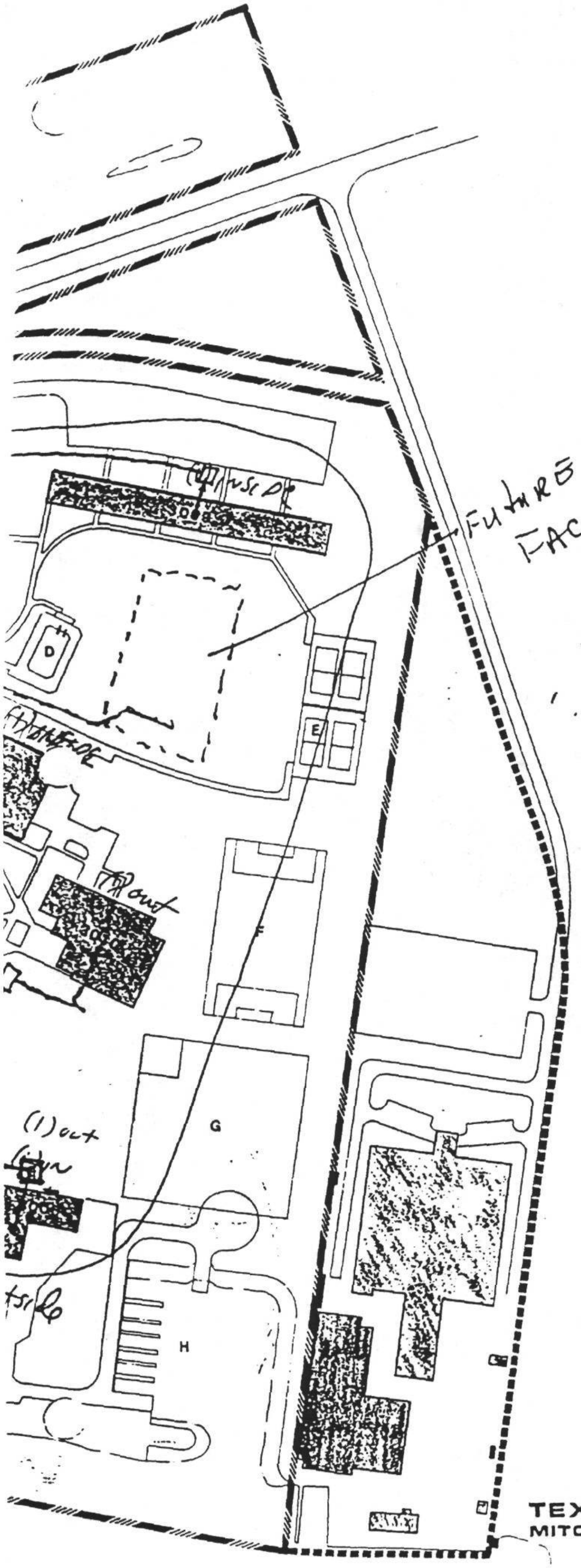
SOUTHERN UNION GAS UTILITY METER @ WEST SIDE BY XFMR VAULT BUILDING

BLDG ELECTRIC



OLD SERVICE - BLDG 3006 C.U.P.
@ MSB-1R, CT'S IN TOP SECTION
ON LINE SIDE OF BUS FEED.
REF VOLTS FOR KWH XDUCER @ MCC-1
DISC. #12 CONT. AIR COMP @ LOAD SIDE
OF DISC - 277/480.

NOTE: XDUCER & (3)
2A INLINE FUSES
ON TOP OF MCC-1



RED LINES SIGNIFY
UNDERGROUND COMMUNICATION
CONDUIT SYSTEM.

DATA SYSTEM & RTU
METER @ BLDG 3006

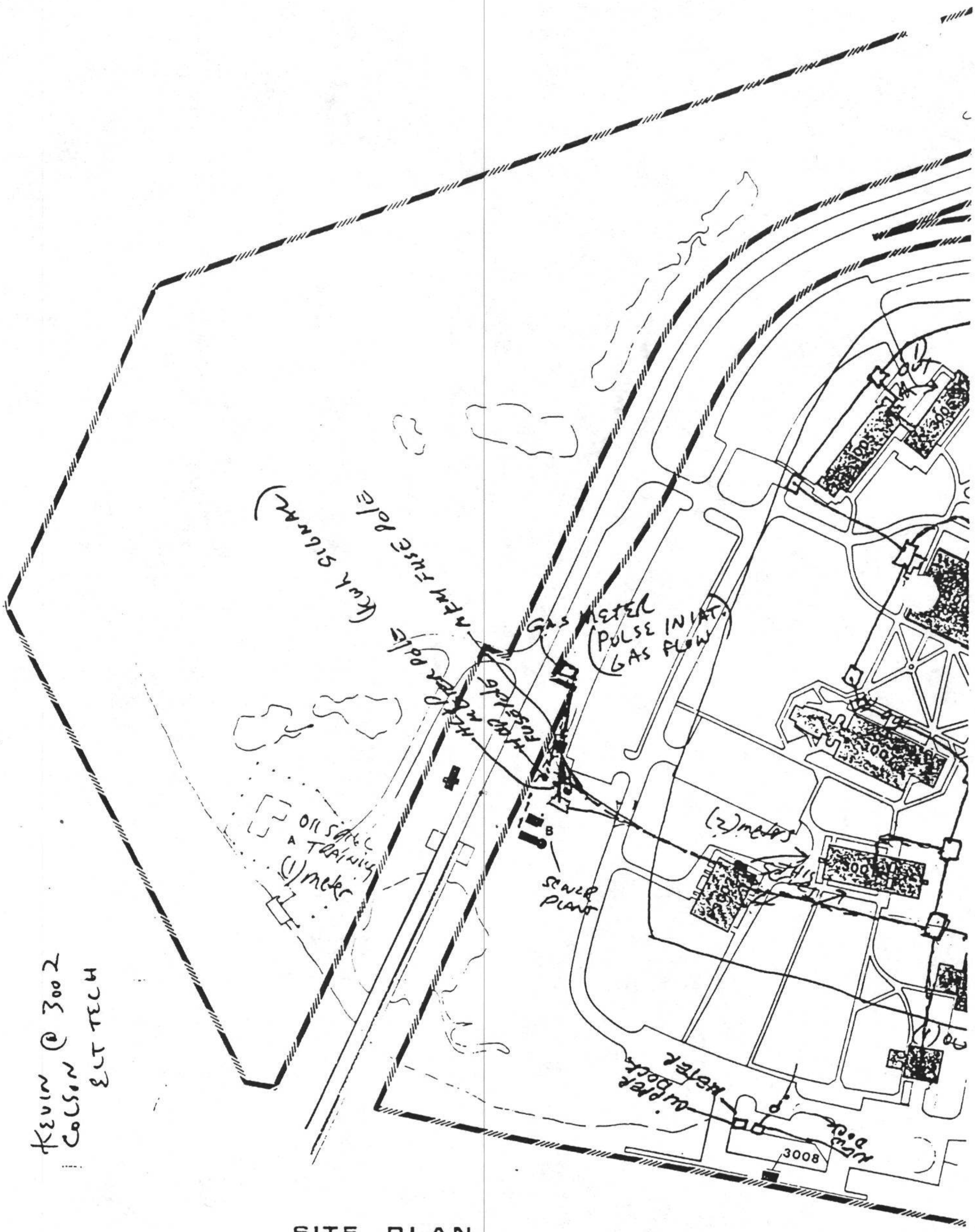
BUILDING INDEX

3001	ACADEMIC/CLASSROOM BUILDING
3002	ENGINEERING LABORATORY BUILDING
3003	OCEANOGRAPHIC STAGING FACILITY
3004	MARY MOODY NORTHEN STUDENT CENTER
3005	DORMITORIES 'A' & 'B'
3006	CENTRAL SERVICE BUILDING
3007	CLASSROOM/LABORATORY BUILDING
3008	DOCK BOILER BUILDING
3009	DORMITORY 'C'
3010	JACK K. WILLIAMS LIBRARY

ADDITIONAL FACILITIES

A	OIL AND HAZARDOUS MATERIAL CONTROL SCHOOL - TEES
B	SEWER TREATMENT PLANT
C	ELECTRICAL SUB-STATION
D	POOL
E	TENNIS/BASKETBALL
F	SOCCER/FOOTBALL
G	BASEBALL/SOFTBALL
H	SMALL BOAT BERTHING FACILITY

TEXAS A&M UNIVERSITY AT GALVESTON
MITCHELL CAMPUS PELICAN ISLAND



SITE PLAN
SCALE : 1" = 100'

FORM #: INSTALL2; REV 5/30/90

Request for Permission to Interrupt Service

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [initials]

The National Center for Appropriate Technology, in the course of its work installing energy monitoring equipment for the Texas Engineering Experiment Station, will need to temporarily interrupt the following service:

Building: CUP 3006 PHYSICAL PLANT

Type of service to be interrupted: WHOLE BLDG

Date: 10/12/91 Time: 730 – 9AM

Loads affected: ALL BLDG LOADS

[signature]
NCAT Representative

Approved by: FRED BREWER

Title: MAINT CHIEF

Date: 10-7-91

NOTE: FACILITY MAINTENANCE TO BE ON SITE & PARTICIPATE. NCAT TO HAVE J.M. ELECTRICIAN ON SITE FOR NCAT WORK (CT INSTALLATIONS) & TO ASSURE ALL LOADS ARE RESTORED UPON COMPLETION & RESTART.

FORM #: INSTALL1; REV 5/30/90

PRE-INSTALLATION CHECKLIST

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

✓ SITEMAP approved by TEES

✓ Electrician notified of special equipment requirements

Permits from:	Date Req.	Received
NONE REQUIRED		

✓ Installation scheduled with site contact Date 10-7→10-25 Time AM

___ Installation scheduled with electrician Date 10-7→10→25 Time AM

Appointments scheduled for:

✓	Electric meter installation	Date BY 10/24	Time
✓	Gas meter installation	Date ON 10/26	Time AM
✓	Telephone line installation	Date BY 10/11	Time
✓	Flow sensor installation	Date ON 10/9	Time ALL DAY
		Date	Time
		Date	Time

→ THEY WILL PARTICIPATE,

N/A Written permission to interrupt service received (form INSTALL2)

✓ Penetrations in occupied areas coordinated with building or site contact, FRED BREWER.

CONTINUED VERIFICATIONS

WITH DATA INDUSTRIAL FLOW METER

(*7) 5. 32 PULSES/HR = 3200 K BTU/HR @ LOGGER

1 PULSE/113 SEC = 3190 KBTU/HR @ DK

@ 3200 KBTU/HR & 59,900 gal/HR

$\Delta T = 6.4$ °F & FLOW = 998 gPM

&

Actual ΔT @ FACILITY TEMP SENSORS =

$T_R - T_S = 51 - 44.5 = 6.5$ °F

6. 599 pulses/HR = 59900 gal/HR =

= 998 gPM @ DATA LOGGER

&

18 PULSES/113 SEC = 573/HR = 57,300 gal/H

998 gpm ≈ 955 gPM

*1 10 COUNTS / 39.9 SEC = $\frac{3600}{(39.9/10)} \times 1.5 =$ 1353 KW

5 REVS / 28.69 SEC = (3.6)(CTR)(PTR)(K_h)(REV) ÷ (SEC)
= (3.6)(20)(60)(1.8)(5) ÷ 28.69 =
= 1355 KW

---

*2 HOURLY DATA FOR THIS CHANNEL = HOURLY DATA FROM SOUTHERN UNION GAS COMPANY.

---

*3 5 PULSES PER 44.46 SEC = $\frac{3600}{44.46}(5)(1.2) =$ 486 KW

715 AMPS AVG @ MSB = $P = \frac{I V \sqrt{3}\, pf}{1000}$
$= \frac{(715)(480)(\sqrt{3})(.85)}{1000} =$ 505 KW

---

*4 (1) PULSE PER 13.85 SEC AVG = $\frac{3600}{13.85} \times .6 =$ 156 KW

218 AMPS AVG @ DISCONNECT = $P = \frac{I V \sqrt{3}\, P_f}{1000}$
$= \frac{(218)\cdot(480)(1.732)(.85)}{1000} =$ 154 K

---

*5 39 PULSES / HR = 3900 K BTU/HR @ LOGGER

1 PULSES / 92 SEC = 3913 K BTU/HR @ DK

@ 3900K BTU/HR & 75500 gal/HR ΔT = 6.2 °F

—— ACTUAL ΔT @ FACILITIES TEMP SENSORS = $T_R - T_S = 48° - 41° = \Delta T = 7°F$

H
FLOW
SEARCH
LOW
METER

---

*6 755 PULSES / HR = 75,500 gal/HR = 1258 gpm @ logger

19 PULSES / 92 SEC = 743/HR = 74300 gal/HR = 1239 gpm @ DK

ALSO! @ DK TEMP PROBES
$T_R = 21.07 k\Omega \simeq 48°F$
$T_S = 25.45 k\Omega \simeq 41°F$
$\Delta T = 7°F$

WITH
LOW RESEARCH
FLOW METER.

FORM #: INSTALL4; REV 5/30/90

PH (409) 740-5724

DIGITAL CHANNEL VERIFICATION

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials (B)

LOGGER ID 01651N LOGGER SERIAL# 1651

SEE BACK

	CHAN	SENSOR TYPE	UNITS	SCALE	VERIFICATION LOGGER PULSES/TIME	VERIFICATION MEASURED UNITS/TIME		
*1	0	KWH	KWH	1.5	10/39.9 SEC	5 REV/28.64 SEC	WHOLE CAMPUS ELEC MTR.	PULSE INITIATOR @ POLE.
*2	1	FLOW	MCF	1	23/HR	23/HR	WHOLE CAMPUS GAS MTR.	PULSE INITIATOR @ METER.
*3	2	KWH	KWH	1.2	5/44.46 SEC	715 AMPS AVG	C.U.P OLD SVC ELEC	WL 3968 @ MSB-1R.
*4	3	KWH	KWH	.6	4/13.85 SEC	218 AMPS AVG	C.U.P. NEW SVC ELEC	WL 3968 @ MSB-2.
WITH FLOW RESEARCH *5	4	CHW BTU	KBTU	100	34/HR	1/92 SEC	WHOLE CAMPUS CHW BTU MTR.	DK 90 @ CHWR & CHWS LO
WITH FLOW RESEARCH *6	5	CHW FLOW	GAL	100	755/HR	19/92 SEC	WHOLE CAMPUS CHW FLOW MTR.	DK 90 @ CHWR-LOOP.
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
WITH DATA INDUSTRIAL *7	5	CHW BTU	KBTU	100	32/HR	1/113 SEC	WHOLE CAMPUS CHW BTU MTR.	WITH DATA INDUSTRY FLOW METER.
WITH DATA INDUSTRIAL *7	6	CHW FLOW	GAL	100	599/HR	18/113 SEC	WHOLE CAMPUS CHW FLOW MTR.	WITH DATA INDUSTRY FLOW METER.

↑ # 5 & 6 W/FLOW RESEARCH FLOW METER

*7 SEE NEXT PAGE

FO. #: INSTALLS: REV 5/30/90

ELECTRIC POWER CHANNEL VERIFICATION

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

LOGGER ID 01651N LOGGER SERIAL# 1651

CHAN	NODE NAME	PHASE	CT CODE	# of CT's	CONN TYPE	FULL SCALE AMPS	VERIFICATION LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		

N/A DATA MATE #20

FORM #: INSTALL5; REV 5/30/90

INSTALLATION CHECKLIST

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials CB

✓ 1. Connected load verification complete.

✓ 2. Communications connect check successful.

✓ 3. Panels marked to indicate location of power for monitoring equipment.

✓ 4. Warning labels posted on each monitored panel and on each data recorder.

✓ 5. Location of all metering equipment identified for site contact, BOBBY & FRED.

✓ 6. Location of breakers powering data recorders identified for site contact.

✓ 7. Actual hardware use recorded.

✓ 8. Acceptance test performed in presence of TEES representative, if requested.

✓ 9. Submit verification package to TEES.

____ 10. Installation re-work report complete (if punch list received from TEES).

____ 11. Installation approved by TEES.

FORM #: INSTALL4; REV 5/30/90 ANALOG

CHANNEL VERIFICATION

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [initials]

LOGGER ID 01651N LOGGER SERIAL# 1651

CHAN	SENSOR TYPE	UNITS	SCALE	VERIFICATION LOGGER PULSES/TIME	VERIFICATION MEASURED UNITS/TIME
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

N/A DATAMATE #20

FORM #: INSTALL6; REV 1/15/91

INVENTORY TRANSFER

TRANSFER FROM: STOCK

Site ID STOCK Building ID N/A Date 10-28-91 Initials [initials]

TRANSFER TO:

Site ID 0061 Building ID TAMU GALVESTON Date 10-28-91 Initials [initials]

The following items are provided by NCAT to:

SITE #006 - TAMU GALVESTON

Quantity	Description	P.O.#	Cost
6	2-CONDUCTOR TERMINAL BLOCKS	from Stock	
22	1-CONDUCTOR TERMINAL BLOCKS	" "	
8	2 AMP IN-LINE FUSES & HOLDERS	" "	
3	1 AMP IN-LINE FUSES & HOLDERS	" "	
4	10 x 10 x 4 JB w/ SC	" "	
2	6 x 6 x 4 JB w/ SC	" "	
2	1900 JB w/ SC	" "	
40 ft	1/2" EMT	" "	
2400 ft	2 PR. CABLE	" "	
210 ft	1 PR. CABLE	" "	
160 ft	4 COND. CABLE	" "	
MISC	FTGS, CONNECTORS, TIE WRAPS	" " (CONSUMABLES)	

[signature]

NCAT representative

Received by: ______________________ ______________

Name, title Date

FORM #: INSTALL6; REV 1/15/91

INVENTORY TRANSFER [redacted]

TRANSFER FROM:
Site ID [redacted] Building ID UT PAN AM Date 8/~~21~~/91 Initials CH

TRANSFER TO:
Site ID [redacted] Building ID / Date / Initials CH

The following items are provided by NCAT to:

TAMU GALV. SITE #006

Quantity	Description	P.O.#	Cost
1	ROLL PULL STRING	(REPO #1753 PO # 6580)	

____
NCAT representative

Received by: ______________________ ______________
Name, title Date

FORM #: SITEMAP1; REV 6/25/90

SITEMAP CHECKSHEET

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91

1. SITEMAP Checksheet Complete ✓
2. Electric Power Channel Assignment ✓
3. Digital Channel Assignment ✓
4. Equations ✓
5. Shunted CT Requirements Worksheet ✓
6. Non-Shunted CT Requirements Worksheet ✓
7. Cable Requirements Worksheet ✓
8. Multi-pair Cable Guide ✓
9. Hardware Requirements ✓
10. Site Cost Spreadsheet ✓
11. Data Logger Equipment Locations ✓
12. SITEMAP Sketch ✓

FORM #: SITEMAP2; REV 6/25/90

ELECTRIC POWER CHANNEL ASSIGNMENT FORM

PH 409 740 5724

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

LOGGER ID 0165IN LOGGER SERIAL# 1651

CHAN	NODE NAME	CIRCUIT DESCRIPTION	END USE	PHASE (HI-Ref)	Low Ref	PT #	CT TYPE	# of CT's	CONN TYPE	FULL SCALE AMPS	VOLT CONF	COMMENTS
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

*1 PT1 Node: N/A Brkr: ______ Volt Config: ______ Total Combiner Boards: ______

PT2 Node: N/A Brkr: ______ Volt Config: ______

*2 Bell XFmr Node: NORTH OUTLET Brkr: BY DESK (1) 2A IN LINE FUSE

Comments: *2 (2) 24 VAC XFMRS @ OUTLET IN 10x10x4 JB W/(1) 2A IN LINE FUSE

*1 NOTE: (2) KWH REF VOLTS / INSTR POWER DETAILED ON SITEMAP #1.

FORM #: SITEMAP3; REV 6/25/90

PH 4097405724

DIGITAL CHANNEL ASSIGNMENT FORM

Site ID 135N / 006 Building ID TAMU / GALV Date 10-30-91 Initials [illegible]

LOGGER ID 01651 N LOGGER SERIAL# 1051

CHAN	SENSOR TYPE	DESCRIPTION	SEARCH STRING	SCALE	UNITS	METER #	LOCATION	COMMENTS
0	KWH	WHOLE CAMPUS ELEC. MTR	MTRA	1.5	kwh	82204938	UTILITY POLE	WEST SIDE OF CAMPUS
1	FLOW	WHOLE CAMPUS GAS MTR.	GASF	1	MCF	MERCER EC.	UTILITY METER	WEST SIDE OF CAMPUS
2	KWH	C.U.P. OLD SVC. ELEC. MTR.	MTRB	1.2	kwh	WL3468	C.U.P. @ MSB 1	BLDG 3001
3	KWH	C.U.P. NEW SVC ELEC. MTR.	MTRC	.6	kwh	WL3468	CUP @ MSB 2	" "
4	BTU	WHOLE CAMPUS CHW BTU MTR	CHWB	100	KBTU	DK 90	CUP @ CHWS & R	" "
5	FLOW	WHOLE CAMPUS CHW FLOW MTR	CHWF	100	GAL	DK 90	CUP @ CHWR	" "
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

COMMENTS:

FORM #: SITEMAP3; REV 6/25/90 ANALOG

CHANNEL ASSIGNMENT FORM

Site ID 135N 006 Building ID TAMU GALVESTON Date 10-30-91 Initials [illegible]

LOGGER ID 01651N LOGGER SERIAL# 01651

CHAN	SENSOR TYPE	DESCRIPTION	SEARCH STRING	SCALE	UNITS	METER #	LOCATION	COMMENTS
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

COMMENTS: NOT APPLICABLE FOR DATA MATE #20

TAMU @ GALVESTON

.... Configuration for Logger: 1651 Parameter Set Code: N ....

----- DIGITAL CHANNELS -----

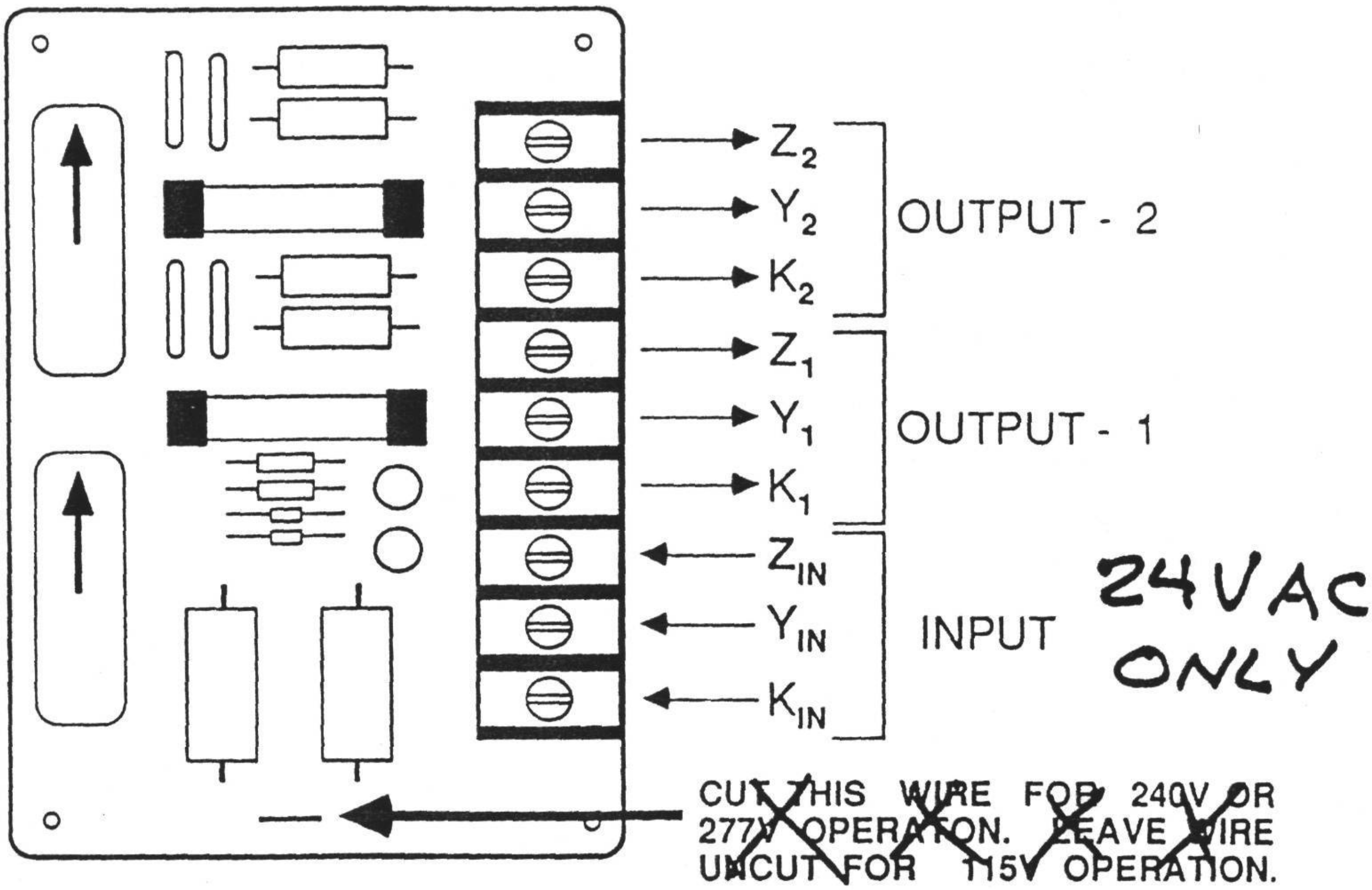
Chan	Description	Search String	STA	Scale	Units	TSR	AVG	RTS
D 0	CAMPUS ELEC ENER	MTRA	ON	1.5	KWH	*		
D 1	CAMPUS GAS FLOW	GASF	ON	1	MCF	*		
D 2	C.U.P.ELEC ENER	MTRB	ON	1.2	KWH	*		
D 3	C.U.P.ELEC ENER	MTRC	ON	.6	KWH	*		
D 4	CAMPUS CHW BTU	CHWB	ON	100	MBTU	*		
D 5	CAMPUS CHW FLOW	CHWF	ON	100	GAL	*		
D 6			ON	1		*		
D 7			OFF	0				
D 8			OFF	0				
D 9			OFF	0				
D10			OFF	0				
D11			OFF	0				
D12			OFF	0				
D13			OFF	0				
D14			OFF	0				
D15			OFF	0				

Chan	Field Notes
D 0	WHOLE CAMPUS ELECTRICAL ENERGY; METER @ POLE ON NORTH SIDE OF CAMPUS.
D 1	WHOLE CAMPUS GAS FLOW; METER @ GAS SERVICE ON NORTH SIDE OF CAMPUS.
D 2	C.U.P. ELECTRIC ENERGY OLD SVC; EQUIP @ MSB 1R & MCC 1,CUP BLDG.
D 3	C.U.P. ELECTRIC ENERGY NEW SERVICE; EQUIP @ MSB 2 (chiller # 3)
D 4	WHOLE CAMPUS CHILLED WATER BTU ENERGY; EQUIP IN C.U.P. BLDG.
D 5	WHOLE CAMPUS CHILLED WATER FLOW; EQUIP IN C.U.P. BLDG.
D 6	
D 7	
D 8	CHANNELS D0 HAS EQUIPMENT FOR SPLITTING SIGNAL LOCATED IN THE
D 9	ELECTRIC VAULT BLDG LOCATED ON THE NORTH SIDE OF CAMPUS BETWEEN THE
D10	ELECTRIC METER AND THE GAS METER.
D11	
D12	TEXAS A & M UNIVERSI[illegible]
D13	MITCHELL CAMPUS - PELICAN ISLAND
D14	GALVESTON, TX [illegible]
D15	LOGGER PHONE NUMBER (409) 740-572[illegible]

NOTE: D1 CAMPUS GAS FLOW SHOWS A SCALE OF 1MCF.

RPR-2

RELAY INSTALLATION INSTRUCTIONS
PULSE ISOLATION RELAY · 2 ISOLATED OUTPUTS



INPUT

The AC line's L_1 voltage (or the DC's negative voltage) should be connected to the K_{in} terminal on the RPR-2 relay. The AC line's L_2 voltage (or the DC's positive voltage) should be connected to the K_{out} terminal on the pulse source (meter). Connect the RPR-2's Y_{in} terminal to the pulse source's Y_{out} terminal. Connect the RPR-2's Z_{in} terminal to the pulse source's Z_{out} terminal.

OUTPUT

The outputs are by terminals K_1, Y_1, & Z_1, and K_2, Y_2 & Z_2. Output load currents should be limited to 1 Amp. by fuses F_1 and F_2. Output transient protection is provided.

MOUNTING

The RPR-2 relay must be mounted in a vertical position for the mercury wetted relays to operate correctly. Make sure that the arrows on the relays are pointed upward when mounted.

SOLID STATE INSTRUMENTS INC.
DENVER, COLORADO 80221 (303) 452-2604

COTEMP
CHILLER SERVICES, INC.

P.O. BOX 7373
HOUSTON, TEXAS 77248-7373
(713) 869-4861
FAX: (713) 869-0512

NO. 911015

DATE: 10-11-91

CHARGE TO: NCAT- The National Center for
Appropriate Technology
3408 Owen Ave.
Austin, Tx 78705
Chuck Bohmer

PURCHASE ORDER NO.

JOB # C91587

INVOICES PAYABLE IN HOUSTON, TEXAS UPON RECEIPT

TERMS: NET CASH
10% PER ANNUM LATE CHARGE

DATE	DESCRIPTION OF SERVICE AND PARTS	AMOUNT
	GALVESTON Site #006 Contract #021 Labor and material to make three hot tpas on one chilled water service entrances as specified. Quote	$875.00
	Approved for Payment 10/21/91 Chuck Bohmer	

PLEASE REMIT FROM THIS INVOICE

LICENSE NO. HOU 673, GALV 121, TACLA127

APPENDIX F

PreMAP, SiteMAP, and INSTALL Forms

FORM #: PREMAP2; REV 6/25/90

GENERAL SITE INFORMATION FORM

Site ID:____ Date:___________ Initials:_______

SITE NAME: ____________________________

Address: ____________________________ City ______________________

SITE CONTACTS:

Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

UTILITY CONTACTS:

Utility: (electric)______________
Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Utility: (gas)______________
Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Utility: ________________________
Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Utility: ________________________
Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Number of Monitored Buildings at site: ____

(Make one copy for each building notebook.)

FORM #: PREMAP3; REV 6/25/90

GENERAL BUILDING INFORMATION FORM

Site ID ____ Building ID _____ Date ________ Initials __________

Building name: ______________________________

Address: ______________________________

City: ______________________________ Zip: _______

BUILDING CONTACTS:

Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Name: ________________________
Title: ________________________
Address: ________________________
____
____
Phone: ________________________

Level of monitoring:

__ 0 (Pulse output electric meter, no DAS)
__ 1 (Meter plus 1-5 channels)
__ 2 (Meter plus 5-20 channels)
(PREMAP/SITEMAP budget limit = $1500 without prior written approval.)
__ 3 (Meter plus 20 or more channels)
(PREMAP/SITEMAP budget limit = $3000 without prior written approval.)

Thermal energies monitored:

Y N N/A Chilled water

Y N N/A Steam condensate

Fuels monitored:

Y N N/A Gas

Y N N/A Oil

FORM #: PREMAP4; REV 6/25/90

BUILDING TOUR INFORMATION FORM

Site ID ____ Building ID ____ Date ________ Initials ________

ELECTRICAL METERING and DISTRIBUTION

Date ____________ Time: ________ Tour guide: __________________

ELECTRICAL SYSTEMS in BUILDING

Date ____________ Time: ________ Tour guide: __________________

STEAM/CONDENSATE

Date ____________ Time: ________ Tour guide: __________________

CHILLED WATER

Date ____________ Time: ________ Tour guide: __________________

TELEPHONES

Date ____________ Time: ________ Tour guide: __________________

MECHANICAL EQUIPMENT LOCATIONS

Date ____________ Time: ________ Tour guide: __________________

ASBESTOS INSPECTION:

Date ____________ Time: ________ Tour guide: __________________

FORM #: PREMAP5; REV 6/25/90

OPERATIONAL/INSTALLATION CONSTRAINTS

Site ID ____ Building ID _____ Date ________ Initials __________

Schedule limitations: ____

____

____

____

____

Loads affected by power interruption:

COMPUTERS ALARMS TELEPHONE TIMERS HVAC OTHER NONE

____

____

____

Special restart procedures: ____

____

____

____

Limited access areas: ____

____

____

____

Aesthetic sensitivities: ____

____

____

____

Other Factors: ____

____

____

____

____

FORM #: PREMAP6; REV 6/25/90

RISER DIAGRAM

Electric______ Gas______

Site ID ____ Building ID _____ Date ________ Initials __________

(Include transformers with voltages above and below.)

FORM #: PREMAP7; REV 6/25/90

RISER INFORMATION FORM

Site ID ____ Building ID _____ Date ________ Initials __________

MONITORED NODES

Node Type	Node Name	Location	Voltage Config.	Volts	Current Rating	Served From		

FORM #: PREMAP8; REV 5/30/90

SERVICE ENTRANCE INFORMATION -- 1

Site ID ____ Building ID _____ Date ________ Initials __________

ELECTRIC METERS and FEEDS

METER ID ___ METER # _________
Location ____________________
If paired, Left____ Right_____
Mfg.______________ Model _____
Year mfg. _____
KYZ? Y N Available? Y N
Multiplier or "k" ________
K_h _____; CT: ____ ;PT: ____
Measured time for __ rev.: ___ seconds
Measured kW: _________
Secondaries:
Rated bus or disconnect amps ____ volts ____
Type _______________________
Sub-feeds to outdoor/other bldgs? Y N
Monitoring point location: _______________

METER ID ___ METER # _________
Location ____________________
If paired, Left____ Right_____
Mfg.______________ Model _____
Year mfg. _____
KYZ? Y N Available? Y N
Multiplier or "k" ________
K_h _____; CT: ____ ; PT ____
Measured time for __ rev.: ___ seconds
Measured kW: _________
Secondaries:
Rated bus or disconnect amps ____ volts _
Type _______________________
Sub-feeds to outdoor/other bldgs? Y N
Monitoring point location: _______________

Comments:

METER ID ___ METER # _________
Location ____________________
If paired, Left____ Right_____
Mfg.______________ Model _____
Year mfg. _____
KYZ? Y N Available? Y N
Multiplier or "k" ________
K_h _____; CT: ____ ;PT: ____
Measured time for __ rev.: ___ seconds
Measured kW: _________
Secondaries:
Rated bus or disconnect amps ____ volts ____
Type _______________________
Sub-feeds to outdoor/other bldgs? Y N
Monitoring point location: _______________

METER ID ___ METER # _________
Location ____________________
If paired, Left____ Right_____
Mfg.______________ Model _____
Year mfg. _____
KYZ? Y N Available? Y N
Multiplier or "k" ________
K_h _____; CT: ____ ;PT: ____
Measured time for __ rev.: ___ seconds
Measured kW: _________
Secondaries:
Rated bus or disconnect amps ____ volts
Type _______________________
Sub-feeds to outdoor/other bldgs? Y N
Monitoring point location: _______________

Comments:

GAS METERS

METER ID	METER #	MFG. & MODEL	LOCATION	EXISTING PULSE INIT.?	TYPE OF GAS	STORAGE CAPACITY	MEASU CU.FT/S
____	__________	__________	__________	Y N	_____	________	____/_
____	__________	__________	__________	Y N	_____	________	____/_
____	__________	__________	__________	Y N	_____	________	____/_

New meter location:

FORM #: PREMAP9; REV 6/1/90

SERVICE ENTRANCE INFORMATION -- 2

Site ID ___ Building ID ____ Date _______ Initials _________

STEAM

Number of feeds, building total ______

Feed ID _______ Location _________________________
High pressure: Pipe size _____ Pressure _________ Temp._______
Low pressure: Pipe size _____ Pressure _________ Temp._______
Reducing valve: Mfg. ___________ Model ________ Capacity __________
Existing flow meter? Y N Calibration ________ Measured __________

New meter location:

Feed ID _______ Location _________________________
High pressure: Pipe size _____ Pressure _________ Temp._______
Low pressure: Pipe size _____ Pressure _________ Temp._______
Reducing valve: Mfg. ___________ Model ________ Capacity __________
Existing flow meter? Y N Calibration ________ Measured __________

New meter location:

CONDENSATE RETURN

Number of condensate lines from building, total ______

Line ID _______ Location _________________________
Pump HP ____ Measured amps ______ Label flow _______ Pump outlet diameter ______
Return line diameter ______ Receiver capacity, gallons _______ Gravity return? Y N
Existing flow meter? Y N Calibration ________ Measured __________
Measured pump output: _________/_______ = _________gpm.
quantity / time.
New meter location: ____________________

Line ID _______ Location _________________________
Pump HP ____ Measured amps ______ Label flow _______ Pump outlet diameter ______
Return line diameter ______ Receiver capacity, gallons _______ Gravity return? Y N
Existing flow meter? Y N Calibration ________ Measured __________
Measured pump output: _________/_______ = _________gpm.
quantity / time

New meter location:

SERVICE ENTRANCE INFORMATION -- 3

Site ID ____ Building ID ____ Date ________ Initials __________

CHILLED WATER

Number of feeds, building total ______

Feed ID ________ Location ______________________________
Pipe sizes: Supply ______ Return ______ Calibration ____________
Existing flow meter type ____________________ Return temp ________
Measured: Flow rate __________ Supply temp ______
CHW pumps, label data HP: 1. ______ 2. ______ 3. ______
CHW pumps, label data gpm: 1. ______ 2. ______ 3. ______
CHW pumps, measured inlet pressure: 1. ______ 2. ______ 3. ______
CHW pumps, measured outlet pressure: 1. ______ 2. ______ 3. ______
New flow meter location: ____________________
CHW supply temp sensor location: ____________________
CHW return temp sensor location: ____________________

Feed ID ________ Location ______________________________
Pipe sizes: Supply ______ Return ______ Calibration ____________
Existing flow meter type ____________________ Return temp ________
Measured: Flow rate __________ Supply temp ______
CHW pumps, label data HP: 1. ______ 2. ______ 3. ______
CHW pumps, label data gpm: 1. ______ 2. ______ 3. ______
CHW pumps, measured inlet pressure: 1. ______ 2. ______ 3. ______
CHW pumps, measured outlet pressure: 1. ______ 2. ______ 3. ______
New flow meter location: ____________________
CHW supply temp sensor location: ____________________
CHW return temp sensor location: ____________________

OIL

Number of feeds, building total ______

Feed ID ________ Location ____________________ Tank capacity ________
Pipe size ______ Pump HP ______ Label flow ________
Burner input capacity ________

Feed ID ________ Location ____________________ Tank capacity ________
Pipe size ______ Pump HP ______ Label flow ________
Burner input capacity ________

M #: PREMAP11: REV 5/30/90

BUILDING EQUIPMENT LIST

Page __ of __

.e ID ____ Building ID _____ Date ________ Initials __________

From: __Drawing __Audit __Site visit

			Electric Inputs					Other Inputs		Output					
pt. ID	Description	Area Served	Volts	Amps	No. of Phases	Capa- city	Units	Fuel Type	Rate	Rate	Units	Measured data	Comments	Node name	Breaker Numbers

FORM #: PREMAP12; REV 6/25/90

PANEL DOCUMENTATION FORM

Site ID ____ Building ID _____ Date _________ Initials __________

PANEL ID: ________________ ___Left ___Right

Location: Floor ____ Room ____

From: ___Drawing ___Audit ___Site visit

Onto floor plan? _____

Fed from: ________________

Phase	A	B	C
Line Volts	_____	_____	_____
Rated Amps	_____	_____	_____
Meas Amps	_____	_____	_____
Wire size	_____	_____	_____
CT Quantity	_____	_____	_____
CT Type	_____	_____	_____
Logger ID	_____	_____	_____
Channel No.	_____	_____	_____

Breaker Capacity A	B	C	No.	Circuit Description	Meas Amps	Wires/ phase	Wire diam	End use	Logger ID	Chan-nel	CT type	Remarks

FORM #: PREMAP13; REV 6/25/90

SWITCHGEAR DOCUMENTATION FORM

Site ID ____ Building ID _____ Date ________ Initials __________

SWITCHGEAR ID: ____________________

Location: Floor ____ Room ____

From: ___Drawing ___Audit ___Site visit

Onto floor plan? _____

Fed from: ________________

Phase	A	B	C
Line Volts			
Rated Amps			
Meas Amps			
Wire size			
CT Quantity			
CT Type			
Logger ID			
Channel No.			

SW. #	Switch ID	Description	H.P.	PH.	Fuse amps	Meas amps	Wires/ phase	Wire diam	End use	Logger ID	Chan-nel	CT Type	Remarks
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									
				A									
				B									
				C									

FORM #: PREMAP15; REV 6/25/90

FLOW SENSOR REQUIREMENTS SITESHEET

Site ID ____ Building ID _____ Date ________ Initials __________

Location	Chilled water BTU meters	Condensate Flow meters
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
TOTALS:	______	______

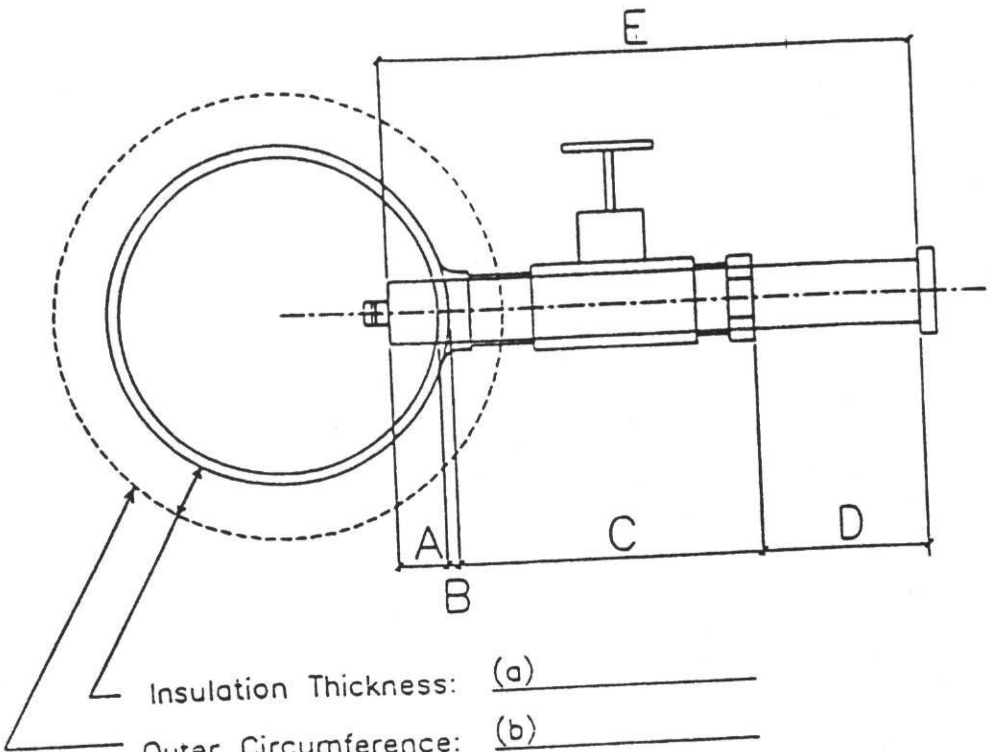
AGGIE FLOWMETER INSERTION DEPTH TABULATOR

Site ID: ________ Building Name: ______________________

Installation Date: ____________ DK S4 Switch Setting ________

Flowmeter Description: ____________ Line Description: ____________

Serial # Installed: ____________ Serial # Removed: ____________



Insulation Thickness: (a) ____________

Outer Circumference: (b) ____________

Calculated Pipe O.D.: (c) ____________ c=b/3.141−2*a

Nominal Pipe Size: ____________

A) Insertion Depth ____________

B) Pipe Thickness ____________

C) Pipe to Hex Fitting ____________

D) Hex Fitting to Inside of FM ____________ D=E−(A+B+C)

E) Flow Sensor Length ____________ Data Industrial=16.375 Flow Research=14.625

Note: Remember to Verify Orientation of Flow Meter Body with Pipe

VERIFICATION

	Time (seconds)	Counts	Parameter Set Scale	Rate	
Flow	(a) ______	(b) ______	(c) ______	(d) ______ (gpm)	d=60*b*c/a
Btu	(e) ______	(f) ______	(g) ______	(h) ______ (kbtu/hr)	h=3600*f*g/e

ΔT ____________ ΔT=2*h/d (normally between 2 and 20 degrees F)

FORM #: PREMAP16; REV 5/30/90

Site ID ____ Building ID _____ Date ________ Initials __________

PHONE LINE ORDER FORM

PHONE CO. VERBIAGE = NEW SINGLE LINE, EXISTING ACCOUNT, NEW LOCATION

Site Name:

New Service Address:

Phone Company Order Center (Indicate the office for the above location.)
Phone number:

Arlington
Austin
Dallas
Denton
Galveston
Houston
Lubbock
San Antonio
Other:

Existing Account Number:

Name of Business:

Send Billing To:

Service Info:
- Install single line touch tone service
- Install single RJ11 jack at the location specified
- Number should be UNLISTED
- NO wire warranty
- ATT long distance carrier

Location of Jack:

Site Contact Name:
Phone:

Alternate Name:
Phone:

--------- FILL THIS OUT WHEN ORDERING THE PHONE LINE: ---------

Installation Date and Time :

New Phone Number:

Telephone Co. Order Number:

FORM #: PREMAP17; REV 6/25/90

SPECIAL EQUIPMENT REQUIREMENTS

Site ID ____ Building ID _____ Date ________ Initials __________

ADDITIONAL BREAKERS:

Node Name	Panel or Breaker Type	Volts	Snap or Screw?	Comments

J-BOX REQUIREMENTS:

# CT Junctions	Other Components	Location

OTHER SPECIAL EQUIPMENT:

____
____
____
____
____
____
____
____
____
____

FORM #: PREMAP18; REV 6/25/90

Site ID ____ Building ID _____ Date ________ Initials __________

EQUIPMENT LOCATION and ASBESTOS INSPECTION DOCUMENTATION

Location #	Equipment Type	Equipment location	Test results

LOCATION #

TEXAS LOANSTAR PROJECT

FUTURE EQUIPMENT LOCATION

BUILDING ______________________________

INSTITUTION ______________________________

EQUIPMENT TYPE ______________________________

NOTES ______________________________

____

____

QUESTIONS or EMERGENCIES, CALL
Texas A&M Energy Systems Lab
(409) 845-1560

BY: ____________

DATE: ____________

PLEASE DO NOT REMOVE THIS TAG UNLESS INSTALLING EQUIPMENT

FORM #: SITEMAP1; REV 9/14/94

SITEMAP CHECKSHEET

Site ID ____ Building ID _____ Date ________

---

1. SITEMAP Checksheet Complete ______
2. Electric Power Channel Assignment ______

3a. Digital Channel Assignment ______

3b. Analog Channel Assignment ______

4. Equations ______
5. Shunted CT Requirements Worksheet ______
6. Non-Shunted CT Requirements Worksheet ______
7. Cable Requirements Worksheet ______
8. Multi-pair Cable Guide ______
9. Hardware Requirements ______
10. Site Cost Spreadsheet ______
11. Data Logger Equipment Locations ______
12. SITEMAP Sketch ______

FORM #: SITEMAP2; REV 6/25/90

ELECTRIC POWER CHANNEL ASSIGNMENT FORM

Site ID ____ Building ID _____ Date ________ Initials __________

LOGGER ID __________ LOGGER SERIAL# _____________

CHAN	NODE NAME	CIRCUIT DESCRIPTION	END USE	PHASE (Hi-Ref)	Low Ref	PT #	CT TYPE	# of CT's	CONN TYPE	FULL SCALE AMPS	VOLT CONF	COMMENTS
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

PT1 Node: ____ Brkr: ________ Volt Config: _______ Total Combiner Boards: _________

PT2 Node: ____ Brkr: ________ Volt Config: _______

Bell Xfmr Node: ____ Brkr: ____

Comments:

FORM #: SITEMAP3a; REV 9/14/94

DIGITAL CHANNEL ASSIGNMENT FORM

Site ID ____ Building ID _____ Date ________ Initials __________

LOGGER ID __________ LOGGER SERIAL# _____________

CHAN	SENSOR TYPE	DESCRIPTION	SEARCH STRING	SCALE	UNITS	METER #	LOCATION	COMMENTS
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

COMMENTS:

FORM #: SITEMAP3b; REV 9/14/94

ANALOG CHANNEL ASSIGNMENT FORM

Site ID ____ Building ID _____ Date ________ Initials __________

LOGGER ID __________ LOGGER SERIAL# _____________

CHAN	SENSOR TYPE	DESCRIPTION	SCALE	OFF SET	UNITS	SNAP?	GATE?	LOCATION	COMMENTS
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

COMMENTS:

EQUATIONS

Site ID ____ Building ID _____ Date ________ Initials __________

```
'All referenced logger IDs in this file must be contained in
'the NETWORK.DRV file in PCDAS.
' Site Number  (required entry)
SITE = 781
' Energy End-Use Equations  (Units = KW) (OK to leave unused end uses blank)
' Format:  @AWN        power channel N on logger A
'          @AKN        apparant power channel N on logger A
'          @AVN        line voltage channel N on logger A
'          @ALN        line current channel N on logger A
'          @AAN        analog channel N on logger A
'          @ADN        digital channel N on logger A
'
' For Measurement Numbers Format: @MN where N is the measurement number
' The @ character is required for the CH2M and M2CH parsers
LITE =
SUPP =
RAFN =
AHUN =
AHUI =
HVAC =
CHWP =
COND =
DHWC =
SUMP =
EXTL =
MTRA =
PULS =
' Powerfactor End-Use Equations
LITF =
SUPF =
RAFF =
AHNF =
AHIF =
HVAF =
CHWF =
CONF =
DHWF =
SUMF =
EXTF =
' NonElectric End-Use Equations
CHIL =
STEM =
' Energy Balance Data Quality Criterion
' Format:    Title: Equation  (in terms of loggerID/channel number)


' Range check equations.  Required for all temperature sensors
RANGE:
' Repeat check equations.  Required for all temperature and GAS sensors
REPEAT:
REPEAT:
```

FORM #: SITEMAPS; REV 5/30/90

SHUNTED CT REQUIREMENTS WORKSHEET

Site ID ____ Building ID _____ Date ________ Initials __________

NODE	5 solid	30 solid	50 solid	50 split	100 solid	100 split	200 solid	200 split	400 solid	400 split	Other:	
TOTALS												

FORM #: SITEMAP6; REV 5/30/90

NON-SHUNTED CT REQUIREMENTS WORKSHEET

Site ID ____ Building ID _____ Date ________ Initials __________

NODE	KWH Transducers	5 solid	30 solid	50 solid	50 split	100 solid	100 split	200 solid	200 split	400 solid	400 split	Other:
TOTALS												

FORM #: SITEMAPB; REV 6/25/90

MULTI-PAIR CABLE GUIDE

Site ID ____ Building ID ____ Date ________ Initials ________

Logger ____

	Cable #	1	2	3	4	5
4-pair	Node name ...	____	____	____	____	____
	cable ID ...	____	____	____	____	____
	destination...	____	____	____	____	____
low/high						
black/white	1	____	____	____	____	____
brown/blue	2	____	____	____	____	____
red/green	3	____	____	____	____	____
orange/yellow	4	____	____	____	____	____
2-pair	Node name ...	____	____	____	____	____
	cable ID ...	____	____	____	____	____
	destination...	____	____	____	____	____
low/high						
blue/lt.blue	1	____	____	____	____	____
orange/lt. or.	2	____	____	____	____	____
1-pair	Node name ...	____	____	____	____	____
	cable ID ...	____	____	____	____	____
	destination...	____	____	____	____	____
low/high						
black/white	....	____	____	____	____	____
Phone wire	Node name ...	____	____	____	____	____
	cable ID ...	____	____	____	____	____
	destination...	____	____	____	____	____
green/red	....	____	____	____	____	____
black/yellow	....	____	____	____	____	____

FORM SITE MAP #9b: INVENTORY CONTROL, HARDWARE REQUIREMENTS TRANSFER FORM

Site ID ______ Building ID ______ Date ______ Initials ______

ITEM DESCRIPTION	QTY RECEIVED	P.O. #	QTY TRANSFR'D	QTY IN STOCK
C180-M1 DATA LOGGER				
C180-A-M1 DATA LOGGER				
C140-M1 DATA LOGGER				
C140-A-M1 DATA LOGGER				
DATA MATE M# ______				
DATA MATE M# ______				
POTENTIAL TRANSDUCER				
BELL TRANS 120 to 24VAC				
BELL TRANS 208/480-24VAC				
CT COMBINER BOARDS				
MODEM				
KWH TRANSDUCERS; M# ______				
KWH TRANSDUCERS; M# ______				
______ AMP CURRENT TRANS.				
CHW BTU/GAL METERS				
CHW TEMP SENSORS				
CHW FLOW METERS				
COND RET FLOW METERS 1 1/2"				
COND RET FLOW METERS 2"				
1 PAIR CABLE				
2 PAIR CABLE				
4 PAIR CABLE				
8 PAIR CABLE				
4 CONDUCTOR PHONE WIRE				
2 AMP INLINE FUSES & HOLDERS				
1 AMP INLINE FUSES & HOLDERS				
TERMINAL BLOCKS 1 CONDUCTOR				
TERMINAL BLOCKS 2 CONDUCTOR				
OTHER EQUIPMENT (DESC)				

______________________ Date ______________
representative

Received by: ______________________ Date ______________
Name, title

DATA LOGGER EQUIPMENT LOCATIONS

Site ID ___ Building ID ____ Date _______ Initials _________

LOGGER ID: _____

DATA LOGGER LOCATION: Level # _______ Room # _______ Wall: N S E W

REFERENCE VOLTAGE #1: Level # _______ Room # _______

Voltage configuration: ___ Node name ______________ Breaker # _______

Existing or install? New breaker description __________________________

REFERENCE VOLTAGE #2: Level # _______ Room # _______

Voltage configuration: ___ Node name ______________ Breaker # _______

Existing or install? New breaker description __________________________

LOGGER POWER SUPPLY: Level # _______ Room # _______

Voltage configuration: ___ Node name ______________ Breaker # _______

Existing or install? New breaker description __________________________

*** *** ***

BTU METER LOCATION: Level # _______ Room # _______ Wall: N S E W

BTU METER POWER SUPPLY: Level # _______ Room # _______

Voltage configuration: ___ Node name ______________ Breaker # _______

Existing or install? New breaker description __________________________

SITEMAP SKETCH
(Locations of monitoring equipment)

Site ID ____ Building ID ____ Date ________ Initials __________

Floor Number ____ of ____ ____ Above grade ____ Below grade

FORM #: INSTALL1; REV 5/30/90

PRE-INSTALLATION CHECKLIST

Site ID ____ Building ID _____ Date ________ Initials __________

____ SITEMAP approved by TEES

____ Electrician notified of special equipment requirements

Permits from:	Date Req.	Received
____________________	_______	____
____________________	_______	____
____________________	_______	____
____________________	_______	____

____ Installation scheduled with site contact Date ________ Time __________

____ Installation scheduled with electrician Date ________ Time __________

Appointments scheduled for:

____	Electric meter installation	Date ________	Time __________
____	Gas meter installation	Date ________	Time __________
____	Telephone line installation	Date ________	Time __________
____	Flow sensor installation	Date ________	Time __________
____	________________________	Date ________	Time __________
____	________________________	Date ________	Time __________

____ Written permission to interrupt service received (form INSTALL2)

____ Penetrations in occupied areas coordinated with building or site contact,

________________________.

FORM #: INSTALL2; REV 9/14/94

Request for Permission to Interrupt Service

Site ID ____ Building ID _____ Date ________ Initials ______

____, in the course of its work installing energy monitoring equipment for the Texas Engineering Experiment Station, will need to temporarily interrupt the following service:

Building: ______________________________________

Type of service to be interrupted: ________________

Date: ______________ Time: ______________________

Loads affected: ________________________________

____
DASS Representative

Approved by: ____________________

Title: _________________________

Date: __________________________

FORM #: INSTALL3; REV 5/30/90

ELECTRIC POWER CHANNEL VERIFICATION

Site ID ____ Building ID _____ Date ________ Initials __________

LOGGER ID __________ LOGGER SERIAL# _____________

CHAN	NODE NAME	PHASE	CT CODE	# of CT's	CONN TYPE	FULL SCALE AMPS	VERIFICATION LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.	LOGGER	MEAS.
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		

FORM #: INSTALL4a; REV 9/14/94

DIGITAL CHANNEL VERIFICATION

Site ID ____ Building ID _____ Date ________ Initials __________

LOGGER ID __________ LOGGER SERIAL# _____________

CHAN	SENSOR TYPE	DESCRIPTION	UNITS	VERIFICATION: LOGGER PULSES/TIME	VERIFICATION: MEASURED UNITS/TIME
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

FORM #: INSTALL4b; REV 9/14/94

ANALOG CHANNEL VERIFICATION

Site ID ____ Building ID _____ Date ________ Initials __________

LOGGER ID __________ LOGGER SERIAL# _____________

CHAN	SENSOR TYPE	DESCRIPTION	UNITS	VERIFICATION LOGGER VALUE	VERIFICATION MEASURED VALUE
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

INSTALLATION CHECKLIST

Site ID ____ Building ID _____ Date ________ Initials __________

____ 1. Connected load verification complete.

____ 2. Photos taken of installed equipment locations.

____ 3. Communications connect check successful.

____ 4. Panels marked to indicate location of power for monitoring equipment.

____ 5. Warning labels posted on each monitored panel and on each data recorder.

____ 6. Location of all metering equipment identified for site contact,

______________________.

____ 7. Location of breakers powering data recorders identified for site contact.

____ 8. Actual hardware use recorded.

____ 9. Acceptance test performed in presence of TEES representative, if requested.

____ 10. Verification package submitted to TEES.

____ 11. Installation re-work report complete (if punch list received from TEES).

____ 12. Installation approved by TEES.

FORM #: INSTALL6; REV 1/15/91

INVENTORY TRANSFER

TRANSFER FROM:

Site ID _____ Building ID _____ Date ______ Initials ______

TRANSFER TO:

Site ID _____ Building ID _____ Date ______ Initials ______

The following items are provided by NCAT to:

____

____

Quantity	Description	P.O.#	Cost
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________
______	____________________	__________	__________

____

representative

Received by: _________________________ _____________

Name, title Date

FORM #: INSTALL 7

EQUIPMENT CHANGE FORM

Site ID ________ Building ID _______ Date ________ Initials __________
Logger ID ____________ Channel ID ____________ Phone # ____________

Purpose of Change: _____ Scheduled maintenance / calibration check
_____ Equipment Failure
_____ Other ______________________________

Date and Time of Change ______________

PRE-CHANGE DATA:

Equipment Brand & Model # ____________________ Serial # __________
Input ______________________ Scale ______________________
Output ______________________ Offset ______________________

Equipment Type and Description ______________________________
____
____

Is Pre-change data salvageable? _______ Method of salvage? __________
____
____

Notes: ____
____
____

POST-CHANGE DATA:

New Equipment Calibration Date: ______________
Equipment Brand & Model # ____________________ Serial # __________
Input ______________________ Scale ______________________
Output ______________________ Offset ______________________

Equipment Type and Description ______________________________
____
____

Notes: ____
____
____

FORM #: INSTALL 8; REV 04/15/92

TIME SERIES RECORD PLOT CHECK FORM

Site ID________ Building ID_________ Date__________ Initials__________

Logger ID________________ Logger Serial#________________ Phone #____________________

CHAN	SENSOR TYPE	DESCRIPTION	CHANNEL LABELS	DATA RANGE	MAX VAL	MIN VAL	DIURNAL PERFORM	NOTES
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

APPENDIX G

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APPENDIX H

Sample Purchase Order