SOLAR/0001-77/15

Instrumentation Installation Guidelines

November 1, 1977

Contract EG-77-C-01-4049

United States Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

NOTICE

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IBM Corporation
Huntsville, AL 35805

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FOREWORD

The purpose of this document is to identify and describe the various activities which must be performed in instrumenting solar systems for evaluation of their performance. In addition, this document will define the responsibilities of ERDA, or ERDA's contractors, and the site contractor in the definition and installation of required instrumentation for monitoring solar energy systems.

An important goal of the National Solar Data Program is to establish the thermal performance characteristics of residential and commercial demonstration sites and to assure the dissemination of this information to all interested parties. In order to insure that uniform and comparable data are obtained from each solar site, a systematic approach to developing the data requirements, instrumentation techniques, and data analysis methods is being utilized. It is recognized that complete instrumentation and technical evaluation of each solar system/building/climate combination is not practical on all government sponsored solar demonstration sites. Therefore, only selected installations will be instrumented in the various U.S. geographic regions.

In order to meet the goals of the National Solar Data Program, carefully defined sensors, clearly defined installation techniques, and detailed utilization procedures are being used to minimize cost, provide uninterrupted scheduling, and reduce operational problems. Through clear communications in which both ERDA, ERDA's contractors, and the site contractor are active participants, a good instrumentation system can be implemented that will render valuable data to all present and future solar systems designers, contractors, and other data users.

ABBREVIATIONS

AGA	American Gas Association
AIP	Approved Instrumentation Plan
AUX	Auxiliary
AVG	Average
BTU	British Thermal Unit
CDPS	Central Data Processing System
CFH	Cubic Feet Per Hour
CIRC	Circulating
CLG	Cooling
CO	Company
COLL	Collector
COND	Conductor
CONV	Conversion
COP	Coefficient of Performance
DAA	Data Access Arrangement
DB	Dry Bulb
^oF	Degrees Fahrenheit
DHW	Domestic Hot Water
DIFF	Differential
DoD	Department of Defense
DRF	Deviation Requirement Form
ERDA	Energy Research & Development Administration
FAB	Fabrication
FT^2	Square Foot
GPM	Gallons Per Minute
GFE	Government Furnished Equipment
GSA	General Services Administration
HC	Heating & Cooling
DIA	Diameter
HTG	Heating
HP	Horsepower
HR	Hour
HUD	Housing & Urban Development
HVAC	Heating, Ventilating, & Air Conditioning
HX	Heat Exchanger
ISPI	Instrumentation System Planning Information
J-BOX	Junction Box
KWH	Kilowatt Hour
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NEMA	National Electrical Manufacturing Association
OPER	Operation
PN	Part Number
PSID	Pounds Per Square Inch Differential
RH	Relative Humidity
RTD	Resistance Temperature Detector
SDAS	Site Data Acquisition Subsystem
STD	Standard
TEMP	Temperature

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1.0 INTRODUCTION

In order to meet the data collection, performance evaluation, and data dissemination goals of the National Program for Solar Heating and Cooling, selected demonstration site contractor's must participate in the installation of a comprehensive instrumentation system on his project. This document provides the definition of the responsibilities of both the site contractor and ERDA in accomplishing the required instrumentation installation.

1.1 DATA COLLECTION

The goal of ERDA's data collection activity is to provide the information necessary for evaluation of the performance and operation of solar systems and subsystems under different climatic conditions. The information generated as a result of this data collection activity will be utilized to stimulate industrial and commercial capability, including that of small business, to produce and distribute solar heating and cooling systems and through widespread applications, to reduce the demand on conventional fuel supplies. This information will also be used to improve the general knowledge and understanding of solar energy systems, to develop definitive solar energy system performance criteria, to provide the basis for component system improvements and to estimate the economics of solar energy systems in reducing the consumption of conventional fuels. Results will be available for use by property owners, the building industry and related sections of the economy to compare costs and benefits of solar heating and cooling systems. This information will also provide the data base for design of new applications in the private sector. ERDA's Technical Information Center at Oak Ridge, Tennessee, will be the National Solar Heating and Cooling Data Bank and will be the focal point for distribution of this information.

1.2 DATA SYSTEM OVERVIEW

The Data System depicted in Figure 1-1 provides for the automatic gathering, conversion, transfer, reduction, and analysis of demonstration site data. This system is made up of three basic elements: installed sensors, a Site Data Acquisition Subsystem (SDAS), and a Central Data Processing System (CDPS). The process of collecting uniform and comparable data requires a thorough understanding of responsibilities and a close working relationship between ERDA and the site contractor. In order to evaluate performance, ERDA will specify type, number, and location of measurements based on required evaluation factors for a particular system. After approval by ERDA of final installation drawings incorporating the sensors, ERDA will furnish the sensors for site contractor installation. The site contractor will connect the output of each sensor to terminal strips in a junction box which is the interface to the Site Data Acquisition Subsystem (SDAS). The junction box will be furnished by ERDA along with a wire list or wiring information for identifying the terminals to which each sensor will be connected. The junction box output (terminals to output connectors) will be prewired prior to shipment to the site. ERDA will furnish, and mutually arrange with the site contractor to install the SDAS, ERDA will install the junction box/SDAS interface cables, and arrange for telephone coupler installation.

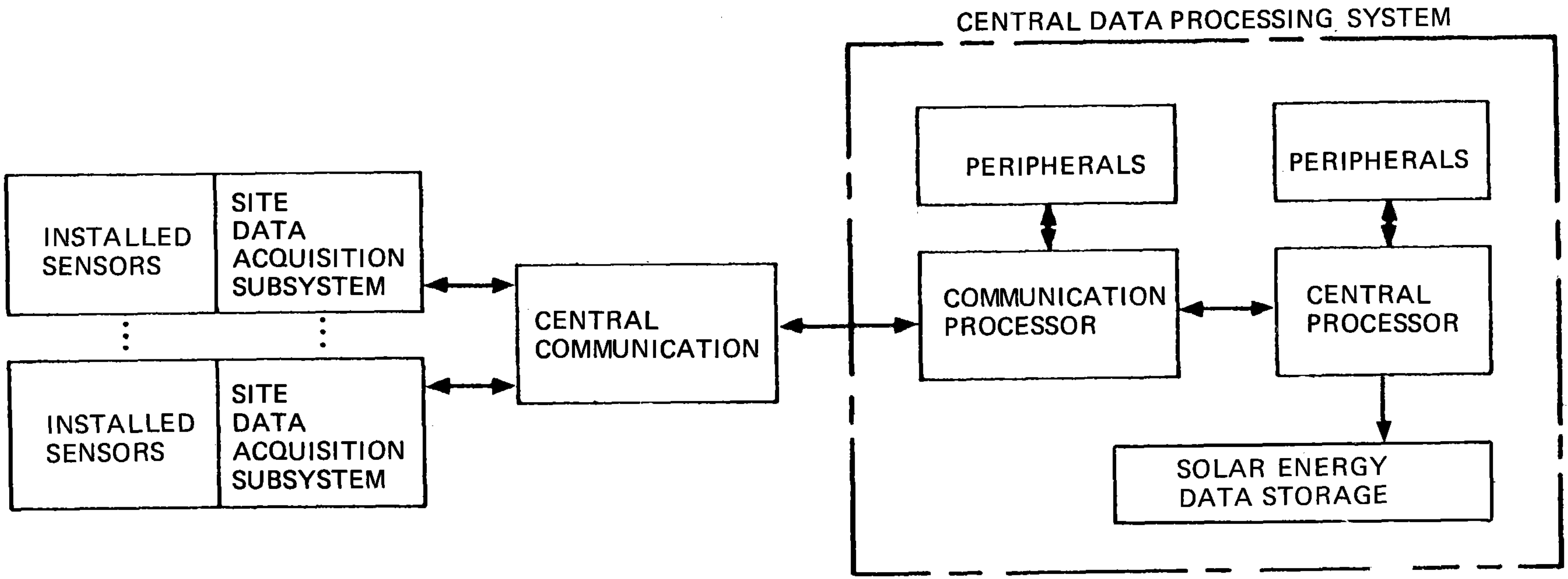


Figure 1-1. Data System (General)

The data will be gathered at each operational site at predetermined intervals of time and stored for transfer to the Central Processor. The collected data will be transferred via telephone communications upon request from the Central Data Processing Facility. At the Central Data Processing Facility, the collected data will be processed, analyzed, evaluated, and documented as Performance Evaluation Reports. Each site contractor will receive these reports for his site on a monthly basis.

1.3 INSTRUMENTATION PROCEDURE

Both ERDA and the site contractor have well defined responsibilities in accomplishing the required data collection activities. For cost effectiveness, a standard procedure will be followed in establishing the required instrumentation at each demonstration site. The procedure to be followed is listed in Table 1-1 and also shown as an activity flow in Figure 1-2.

1.3.1 TYPICAL ERDA/SITE CONTRACTOR AGREEMENT

ERDA will agree to supply to the site contractor the sensors required to implement the Approved Instrumentation Plan (AIP) plus the Site Data Acquisition Subsystem required to interface the sensors to the Central Data Processing System after the site is operational. ERDA also will provide the site contractor with performance reports for his site within thirty days after the end of each monthly performance evaluation period.

The site contractor will complete an Instrumentation System Planning Information (ISPI) Package from the guidelines set forth in this document. Once the Approved Instrumentation Plan (AIP) is established, the site contractor agrees to install the AIP sensors supplied by ERDA and verify correct wiring before the Site Data Acquisition Subsystem is installed. At the end of the test the site contractor will remove, upon ERDA's direction, all instrumentation which can be cost effectively removed and reused at another site.

TABLE 1-1. PROCEDURAL RESPONSIBILITIES FOR INSTRUMENTING SOLAR HEATING AND COOLING DEMONSTRATION PROJECTS

STEP NUMBER	ACTION BY	ACTION
1.	ERDA	Supplies to the site contractor copies of the "Instrumentation Installation Guidelines" and Instrumentation System Planning Information (forms) (ISPI) as shown in Appendix A.
2.	Site contractor	Prepares and submits completed Instrumentation System Planning Information (ISPI) as shown in Appendix A.
3.	ERDA	Reviews and modifies ISPI as necessary to comply with performance evaluation requirements.
4.	ERDA	Supplies site contractor with an Approved Instrumentation Plan (AIP).
5.	Site contractor	Incorporates AIP into final drawings then determines installation cost.
6.	Site contractor	Submits cost proposal to ERDA for implementing AIP.
7.	ERDA	Negotiates funding arrangement with the site contractor to implement the AIP and defines installation schedule.
8.	ERDA	Provides and ships all necessary instrumentation as Government Furnished Equipment to the demonstration site for site contractor installation.
9.	ERDA	Arranges for the installation of the necessary telephone transmission equipment to accommodate the Site Data Acquisition Subsystem (SDAS).
10.	Site contractor	Informs ERDA that the AIP has been implemented and that all wiring from J-Box to each sensor has satisfactorily undergone continuity and ground tests.
11.	ERDA	Delivers SDAS for site contractor to install and confirms the satisfactory transmission of the data to the Central Data Processing System.
12.	ERDA	Receives and evaluates the incoming performance data, and prepares monthly performance reports using standardized data reduction procedures.

TABLE 1-1. PROCEDURAL RESPONSIBILITIES FOR INSTRUMENTING SOLAR HEATING AND COOLING DEMONSTRATION PROJECTS (continued)

STEP NUMBER	ACTION BY	ACTION
13.	ERDA	Mails performance reports for each site to the respective site contractor within thirty days after the end of each performance period after the site is determined operational.
14.	ERDA	Negotiates funding and directs removal of SDAS and GFE from the site at the end of the test period.
15.	Site contractor	Upon ERDA's direction, removes all instrumentation defined by ERDA which can be cost effectively removed and returned to ERDA at the end of the test period.

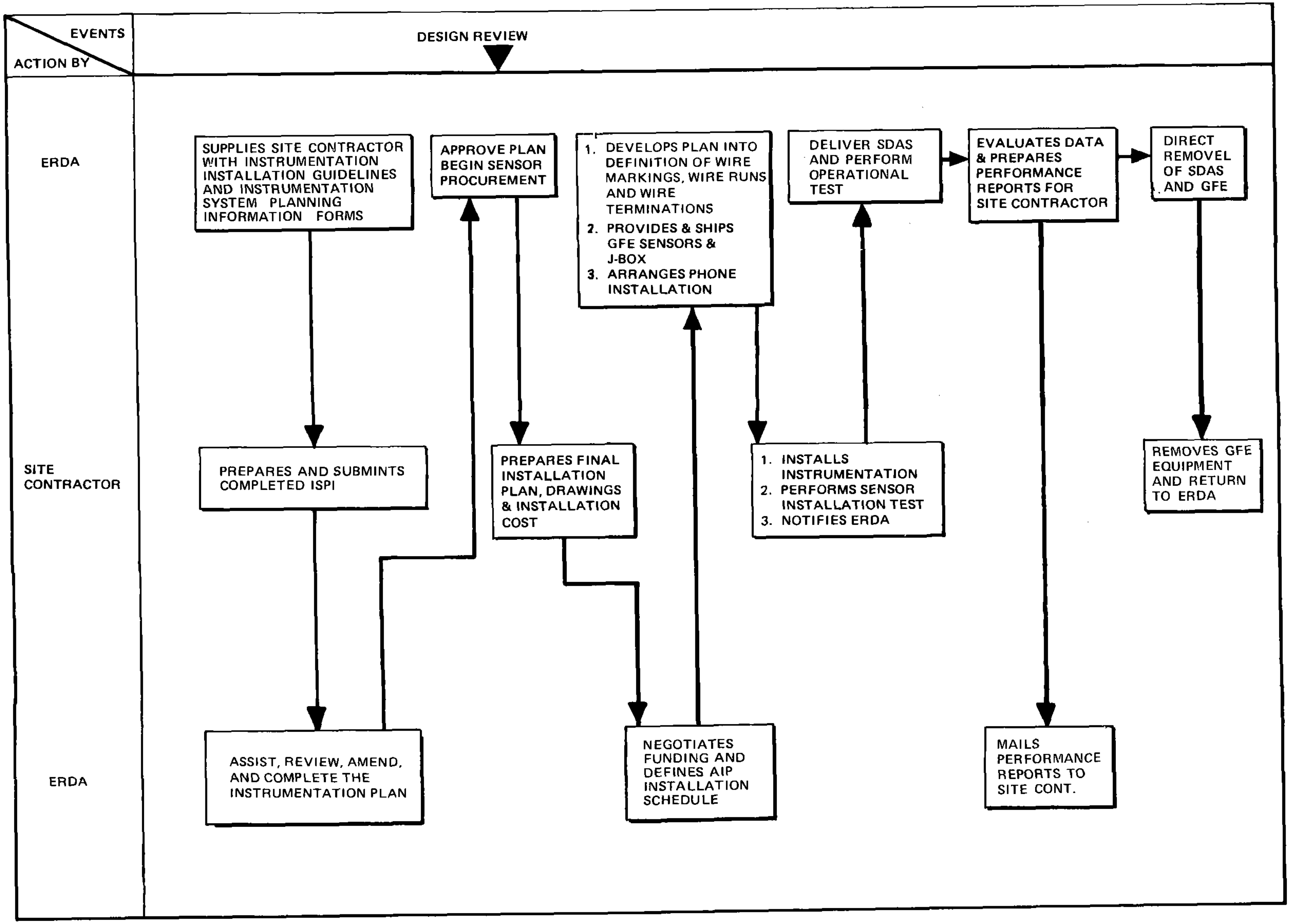


Figure 1-2. Instrumentation Installation Guidline Activity Flow

2.0 SITE CONTRACTOR DELIVERABLE ITEMS

After a thorough review and understanding of the guidelines presented in this document, the site contractor is responsible for delivering an Instrumentation System Planning Information (ISPI) package to ERDA so that approval can be accomplished in a timely and cost-effective manner.

2.1 INSTRUMENTATION SYSTEM PLANNING INFORMATION (ISPI)

The ISPI as shown in Appendix A is the vehicle used by the site contractor to communicate to ERDA all necessary information concerning his site that will be used in defining the location and type of instruments to monitor performance. All site contractor's are requested to follow the format and include additional information that would be considered beneficial.

3.0 INSTRUMENTATION REQUIREMENTS

The performance evaluation of a solar energy system requires that selected parameters be computed from data collected during actual system operation. These parameters, or performance evaluation factors, are based on a system and critical subsystem energy balance concept. The determination of these performance evaluation factors requires that each system be properly instrumented so that the required operational system measurements are made.

3.1 PERFORMANCE EVALUATION FACTORS

The technical performance evaluation of each solar energy system/building/climatic region demonstration will be based upon the following factors:

1. Determining the savings in fossil fuel and electrical energy resulting from the use of solar energy for space heating, space cooling, and/or hot water.

2. Determining the total heating, cooling and/or HW thermal energy loads, and the fraction of each load supplied by solar energy for monthly, seasonal, and/or annual periods.

3. Measuring the solar energy system efficiency for converting solar radiation into useful thermal energy for monthly and seasonal or annual periods.

4. Measuring the thermal performance of major subsystems or components and the thermal interactions between collector array, storage, and energy conversion equipment.

5. Measuring the occupants use of the system by means of parameters such as the temperature level maintained and hot water demand.

6. Determining the major system operational characteristics and degradation over the life of the demonstration.

7. Obtaining records of the incident solar radiation and other pertinent site environmental parameters that could affect the performance of the system over the life of the demonstration.

To develop these results, the appropriate performance factors from among those listed in Table 3-1 are computed for each installation. Table 3-1 is a representative list and is provided for information only.

3.2 SPECIFIC SENSOR LIST

An approved parts list of sensors which meet the requirements for the Solar Heating and Cooling Demonstration Program is shown in Table 3-2. These sensors are recommended for all Demonstration Program systems. Deviations from this list must be approved by ERDA.

TABLE 3-1. PRIMARY PERFORMANCE FACTORS (FOR TYPICAL ACTIVE SYSTEMS)

- Total Solar Energy Incident
- Average Ambient Dry Bulb Temperature
- Average Building Dry Bulb Air Temperature
- Solar Energy Collected
- Hot Water Load
- Space Heating Load
- Space Cooling Load
- Hot Water Electric Energy Savings
- Hot Water Fossil Fuel Energy Savings
- Space Heating Electric Energy Savings
- Space Heating Fossil Fuel Energy Savings
- Space Cooling Electric Energy Savings
- Space Cooling Fossil Fuel Energy Savings
- Solar Fraction of Hot Water Load
- Solar Fraction of Space Heating Load
- Solar Fraction of Space Cooling Load
- Total Energy Delivered to Building Load
- Total Solar Energy Utilized
- Total Electric Energy Saved
- Total Fossil Fuel Energy Saved
- Total Auxiliary Energy Used
- Total Operating Energy Used
- Solar Energy Fraction of Total Load
- System Performance Factor
- Energy Collection and Storage Subsystem Conversion Efficiency
- Total Energy Consumed

TABLE 3-2. APPROVED SENSOR LIST

DATA REQUIREMENT	NAME	MANUFACTURER	MODEL
Total radiation	Pyranometer	Eppley	PSP
Diffuse radiation	Pyranometer w/shadow band	Eppley	PSP w/ shadow band
Ambient outside air temperature/ with radiation shield	Resistance temperature detector/with IS4	Minco Weather Measure	S53-P/S57-P IS4
Temperature (air)	Resistance temperature detectors	Minco	S53-P/S57-P
Temperature (liquid)	Single element resistance temperature detectors	Minco	S53-P/S54-P
	Dual element resistance temperature detectors	Minco	S57-P/S59-P
Surface temperature	Resistance temperature detectors	Minco	S34A/S7301
Flow rate (air)	Flowmeter	Dieterich Std./ Robinson-Halpern	Type 74 157A
	Anemometer	Kurz Instruments	430
Gas	Gas Meter	American Meter (modified by Pedigo Fab Co.)	Diaphram Meter
Flow rate (liquid)	Flowmeter	Ramapo	MK-V
Fuel oil	Flowmeter	Hersey Products	10,20,21, etc.
Electrical power	Watt transducer	Ohio Semitronics	PC5-YYF
Differential pressure (air)	Low pressure transducer	Robinson-Halpern	157A
(liquid)	Pressure transducer	Robinson-Halpern	150D/155D

TABLE 3-2. APPROVED SENSOR LIST (continued)

DATA REQUIREMENT	NAME	MANUFACTURER	MODEL
Relative humidity	RH probe	Weather-Measure	HM111-P/HM14-P
Wind velocity and direction	Skyvane I	Weather-Measure	W101-P-DC/540
Angular displacement	Precision potentiometer	New England Instruments	78EB0502
Position discrete	Microswitch	Denison	C2T-J

*Deviations from this list must be approved by ERDA

3.3 INSTRUMENTATION LOCATION

The general requirement for determination of performance evaluation factors dictates sensor selection and placement. The method used for evaluation is the energy balance concept. Simply stated, the energy entering a system (or subsystem) is equal to the sum of the energy leaving plus the energy accumulated plus the energy lost through thermal leakage and/or conversion inefficiency. The sensors selected are those necessary to accurately and economically determine this energy flow either directly or by computation.

Although specific installation requirements are dependent upon the design characteristics of each system, the following guidelines provide the basic methodology for determining the measurements required and for locating the acceptable sensors used for performance evaluation of space heating, space cooling, and/or hot water systems. These guidelines are to be used in designing the instrumentation installation for each demonstration project utilizing the sensors defined in Table 3-2. Where possible, when differential temperature and absolute temperature measurements are required a dual element RTD shall be placed on the inlet side of the flow path (upstream) and a single element RTD installed in the outlet side of the flow path.

a. Meteorological Data

Provide indication of outdoor ambient temperature and total radiation. Diffuse radiation shall be measured only for installations utilizing concentrating solar energy collectors. Outdoor relative humidity, wind speed, and wind direction shall be measured only for selected systems.

b. Collector Array

Provide indication of absolute temperature and flow rate at the last singular point entering the collector array. Provide indication of the differential temperature between that point and the first singular point leaving the array.

c. Storage

Provide indication of absolute temperature and flow rate at each functional energy entrance to the storage subsystem. Provide indication of the differential temperature between each functional exit from the storage subsystem and its corresponding entrance. Internal energy shall be indicated by average temperature in liquid storage tanks. Depending on the tank design, three temperature measurements may be required to detect stratification and establish a good average temperature. For most rock storage systems three temperature measurements will be required. Additionally, measurements shall be made of all auxiliary energy supplied to the storage subsystem.

d. Space Heating, Space Cooling, and Hot Water Subsystems

Provide indication of absolute temperature and flow rate at each functional energy entrance to the space heating, space cooling, and hot water subsystems. Provide indication of the differential temperature between these entrances to the subsystems and their exits. Measurements shall be made of auxiliary energy supplied to each subsystem.

e. Building Occupancy Related Factors

Provide measurement of representative building internal ambient temperature and the domestic hot water temperature and flow rate. Relative humidity will be measured only for selected systems. Internal ambient temperature is not required for a hot water only installation.

f. Other Subsystems

Provide sufficient flow and temperature measurements to evaluate the interconnecting solar energy transport subsystems. Provide sufficient temperature and flow measurements to utilize the energy balance technique on all subsystems (including the interconnecting energy transport systems) contained in the solar energy system which have not been discussed previously.

3.4 MEASUREMENTS DESIGNATIONS

In order to standardize the performance calculations and identify sensors according to type and location, an alpha-numeric designation is used for each performance factor or sensor. In accordance with the concept adapted in document "Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program", NBSIR 76-1137, a four or five character designation will be used consisting of a letter which defines either the sensor type or the measured or calculated quantity, and a three digit number which identifies the subsystem or data group as follows:

Letter Designations

C = Specific Heat

D = Direction or Position

EE = Electrical Energy

EP = Electrical Power

F = Fuel Flow Rate

HF = Heat Flow Meter

Letter Designations (continued)

I = Incident Solar Flux (Insolation)

N = Performance Efficiency or Effectiveness

P = Pressure

PD = Pressure Differential

Q = Thermal Energy

RH = Relative Humidity

SM = Special Measurement

T = Temperature

TD = Differential Temperature

V = Velocity

W = Heat Transport Medium Flow Rate

TI = Time

Subsystem Designations

Number Sequence	Subsystem/Data Group
001 to 099	Climatological
100 to 199	Collector
200 to 299	Thermal Storage
300 to 399	Domestic Hot Water
400 to 499	Space Heating
500 to 599	Space Cooling
600 to 699	Building/Load

Thus the sensor designation T100 defines an absolute temperature measurement in the collector subsystem and the variable name TD100 defines a differential temperature with reference only to absolute temperature measurement T100.

The designation W100 defines a flow measurement in the collector subsystem associated with temperature measurements T100 and TD100. Variable Q100 would define the solar energy collected by a collector array utilizing the instrumented parameters and the collector performance factors. This convention should be uniformly applied to each defined subsystem/data group.

3.5 SENSOR DELIVERY METHOD

Sensors will be delivered to the test site or site contractor by the most expeditious common carrier. Date of delivery will be mutually established between ERDA and the site contractor. Sensors will be:

a. adequately packed so as to minimize shipping and handling damage,

b. properly identified, i.e., type, location, etc., and

c. packed with any special instructions required for handling, installation, and checkout.

Proper installation of sensors will be the responsibility of the site contractor in accordance with the guidelines in Appendix B.

3.6 SYSTEM INSTRUMENTATION EXAMPLE (FOR INFORMATION ONLY)

Figure 3-1 shows sensor types and locations which result from the application of the instrumentation selection groundrules to a combined domestic hot water, space heating, and space cooling system with a concentrating collector array. Suggested instructions for instrumenting this example are listed in Table 3-3. The measurements required for this example are listed in Table 3-4.

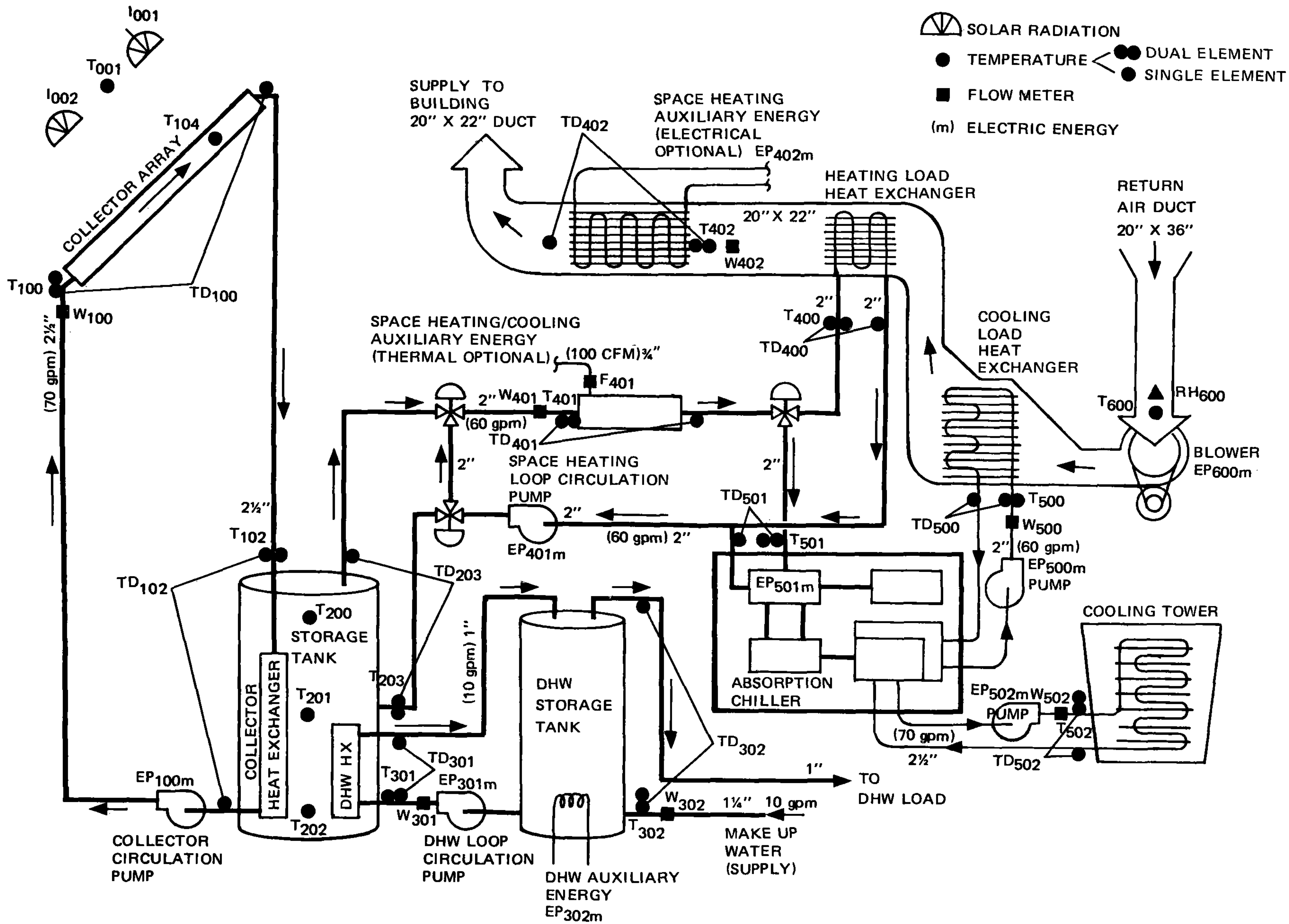


Figure 3-1. Instrumentation Groundrule Example Domestic Hot Water, Space Heating, and Cooling System.

TABLE 3-3. SUGGESTED INSTRUCTIONS FOR INSTRUMENTING A TYPICAL SOLAR ENERGY SYSTEM

Step 1	Prepare a detailed flow schematic of the Solar Energy System that includes all components of the system, and the auxiliary and conventional energy to be used in conjunction with the Solar System. Identify media and media heat transfer properties. (See Section 5.7)
Step 2	Using the flow schematic prepared in Step 1, select instrumentation locations according to the guidelines in Section 3.3, and illustrated in Figure 3-1. As shown in Figure 3-1 place (where possible) all dual element temperature sensors at the inlet to a component or subsystem. Locate flowmeters near a dual element sensor or absolute temperature sensor. Use the nomenclature and measurement designations specified in Paragraph 3.4.
Step 3	Prepare a complete set of mechanical and electrical construction drawings of the solar, auxiliary, and conventional energy system. These drawings must contain detail piping and electrical equipment legends with piping size, material, capacities, design flow rates and power requirements, voltage phase, power, etc.
Step 4	Utilizing the instrumentation locations developed in Step 2 and piping and power definition presented in construction drawings of Step 3, select specific sensors for each sensor location in accordance with Table 3-2.
Step 5	Prepare a list of the sensors selected in Step 4. List sensor identification number, nomenclature, estimated range, and model number as shown in Table 3-4. Define sensor interface requirements such as pipe size, threads, etc. Identify special mounting configuration or restrictions.
Step 6	Using the instrumented flow schematic of Step 2 and the instrumentation listing generated in Step 5, detail the exact sensor location and sensor interface on the construction drawings prepared in Step 3.
Step 7	The construction drawings of Step 6 containing complete instrumentation system detail shall be submitted to ERDA as part of the ISPI.

TABLE 3-4. TYPICAL INSTRUMENTATION EXAMPLES

MEASUREMENT	NOMENCLATURE	ESTIMATED RANGE*	TYPICAL SENSOR MODEL NUMBER
I001	Total radiation	0-350 BTU/FT^2/HR	PSP
I002	Diffuse radiation	0-350 BTU/FT^2/HR	PSP
T001	Outdoor DB temperature	-20 to 120^{0}F	S53-PXX
T100	Collector Inlet temperature	30 to 230^{0}F	S57-PXX
T102	Storage Inlet temperature	30 to 230^{0}F	S57-PXX
T104	Collector absorber temperature	30 to 450^{0}F	S7301
T200	Storage media temperature top	30 to 230^{0}F	S53-PXX
T201	Storage media temperature middle	30 to 230^{0}F	S53-PXX
T202	Storage media temperature bottom	30 to 230^{0}F	S53-PXX
T203	Storage load return temperature	30 to 230^{0}F	S57-PXX
T300	Make-up water temperature	30 to 160^{0}F	S57-PXX
T301	DHW HX inlet temperature	30 to 160^{0}F	S57-PXX
T303	DHW auxiliary inlet temperature	30 to 230^{0}F	S57-PXX
T400	Heating load inlet temperature	30 to 230^{0}F	S57-PXX
T401	Auxiliary inlet temperature	30 to 230^{0}F	S57-PXX
T402	Auxiliary electric duct heater	30 to 160^{0}F	S57-PXX

TABLE 3-4. TYPICAL INSTRUMENTATION EXAMPLES (continued)

MEASUREMENT	NOMENCLATURE	ESTIMATED RANGE*	TYPICAL SENSOR MODEL NUMBER
T500	Load heat exchanger inlet temperature	-20 to 120°F	S57-PXX
T501	Chiller H.W. inlet temperature	30 to 230°F	S57-PXXX
T502	Cooling tower inlet temperature	30 to 160°F	S57-PXX
T600	Internal ambient temperature	-20 to 120°F	S53-PXX
TD100	Collector array differential temperature	0 to 50°F	S53-PXX
TD102	Storage media collector HX differential temperature	0 to 100°F	S53-PXX
TD203	Storage media H/C load differential temperature	0 to 80°F	S53-PXX
TD300	DHW storage make-up/exit differential temperature	0 to 100°F	S53-PXX
TD301	DHW storage HX differential temperature	0 to 100°F	S53-PXX
TD303	DHW auxiliary differential temperature	0 to 100°F	S53-PXX
TD400	Heating load HX	0 to 80°F	S53-PXX
TD401	H/C auxiliary differential temperature	0 to 80°F	S53-PXX
TD402	Auxiliary electric duct heater	0 to 80°F	S53-PXX
TD500	Cooling HX differential temperature	0 to 80°F	S53-PXX
TD501	Chiller HW differential temperature	0 to 80°F	S53-PXX

TABLE 3-4. TYPICAL INSTRUMENTATION EXAMPLES (continued)

MEASUREMENT	NOMENCLATURE	ESTIMATED RANGE*	TYPICAL SENSOR MODEL NUMBER
TD502	Cooling tower differential temperature	0 to 50^{o}F	S53-PXX
W100	Collector flow rate	50-70 gpm	MKV-Y-YY
W300	DHW flow to load	0-5 gpm	MKV-Y-YY
W301	DHW circulation flow	2-5 gpm	MKV-Y-YY
W401	Heating loop flow	25-50 gpm	MKV-Y-YY
W402	Auxiliary electric duct flow	0 - 900 CFM	430
W500	Cooling loop flow	25-50 gpm	MKV-Y-YY
W502	Cooling tower flow	60-70 gpm	MKV-Y-YY
EP100	Solar operating power	.3 KW	PC5-YYF
EP301	DHW circulation pump	.3 KW	PC5-YYF
EP303	DHW auxiliary (electric)	4.5 KW	PC5-YYF
EP400	Space HTG auxiliary (electric)	67 KW	PC5-YYF
EP401	Space HTG circulation pump	.3 KW	PC5-YYF
EP500	Chilled water pump power	.5 KW	PC5-YYF
EP501	Absorption chiller power	.1 KW	PC5-YYF
EP502	Cooling tower pump and fan power	2.0 KW	PC5-YYF
EP600	Blower power	1 KW	PC5-YYF
F401	Space HTG & CLG auxiliary (thermal)	100 CFH	AL175-MOD

TABLE 3-4. TYPICAL INSTRUMENTATION EXAMPLES (continued)

MEASUREMENT	NOMENCLATURE	ESTIMATED RANGE*	TYPICAL SENSOR MODEL NUMBER
RH600	Relative humidity	0-100%	HM-111P

*These values are representative for this example only. Values for a particular site should be design estimates or actual measured values.

XX - Length of probe in tenths of inch (.1") (See Appendix B)

YY - Application identification parameters (See Appendix B)

4.0 INSTRUMENTATION INTERFACE REQUIREMENTS

In order to transmit data from each sensor to the Central Data Processing System, the hardware components shown in Figure 4-1 are utilized at each site. A typical layout of the work space required around the SDAS mounting area is shown in Figure 4-2.

These components are:

1. Sensor wire (supplied and installed by site contractor)

2. Junction box (supplied by ERDA and installed by site contractor)

3. Junction box/SDAS interface cables (supplied and installed by ERDA)

4. Site Data Acquisition Subsystem (SDAS) (supplied by ERDA and installed by site contractor)

5. SDAS telephone interface (supplied by ERDA)

6. SDAS and telephone electrical power interface (supplied by site contractor)

4.1 SENSOR TO JUNCTION BOX WIRING

All wiring from sensors to junction box (J-box) terminal block connections shall be performed by the site contractor in accordance with these guidelines utilizing wire procured by the site contractor and prepared for each sensor according to the instructions in Figure 4-3. The wire size and number of conductors required for each sensor is specified in Table 4-1. The sensor to junction box wire shall be color-coded, audio and instrumentation grade cable to minimize noise problems. Conduit shall be used only in accordance with local codes.

AC POWER LINES AND OTHER POTENTIAL NOISE INDUCING LINES SHOULD NOT BE PLACED IN THE SENSOR WIRING CONDUIT OR ROUTED NEAR THE INSTRUMENTATION CABLES. ALSO, THE INSTRUMENTATION CABLES SHOULD NOT BE ROUTED NEAR NOISE GENERATING EQUIPMENT.

4.2 JUNCTION BOX

ERDA will provide a junction box (Figure 4-4) to the site contractor for installation in a central location with respect to the solar energy system. The installation location shall be selected by the site contractor and shall be specified in the ISPI.

As defined by ERDA, noise suppression may be required at the sensor, J-Box or both in order to provide acceptable data. Remote signal conditioning may be required in order to improve the signal-to-noise ratio that would improve data accuracy.

4.2.1 JUNCTION BOX LOCATION

The junction box, Figure 4-4, shall be mounted by the site contractor so that it is accessible for wiring connections from the sensors and is within four feet of the SDAS location on the same side of wall.

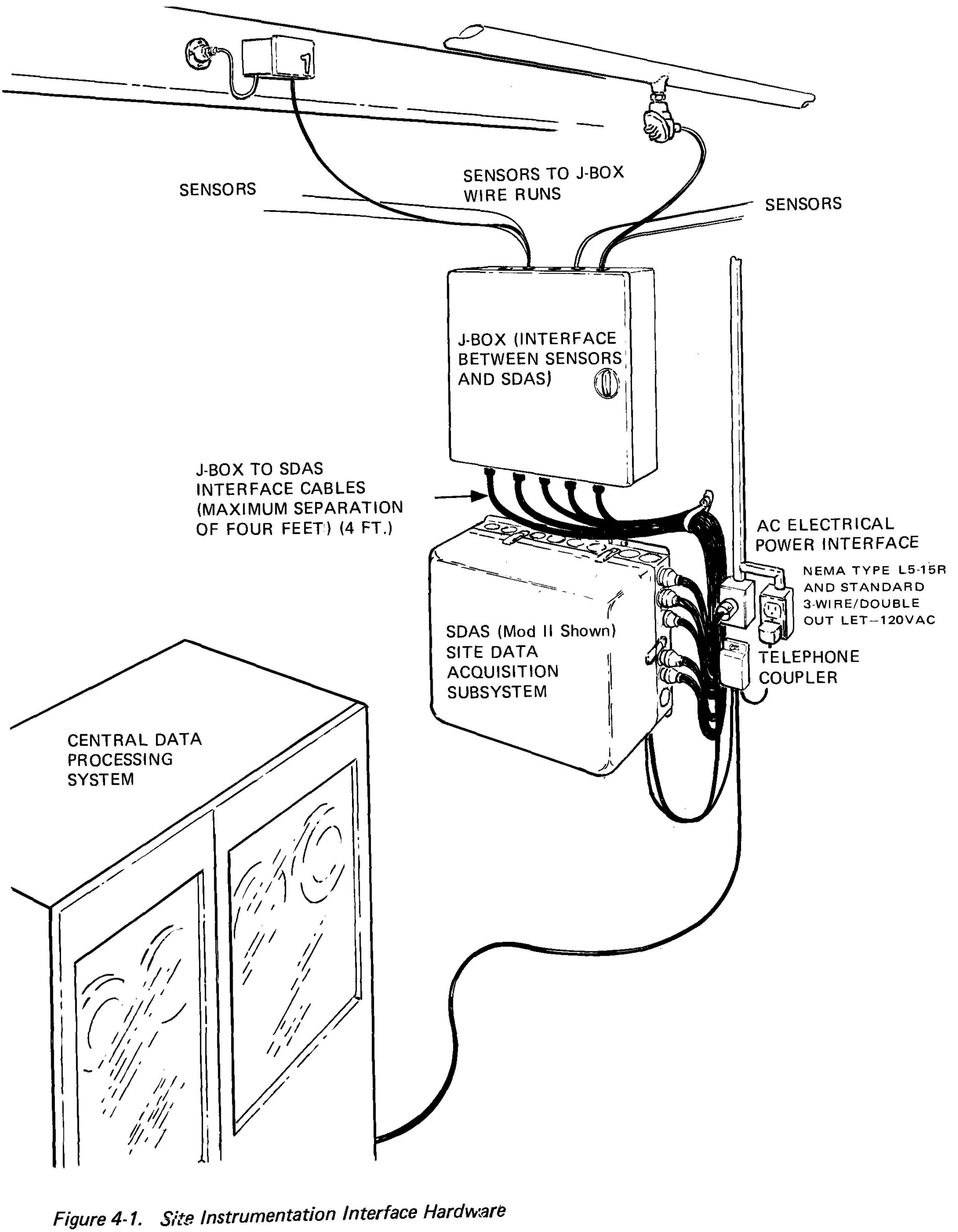
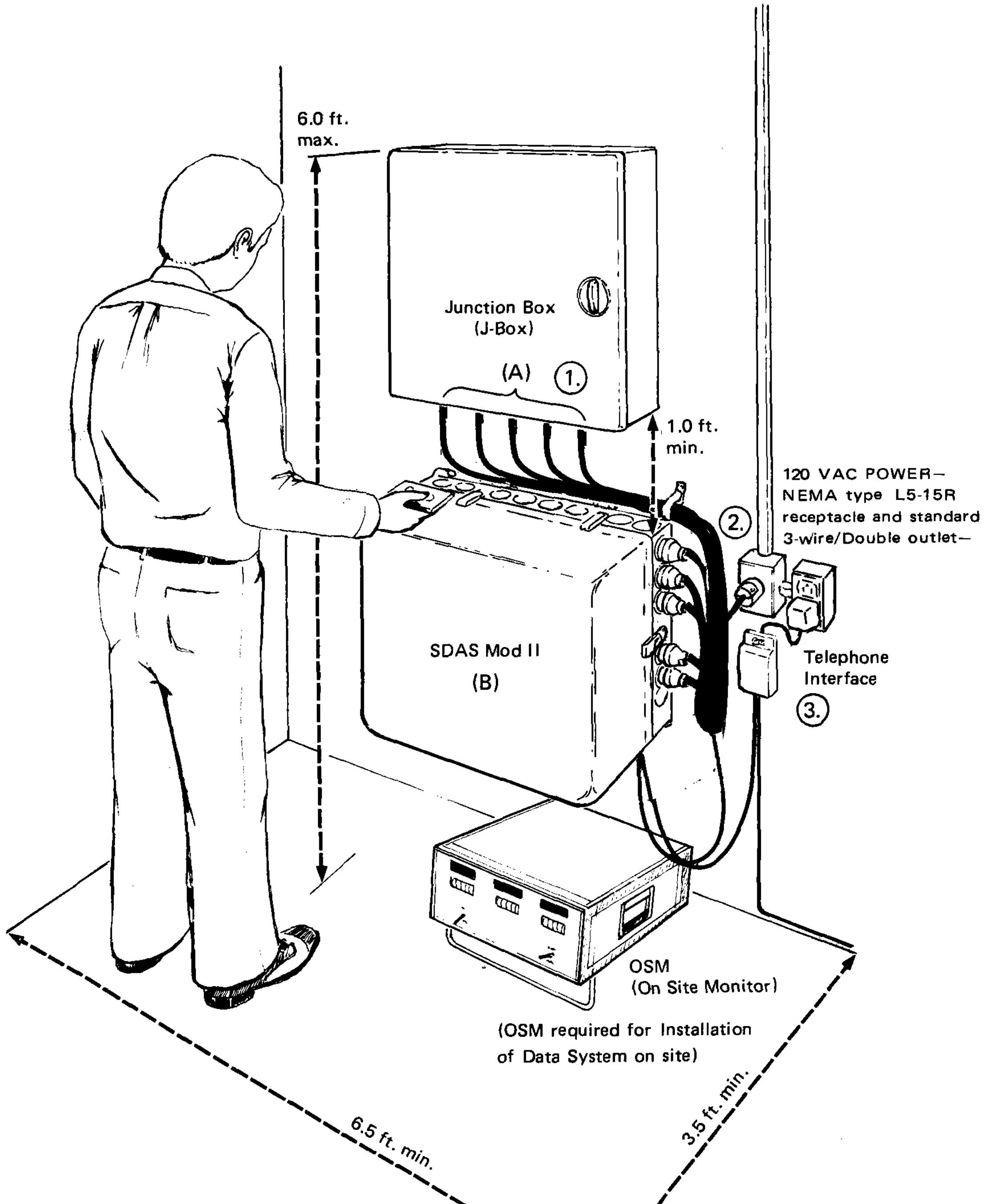


Figure 4-1. Site Instrumentation Interface Hardware



NOTES:

1. J-Box (A) is to be located within a cable run of 4 ft. of the SDAS (B)
2. NEMA type L5-15R receptacle to be within 6 ft. of SDAS (B)
3. Telephone Interface (Coupler) is located within 3 ft. of SDAS (B)

Figure 4-2. Typical SDAS Installation Layout Profile

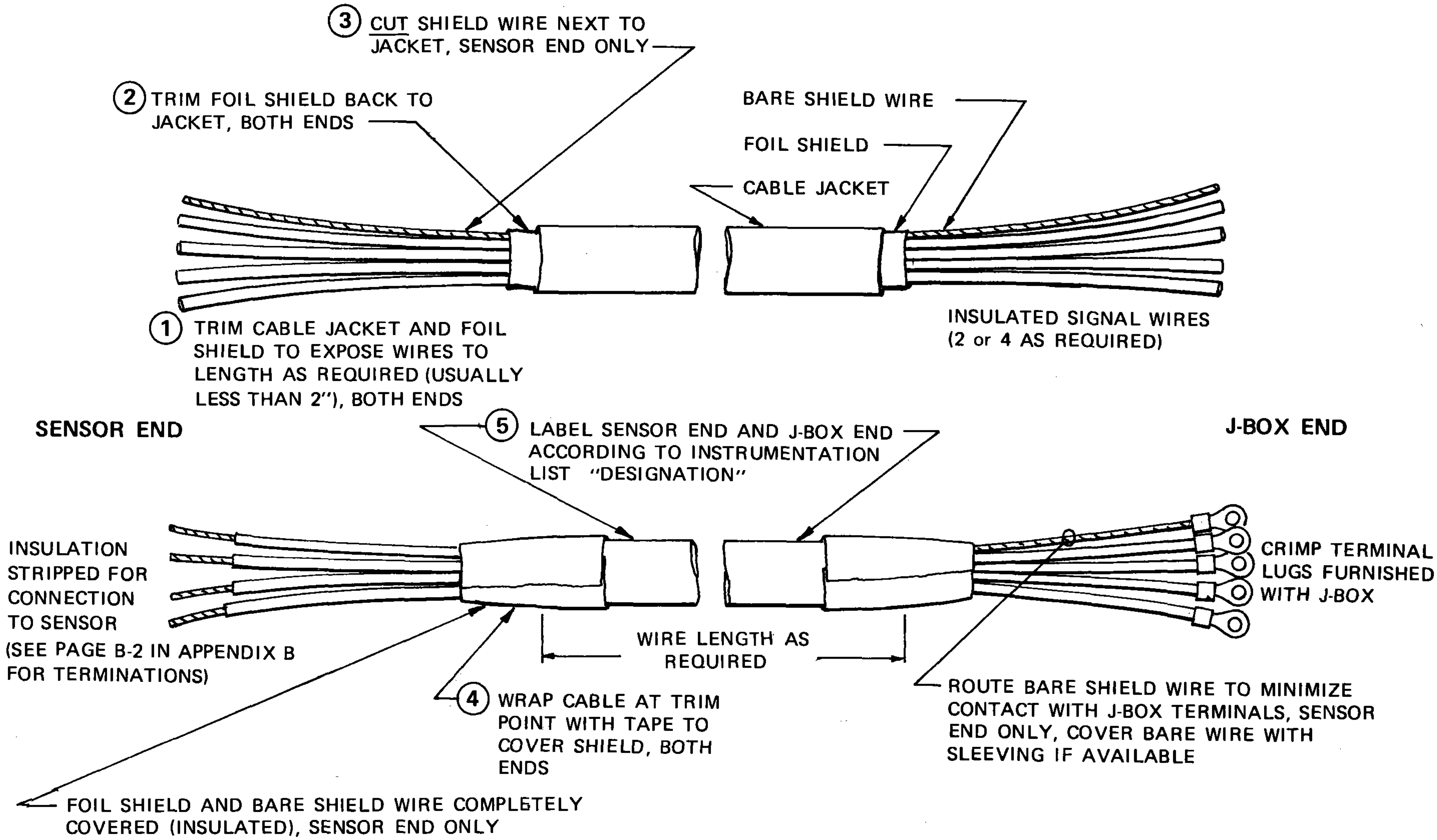


Figure 4-3. Sensor Wire Preparation Procedure

TABLE 4-1. SENSOR WIRE REQUIREMENTS

SENSOR TYPE	CONDUCTORS	AMERICAN WIRE GAUGE
Pressure	3 + shield	#18-3
Temperature		
- Single element RTD	3 + shield	#18-3
- Dual element RTD	3 + shield (2)	#18-3
Fuel oil	3 + shield	#18-3
Flow rate (liquid)	4 + shield	#18-4
Air velocity	2 + shield	#18-2
Solar radiation	2 + shield	#18-2
Electric power	2 + shield	#18-2
Relative humidity	4 + shield	#18-4
Wind speed	2 + shield	#18-2
Wind direction	3 + shield	#18-3
Angular displacement	3 + shield	#18-3

NOTE:

1. Typical wire part numbers include:
   - Alpha P/N 2422-18 gauge, 2 conductor or equivalent
   - Alpha P/N 2423-18 gauge, 3 conductor or equivalent
   - Alpha P/N 2424-18 gauge, 4 conductor or equivalent
   - Dearborn P/N 971804-18 gauge, 4 conductor or equivalent
   - Dearborn P/N 971803-18 gauge, 3 conductor or equivalent
   - Dearborn P/N 971802-18 gauge, 2 conductor or equivalent
   - Manhattan P/N M3242-18 gauge, 2 conductor or equivalent
   - Manhattan P/N M3243-18 gauge, 3 conductor or equivalent
   - Manhattan P/N M3244-18 gauge, 4 conductor or equivalent
2. Two (2) cables required for dual element RTDs.
3. Wire exposed to the outdoor environment or buried shall be in conduit.
4. Rigid conduit runs to all sensors shall be terminated with flexible conduit. All connections shall be made watertight.

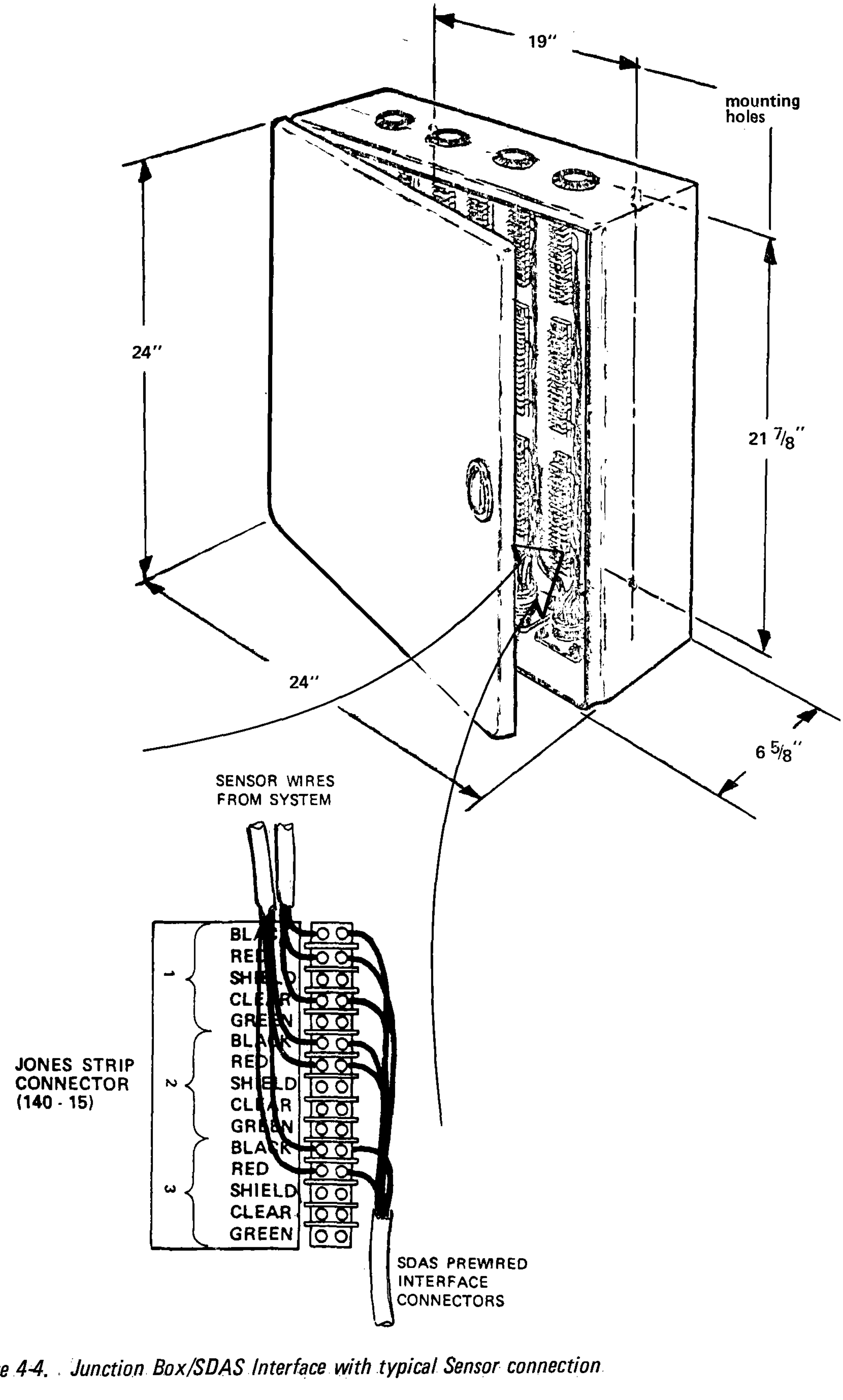


Figure 4-4. Junction Box/SDAS Interface with typical Sensor connection

4.2.2 JUNCTION BOX MOUNTING

At the predefined mounting location, the junction box shall be mounted by the site contractor using the four mounting holes located at the back of the unit. Figure 4-4 provides the dimensional information for mounting. Depending on the characteristics of the mounting surface, Molly bolts, wood screws, or bolt/nut combinations shall be used to mount the unit. The junction box shall be installed in a top-up orientation.

4.2.3 JUNCTION BOX INTERFACES

ERDA will establish the wire run list which identifies where each sensor wire attaches to the junction box terminal strips. This wire run list will be a part of the AIP which the site contractor will implement. A typical example of a wire run list and the connection of typical measurements is shown in Figure 4-5. The junction box will be prewired from the terminal strips to the output connectors of the SDAS prior to delivery to the site. Five conductor terminals will be provided for each sensor input. Either two, three, or four conductor (18 gauge) and shield will be connected between the sensors and the junction box depending on the interface characteristics of the sensors. Figure 4-6 illustrates the sensor to junction box interconnections for each of the approved sensors listed in Table 3-2.

4.3 JUNCTION BOX/SDAS INTERFACE CABLES

ERDA will provide and install the junction box/SDAS interface cables.

4.4 SITE DATA ACQUISITION SUBSYSTEM

The Site Data Acquisition Subsystem (SDAS) location at each demonstration project will be selected by the site contractor and shall be specified in the ISPI for approval.

4.4.1 SDAS LOCATION

The SDAS, Figure 4-7, shall be mounted by the site contractor in a central position with respect to the solar energy system sensors. It shall be located in an indoor environment having temperature limits between 32°F and 100°F and relative humidity limits of 5-80% without condensation. The SDAS shall be located to minimize contamination by elements such as dust or other pollutants. To the extent possible, the SDAS shall be located in an area which minimizes the variations in temperature, relative humidity, and vibration to the SDAS. The SDAS shall be located in an area easily accessible for installation and maintenance.

4.4.2 SDAS MOUNTING

The SDAS shall be mounted in accordance with the installation drawings supplied by ERDA. The mounting space required for the SDAS is dependent on the model as shown in Figure 4-7. Either unit will weigh approximately 70 pounds. The SDAS shall be wall mounted using dimensions in Figure 4-7 both top and bottom. Either Molly bolts, wood screws, or bolt/nut combination shall be used to mount

DATE ____________

SITE IIG WIRE LIST XXXXXXX SHEET X OF XX

SENSOR NUMBER	REF. MEAS. NUMBER	SENSOR CONNECTION	SENSOR/J-BOX WIRE COLOR	TERMINAL STRIP NO.	INTERNAL FROM	JUMPER TO	SDAS CHANNEL	LEVEL
T100	T100	RED	RED	TB1-6			2	LO
		WHITE*	CLEAR	TB1-7			2	HI
		WHITE*	BLACK	TB1-9			2	3RD
			SHIELD	TB1-8S				SHIELD
	TD100L	YELLOW*	BLACK	TB2-4			4	3RD
		YELLOW*	CLEAR	TB2-4			4	3RD
		BLUE	RED	TB2-1			4	LO
			SHIELD	TB2-3S				SHIELD
TD100	TD100H	RED	RED	TB2-2			4	HI
		WHITE*	BLACK	TB2-5			4	3RD
		WHITE*	CLEAR	TB2-5			4	3RD
			SHIELD	TB2-3S				SHIELD
W100	W100	1	RED	TB1-15			3	+5 VDC
		2	CLEAR	TB1-12			3	HI
		3	GREEN	TB1-11			3	LO
		4	BLACK	TB1-14			3	GND
			SHIELD	TBL-13S				SHIELD
I001	I001	B	RED	TB3-2			7	HI
		A	BLACK	TB3-1			7	LO
			SHIELD	TB3-3S				SHIELD
D001	D001	G	RED	TB11-5			31	+5 VDC
		E	CLEAR	TB11-2			31	HI
		F	BLACK	TB11-1			31	LO/GND
			SHIELD	TB11-3S				SHIELD
EP101	EP101	2	RED	TB13-2			34	HI
		1	BLACK	TB13-1			34	LO
			SHIELD	TB13-3S				SHIELD
F300	F300	1	RED	TB2-10			8	+5 VDC
		2	CLEAR	TB3-7			8	HI
		3	BLACK	TB3-6	TB3-6**	TB2-9**	8	LO/GND
			SHIELD	TB3-8S				
V001	V001	A	RED	TB9-2			25	HI
		B	BLACK	TB9-1			25	LO
			SHIELD	TB9-3S				SHIELD
W400	W400	1	RED	TB11-2			31	HI
		2	BLACK	TB11-1			31	LO
			SHIELD	TB11-3S				SHIELD
RH001	RH001	BROWN	RED	TB14-15			39	+3.6 VDC
		PURPLE	BLACK	TB14-14			39	GND
		YELLOW	CLEAR	TB14-12			39	HI
		GREEN	GREEN	TB14-11			39	LO
			SHIELD	TB14-13S				SHIELD
D101	D101	RED 1	RED	TB5-15			15	5 VDC
		BLACK 3	BLACK	TB5-14			15	GND
								LO/GND
		YELLOW 2	CLEAR	TB5-12			15	HI

*EITHER WIRE

**JUMPER ADDED PRIOR TO SHIPMENT

Figure 4-5. Typical Wire Run List for J-Box Terminal Connection

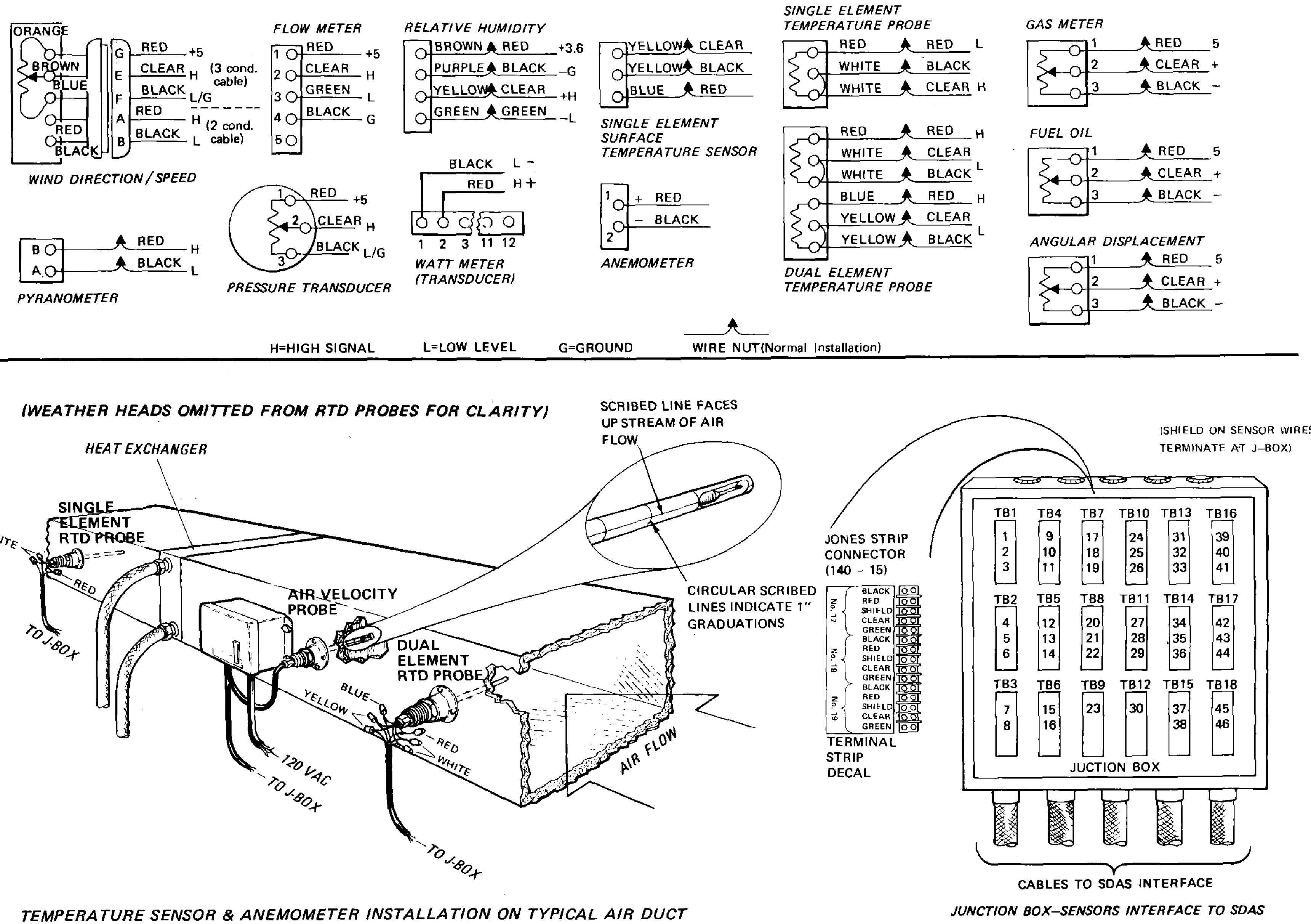


Figure 4-6. Typical Sensor to J-Box Interconnection

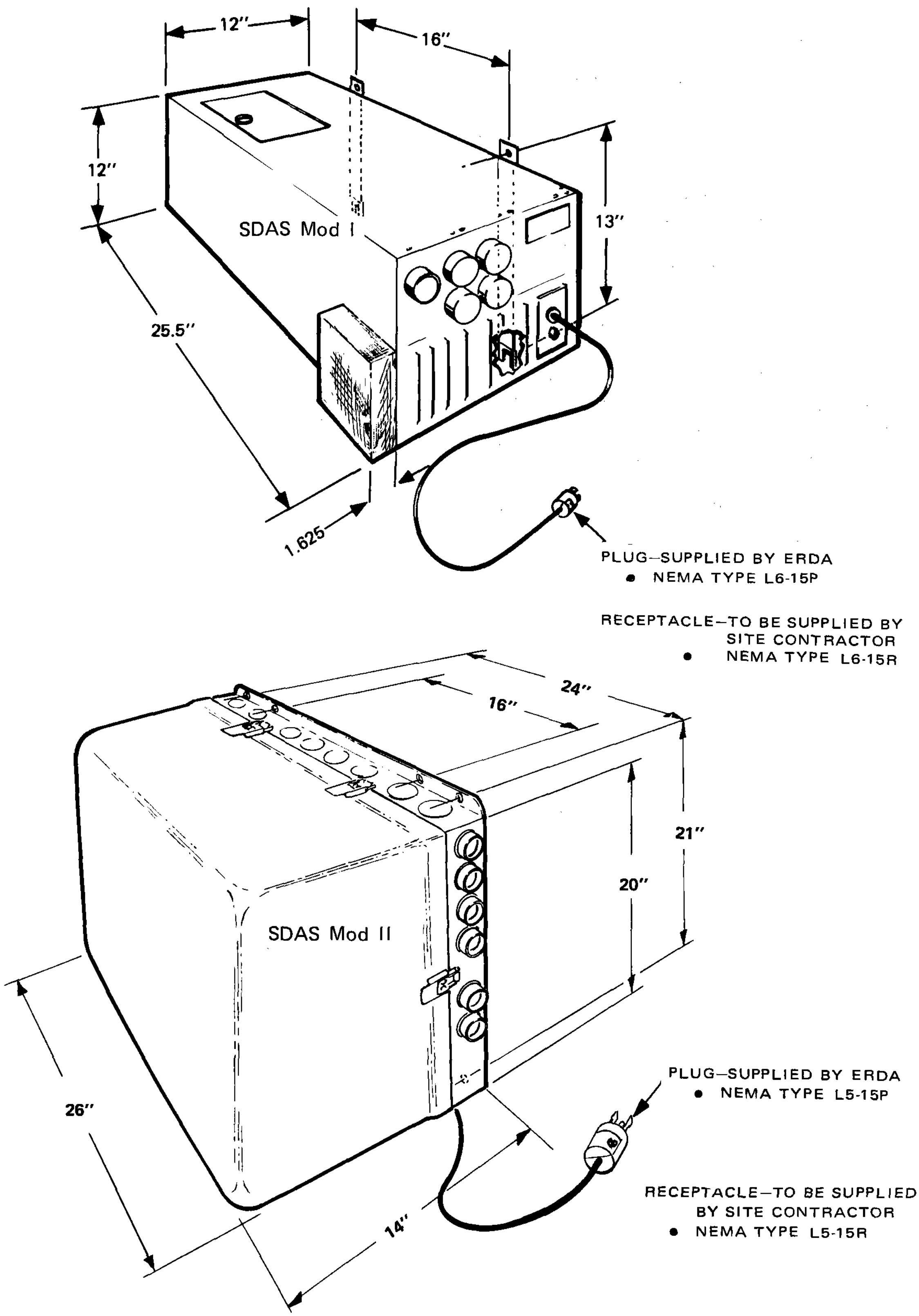


Figure 4-7. Site Data Acquisition Subsystem

the unit depending on the characteristics of the mounting surface. The SDAS shall be mounted between two feet and four feet above floor level measured from the bottom of the SDAS.

4.5 SDAS TELEPHONE INTERFACE

ERDA will arrange for the telephone installation required for the SDAS. The SDAS shall interface with a standard Bell System CBS Data Access Arrangement (DAA), Series 5 or later, or equivalent. The DAA shall be located within three feet of the SDAS on the same side of wall. The DAA connection with the SDAS shall be performed by ERDA. The site contractor shall provide a standard 120 VAC three (3) wire receptacle for power to the coupler.

4.6 SDAS ELECTRICAL INTERFACE

The SDAS interfaces with 110-125V, 60 Hertz, 1 phase, 3 amp service. A standard 3 wire interface (safety ground, power and return) with a standard power cord and twist lock connector shall be provided on the SDAS. A 120 VAC three pin twist lock outlet (actual receptacle should be NEMA Part Numbers L6-15R, 250V, 15 amps for Mod 1 and L5-15R, 120 V, 15 amps for Mod II) shall be provided by the site contractor and located within six feet of the SDAS.

5.0 SPECIAL CONSIDERATIONS

5.1 INSTRUMENTATION IMPACT ON SOLAR HEATING AND COOLING SYSTEMS

The only sensors which will present any impact to the performance of the solar heating and cooling system are the intrusive flowmeters and temperature probe thermowells.

5.1.1 TEMPERATURE PROBES

All temperature probes used in liquid systems shall be installed in thermowells. The probe and thermowell will be sized for each different pipe/tube size in order to minimize flow restriction. The temperature probe used for sensing air temperatures in ducts offers very negligible resistance to flow.

5.1.2 FLOWMETERS/SENSORS

All anticipated flowmeters/sensors are "in-line" intrusive devices and therefore will offer some resistance to flow. The impact type flowmeters used in liquid systems operate on the principle of impact pressure on a target which is located in the flow stream. The pressure loss is a function of the ratio of target diameter and velocity of flowing liquid. Typical values are listed in Table 5-1.

5.2 ADDED SENSOR SIGNAL CONDITIONING

Based on the ISPS definition, low signal level sensors will be evaluated to estimate the effects of:

1. Distance from sensor to Site Data Acquisition System.

2. Existing noise conditions which could render an unfavorable signal to noise ratio.

As the result of this analysis, ERDA will identify in the AIP or after initial site data analysis any additional sensor signal conditioning required.

This additional or remote signal conditioning will be provided by ERDA. The site contractor will install the remote signal conditioning according to directions specified by ERDA.

TABLE 5-1. PRESSURE DROP IN LIQUID SYSTEM FLOWMETERS

PIPE SIZE	FLOW RANGE	PRESSURE LOSS (PSID AT MAX. FLOW)	
		PIPE	WAFER
1/2	.3 to 3 GPM - 3 to 30 GPM	14	14
3/4	1.0 to 10.0 GPM - 6 to 60.0 GPM	8	8
1.0 in.	1.5 to 15 GPM - 8 to 80 GPM	4	4
1-1/4 in.	2.5 to 25 GPM - 10 to 100 GPM	3	3
1-1/2 in.	3.5 to 35 GPM - 12 to 120 GPM	2	2
2.0 in.	5 to 50 GPM - 20 to 200 GPM	1	1
2-1/2 in.	7 to 70 GPM - 25 to 250 GPM	.8	.8
3.0 in.	10 to 100 GPM - 35 to 350 GPM	.6	.6
4.0 in.	25 to 250 GPM - 60 to 600 GPM		.4
5.0 in.	30 to 300 GPM - 100 to 1000 GPM		.3
6.0 in.	40 to 400 GPM - 140 to 1400 GPM		.2
8.0 in.	50 to 500 GPM - 200 to 2000 GPM		<.1
10.0 in.	75 to 750 GPM - 300 to 3000 GPM		<.1
12.0 in.	100 to 1000 GPM - 450 to 4500 GPM		<.1

5.3 RESTRICTION ON USE OF INSTRUMENTAITON

No monitoring, indicating, or readout devices are to be connected to the instrumentation sensors, i.e., paralleled with the Site Data Acquisition System, without prior written approval of ERDA.

5.4 FAILED SENSOR REPLACEMENT

Defective sensors will be initially identified by ERDA as a part of the performance analysis process.

The improperly operating sensor will be identified to the site contractor who will examine the sensor for signs of physical damage such as broken wires, loose connectors, loose terminals, etc. If no physical damage is apparent in the inspection, ERDA shall be notified for further instructions. If mechanical damage is apparent, the sensor shall be replaced by the site contractor with a sensor supplied by ERDA. The defective sensor shall then be returned to ERDA for disposition.

5.5 SYSTEM START UP AND STABILIZATION

During initial SDAS installation, a portable test set is planned to be available for sensor checkout and for monitoring key system operating parameters. This test set will have switch selectable readout capability of any parameter monitored by the SDAS. The test set will operate through the SDAS and will display one or more parameters at a time in engineering units or as output voltage of the sensor.

5.6 ACTION TAKEN AT END OF DATA COLLECTION PERIOD

At the end of the data collection period, ERDA will take the following actions:

1. Remove the Site Data Acquisition Subsystem (SDAS) from the site, and, if required, will have the SDAS refurbished for utilization elsewhere.

2. Direct the site contractor to remove and return all instrumentation which can be cost effectively reused at another site.

5.7 HEAT TRANSFER FLUID PROPERTIES

The properties of the heat transfer fluid (specific heat, viscosity, and density, etc.) as a function of temperature shall be provided for the initial installation by the site contractor. In addition, a sample of the system fluid will be provided upon request of ERDA.

5.8 REPORTS AND DATA AVAILABLE TO SITE CONTRACTORS

The Performance Evaluation Factors shown in Table 3-1 will be used by ERDA to assess and report the performance of each solar energy system in the demonstration program. On a monthly basis, each site contractor will be provided with a Site Performance Report which will summarize these factors for his installation. These data will be provided on a routine basis and no action is required by the site contractor to receive this report.

CONTRACT PRICING PROPOSAL

(RESEARCH AND DEVELOPMENT)

Office of Management and Budget
Approval No. 29-RO184

This form is for use when *(i)* submission of cost or pricing data (see FPR 1-3.807-3) is required and *(ii)* substitution for the Optional Form 59 is authorized by the contracting officer.

PAGE NO.	NO. OF PAGES

NAME OF OFFEROR	SUPPLIES AND/OR SERVICES TO BE FURNISHED
HOME OFFICE ADDRESS	
DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED	TOTAL AMOUNT OF PROPOSAL $
	GOV'T SOLICITATION NO.

DETAIL DESCRIPTION OF COST ELEMENTS

			EST COST ($)	TOTAL EST COST[1]	REFERENCE[2]
1. DIRECT MATERIAL *(Itemize on Exhibit A)*					
a. PURCHASED PARTS					
b. SUBCONTRACTED ITEMS					
c. OTHER—*(1)* RAW MATERIAL					
(2) YOUR STANDARD COMMERCIAL ITEMS					
(3) INTERDIVISIONAL TRANSFERS *(At other than cost)*					
TOTAL DIRECT MATERIAL					
2. MATERIAL OVERHEAD[3] *(Rate %X$ base=)*					
3. DIRECT LABOR *(Specify)*	ESTIMATED HOURS	RATE/ HOUR	EST COST ($)		
TOTAL DIRECT LABOR					
4. LABOR OVERHEAD *(Specify Department or Cost Center)*[3]	O.H. RATE	X BASE =	EST COST ($)		
TOTAL LABOR OVERHEAD					
5. SPECIAL TESTING *(Including field work at Government installations)*			EST COST ($)		
TOTAL SPECIAL TESTING					
6. SPECIAL EQUIPMENT *(If direct charge) (Itemize on Exhibit A)*					
7. TRAVEL *(If direct charge) (Give details on attached Schedule)*			EST COST ($)		
a. TRANSPORTATION					
b. PER DIEM OR SUBSISTENCE					
TOTAL TRAVEL					
8. CONSULTANTS *(Identify—purpose—rate)*			EST COST ($)		
TOTAL CONSULTANTS					
9. OTHER DIRECT COSTS *(Itemize on Exhibit A)*					
10. *TOTAL DIRECT COST AND OVERHEAD*					
11. GENERAL AND ADMINISTRATIVE EXPENSE *(Rate % of cost element Nos.)*[3]					
12. ROYALTIES[4]					
13. *TOTAL ESTIMATED COST*					
14. FEE OR PROFIT					
15. *TOTAL ESTIMATED COST AND FEE OR PROFIT*					

OPTIONAL FORM 60
October 1971
General Services Administration
FPR 1-16.806
5060-101

This proposal is submitted for use in connection with and in response to *(Describe RFP, etc.)*

and reflects our best estimates as of this date, in accordance with the Instructions to Offerors and the Footnotes which follow.

TYPED NAME AND TITLE	SIGNATURE

NAME OF FIRM	DATE OF SUBMISSION

EXHIBIT A—SUPPORTING SCHEDULE *(Specify. If more space is needed, use reverse)*

COST EL NO.	ITEM DESCRIPTION *(See footnote 5)*	EST COST *($)*

I. HAS ANY EXECUTIVE AGENCY OF THE UNITED STATES GOVERNMENT PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

☐ YES ☐ NO *(If yes, identify below.)*

NAME AND ADDRESS OF REVIEWING OFFICE AND INDIVIDUAL	TELEPHONE NUMBER/EXTENSION

II. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify on reverse or separate page)*

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify.)*: ☐ ADVANCE PAYMENTS ☐ PROGRESS PAYMENTS OR ☐ GUARANTEED LOANS

IV. DO YOU NOW HOLD ANY CONTRACT *(Or, do you have any independently financed (IR&D) projects)* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify.)*:

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN AGENCY REGULATIONS?

☐ YES ☐ NO *(If no, explain on reverse or separate page)*

See Reverse for Instructions and Footnotes

OPTIONAL FORM 60 (10-71)

INSTRUCTIONS TO OFFERORS

1. The purpose of this form is to provide a standard format by which the offeror submits to the Government a summary of incurred and estimated costs *(and attached supporting information)* suitable for detailed review and analysis. Prior to the award of a contract resulting from this proposal the offeror shall, under the conditions stated in FPR 1-3.807-3 be required to submit a Certificate of Current Cost or Pricing Data (See FPR 1-3.807-3(h) and 1-3.807-4).

2. In addition to the specific information required by this form, the offeror is expected, in good faith, to incorporate in and submit with this form any additional data, supporting schedules, or substantiation which are reasonably required for the conduct of an appropriate review and analysis in the light of the specific facts of this procurement. For effective negotiations, it is essential that there be a clear understanding of:

a. The existing, verifiable data.
b. The judgmental factors applied in projecting from known data to the estimate, and
c. The contingencies used by the offeror in his proposed price.

In short, the offeror's estimating process itself needs to be disclosed.

3. When attachment of supporting cost or pricing data to this form is impracticable, the data will be described *(with schedules as appropriate)*, and made available to the contracting officer or his representative upon request.

4. The formats for the "Cost Elements" and the "Proposed Contract Estimate" are not intended as rigid requirements. These may be presented in different format with the prior approval of the Contracting Officer if required for more effective and efficient presentation. In all other respects this form will be completed and submitted without change.

5. By submission of this proposal the offeror grants to the Contracting Officer, or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

FOOTNOTES

1 *Enter in this column those necessary and reasonable costs which in the judgment of the offeror will properly be incurred in the efficient performance of the contract. When any of the costs in this column have already been incurred (e.g., on a letter contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your plants, divisions, or organizations under a common control, which are included at other than the lower of cost to the original transferror or current market price.*

2 *When space in addition to that available in Exhibit A is required, attach separate pages as necessary and identify in this "Reference" column the attachment in which the information supporting the specific cost element may be found. No standard format is prescribed; however, the cost or pricing data must be accurate, complete and current, and the judgment factors used in projecting from the data to the estimates must be stated in sufficient detail to enable the Contracting Officer to evaluate the proposal. For example, provide the basis used for pricing materials such as by vendor quotations, shop estimates, or invoice prices; the reason for use of overhead rates which depart significantly from experienced rates (reduced volume, a planned major re-arrangement, etc.); or justification for an increase in labor rates (anticipated wage and salary increases, etc.). Identify and explain any contingencies which are included in the proposed price, such as anticipated costs of rejects and defective work, or anticipated technical difficulties.*

3 *Indicate the rates used and provide an appropriate explanation. Where agreement has been reached with Government representatives on the use of forward pricing rates, describe the nature of the agreement. Provide the method of computation and application of your overhead expense, including cost breakdown and showing trends and budgetary data as necessary to provide a basis for evaluation of the reasonableness of proposed rates.*

4 *If the total cost entered here is in excess of $250, provide on a separate page the following information on each separate item of royalty or license fee: name and address of licensor; date of license agreement; patent numbers, patent application serial numbers, or other basis on which the royalty is payable; brief description, including any part or model numbers of each contract item or component on which the royalty is payable; percentage or dollar rate of royalty per unit; unit price of contract item; number of units; and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.*

5 *Provide a list of principal items within each category indicating known or anticipated source, quantity, unit price, competition obtained, and basis of establishing source and reasonableness of cost.*

CONTINUATION OF EXHIBIT A—SUPPORTING SCHEDULE AND REPLIES TO QUESTIONS II AND V.

OPTIONAL FORM 60 (10-71)

November 1, 1977

Instrumentation System Planning Information (forms)

United States Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

INSTRUMENTATION SYSTEM PLANNING INFORMATION

Date: ______

SITE NAME: ______

SITE Location ______

Time Zone ______ Address ______

Latitude ______

Longitude ______

BUILDING Type & Usage: ______

Building Heat Load Coefficient (UA) ______

Building Equilibrium Temperature ______

SCHEDULE DATA

Sensor delivery date ______ J-Box installation comp. by ______

J-Box delivery date ______ Checkout test of system by ______

Sensor install. comp. by ______ System operational by ______

CONTROL SYSTEM (Submit schedule similar to example below:)

OPERATING MODE SCHEDULE

Operating Mode	Description	Pumps P1	P2	P3	P4	Valves (or Dampers) V1	V2	V3	V4	V5	V6	V7
1	Space Heating Demand Hot Water Demand Adequate Insolation Adequate Storage of Energy	on	on	on	on	C	C	A	B	B	A	C
2	Space Cooling Demand No Hot Water Demand Adequate Insolation Adequate Storage of Energy	on	off	off	on	C	B	B	B	A	A	O

O – Open

C – Closed

M – Mixing

A – Automatic Three-Way Valve is diverting flow.

B – Automatic Three-Way Valve is allowing through flow.

TECHNICAL INTERFACE

Name ______ Phone No. ______

Responsibility: ______

SITE CONTRACTOR Name ______

Affiliation ______

Address ______

Phone No. ______

SOLAR SYSTEM DRAWINGS

Note below and attach the System drawings that provide the following minimum information:

- System Flow Diagram showing all functional elements with applicable legends.
- Piping Diagram noting all sizes, material types, flow rates and approximate lengths.
- Equipment Schedule including phase, no. of wire, input power for all blowers, aux. heat and other electrical power requirements.
- Design Temperature Ranges of major componets, i.e. storage tanks, heat exchangers, collectors.

No.	Title

NOTE: If information requested is on an attached drawing, indicate by drawing number and title

INSTRUMENTATION SYSTEM PLANNING INFORMATION

SITE NAME: ______________________

Date: ______

SOLAR ENERGY SYSTEM ___ Air ___ Liquid ___ Passive

Application ___ Heating ___ Cooling ___ Hot Water ___ Domestic

___ Process

Collector Manuf. ______________________

Model ______________ Reflectors ___ Yes ___ No

Type ___ Air ___ Liquid ___ Concentrating ___ Flat Plate ___ Other______

No. of Collector Panels & Configuration ______________

Cooling Equipment Schedule

___ Heat Pump

Type ___ Absorption Chiller ___ Vapor Compression ___ Other______

Manuf. ______________ ______________

Model ______________ ______________

Size(s) ______________ ______________

System Safety Equipment

Freeze Protection Solution ___ Drain Down ___ Recirculation ___ Not Req'd

___ Other______

Boiling Protection ______________________

Over-Pressure Protection ______________________

Proposed Location of SDAS, J-Box & Telephone

(Example: Existing South Wall of Telephone Switch Room;
See drawning No. – XXXXXXXXX)

A7

Storage	Hot	Cold	Variable
Type			
Capacity (Volume)			
Tank Fill Volume			
Mounting (Vert/Horiz, etc.)			
Envelope Dimensions			
Tank Material			
Tank Wall Thickness			
Insulation Type			
Insulation Thickness			
Storage Medium			
Density			
Specific Heat			
Buried or Accessible			

Access Locations (Dwg No.) ______________

Internal Plumbing (Dwg No.) ______________

Baffling (Dwg No.) ______________

Fluid Transport If other than water or air, provide composition details.

____

____

____

____

____

Auxiliary Equipment Schedule

Dwg No.	Type

Note: If information requested is on attached drawing, indicate the applicable drawing number.

INSTRUMENTATION SYSTEM PLANNING INFORMATION

Date: ______

SITE NAME: ______

TEMPERATURE INSTRUMENTATION REQUIREMENTS				Deviation from IIG Yes*/No	Range (^oF)			Liquid Flow			Air Flow Duct Dimensions			Instal- lation Method	Ref Fig No.	Thermowell Part No.	Probe Part No.
No.	Designation	Justification	Name		Min.	Design	Max.	Pipe Type	Pipe Size	Tube Size	L	W	T				

* Provide details

Note: Sensor Requirements (page 3 thru 6) must be detailed if applicant desires to recommend sensors. DoE* or it's designated representative however, shall make final selection and determine location of all sensors under this contract. * (Department of Energy)

INSTRUMENTATION SYSTEM PLANNING INFORMATION

SITE NAME: ______________________

Date: ______________

FLOW RATE INSTRUMENTATION REQUIREMENTS				Deviation From IIG Yes*/No	Working Fluid**	Range (GPM/FPM)			Fitting Type***	Liquid Flow			Air Flow			Mounting Adapter (If Appl)	Model No.
													Duct Dimensions				
No.	Designation	Justification	Name			Min.	Design	Max.		Pipe Type	Pipe Size	Tube Size	L	W	T		

* Provide details ** If other than water or air, provide composition details *** Flanged, soldered, pipe, etc.

Note: Sensor Requirements (page 3 thru 6) must be detailed if applicant desires to recommend sensors. DoE or it's designated representative however, shall make final selection and determine location of all sensors under this contract.

INSTRUMENTATION SYSTEM PLANNING INFORMATION

Date: ______

SITE NAME: ______

POWER INSTRUMENTATION REQUIREMENTS				Phase	Configuration (3 or 4 Wire)	Full Scale Inputs			No. of Current Transducers	Model No.
No.	Designation	Justification	Name			Volts	Amps	Power (Kilowatts)		

A10

Note: Sensor Requirements (page 3 thru 6) must be detailed if applicant desires to recommend sensors. DoE or it's designated representative however, shall make final selection and determine location of all sensors under this contract.

INSTRUMENTATION SYSTEM PLANNING INFORMATION

SITE NAME: ____________________

Date: __________

OTHER INSTRUMENTATION REQUIREMENTS				*Model No.*	*Comments*
No.	*Designation*	*Justification*	*Name*		

Sampling Requirements

List Priority For Asynchronous Sampling ____________________

Misc. Items

List Any Deviations To IIG Installation Guidelines ____________________

List Any Physical/Clearance and Restrictions ____________________

Attach Any Other Information Necessary for Selecting and Installing Instrumentation ____________________

Note: Sensor Requirements (page 3 thru 6) must be detailed if applicant desires to recommend sensors. DoE or it's designated representative however, shall make final selection and determine location of all sensors under this contract.

APPENDIX B. INSTRUMENTATION INSTALLATION INSTRUCTIONS

The purpose of this Appendix is to provide the information required by a site contractor for planning the installation of the acceptable sensors listed in Table 3-2. General information on each sensor is presented and typical installation alternatives are shown. For intrusive temperature and flow sensors, recommended installations are listed for each pipe or tubing size.

B.1 GENERAL PROVISIONS

ACCESS

All sensors are to be located and installed to provide easy access for checkout, maintenance, and replacement. The site contractor shall provide special access equipment where required (i.e., ladders and/or scaffolding for sensors located on collector array).

WIRING

Wire nuts will be utilized for terminations at the following sensors:

RTD probes	3 each (single element) 6 each (dual element)
Relative humidity probe	4 each
Wind speed/direction	5 each*
Pyranometer	2 each
Gas meter	3 each
Fuel oil	3 each
Angular displacement	3 each

It is recommended that the wire nuts be replaced with a "butt splice" in areas where the connections are exposed to vibration or outside environments.

Ring terminals will be used to terminate the wires at the junction box (ERDA will supply junction box ring terminals only) and at the following sensors:

Flow meter	4 each
Pressure transducer	3 each
Watt transducer	2 each
Anemometer	2 each

If terminations conflict with local codes, local codes shall be applicable.

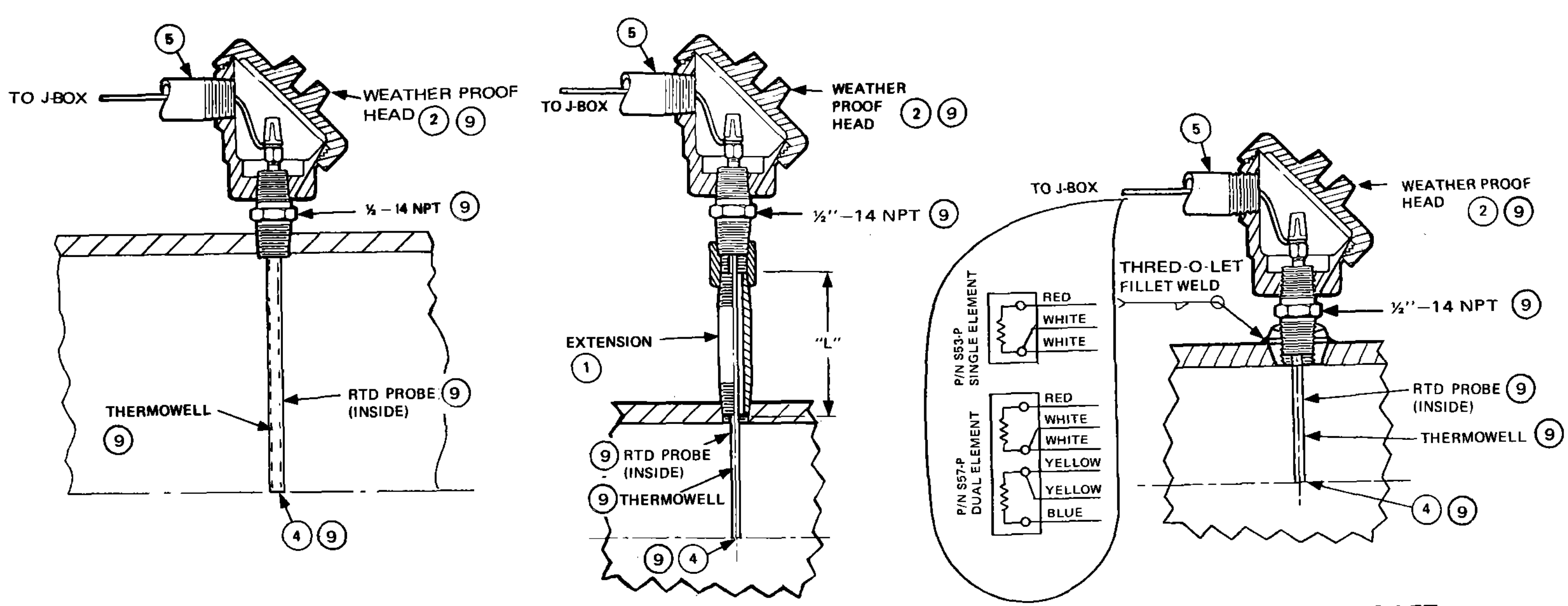
*A connector may be provided that will require soldering to connector pins or "butt splice" to a short piece of cable.

B.2 TEMPERATURE DETECTION

Numerous combinations of installation options are available for the Resistance Temperature Detectors (RTDs). Presented are figures that provide illustrations of typical installations and tables that provide each sensor type, part number, and size of pipe/tube. The illustrations also serve as a guide in the sensor selection process.

INSTALLATION TYPE	INSTALLATION FIGURE NUMBER AND LOCATION
Pipe	B-1 (Pages B-4 and B-5)
Pipe (plastic)	B-2 (Pages B-7 and B-8)
Flared tube	B-3 (Pages B-10 and B-11)
Solder tube/pipe	B-4 (Pages B-13 and B-14)
Air duct	B-5 (Page B-16)
Storage tank	B-6 (Pages B-18 through B-21 see Table 2 Page B-22)

Thermowell lengths were calculated to allow the tip of the RTD probe to enter the fluid stream between the inside wall and center of pipe. Since the thermowells are provided with 1/2 MNPT connections, all illustrations are shown with this configuration. Selected installation methods with RTD probe part numbers according to pipe or tube size are shown. When special installations are required, the site contractor may select another method for which ERDA will provide the necessary installation information and sensors for the application. A standard tank probe length of 18 inches was selected for most tank applications in the vertical position. RTD probe length will vary in horizontal tanks and the formula for obtaining the desired location for the tip of the probe is provided. It should be noted that some installations will require deviations from the normal.



(A) PIPE WALL

(B) PIPE WALL WITH EXTENSION

(C) PIPE WALL THRED-O-LET

EXAMPLE – Select a Thermowell and Dual Element RTD Probe for a 2" pipe with 4" (4.0" X 10 tenths/inch = 40 tenths) Extension ("L" Illustration B)

Sensor Part Numbers:

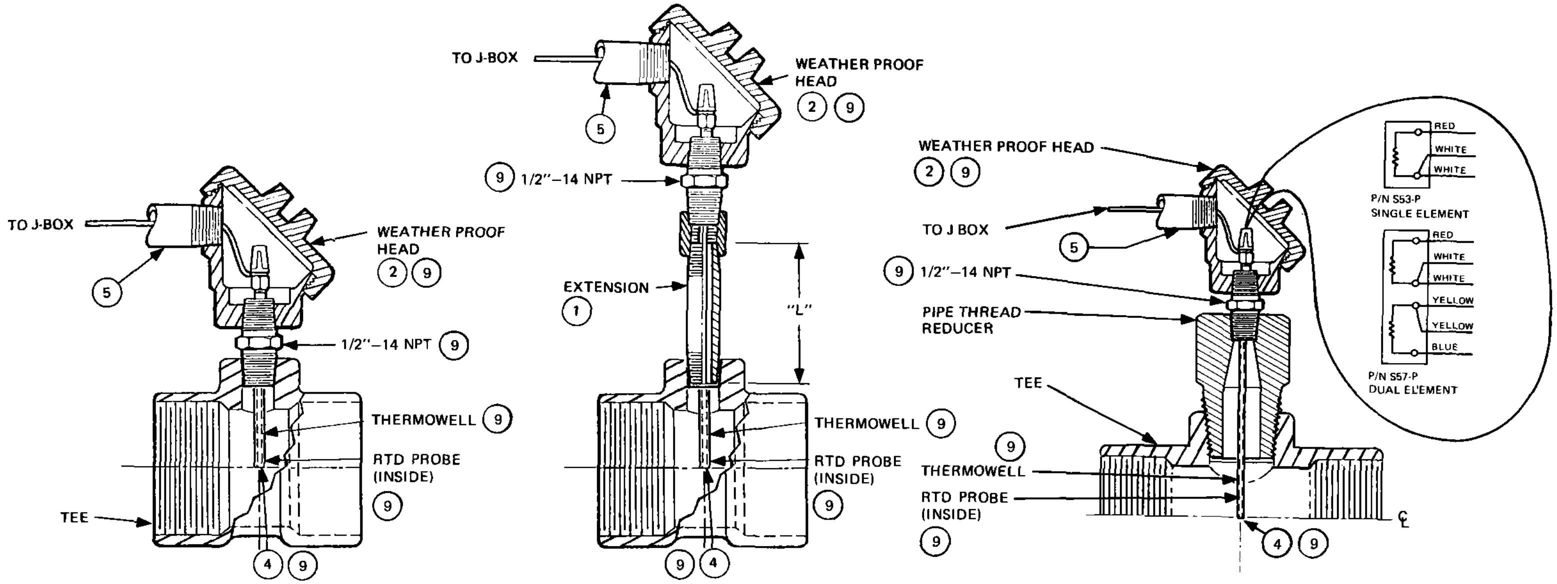
1. – Single Element Probe – S53 –P(XX)Z36
2. – Dual Element Probe – S57 –P(XX)Z36
3. – Thermowell – F203U(WW)

- Thermowell – Part Number is F203U(WW). Under "B" in Table, (WW) = (15 + L), where L = 40. Therefore, Part Number is F203U55.
- RTD Probe – Part Number is S57 – P(XX). Under "B" in Table, (XX) = (45 + L) where L = 40. Therefore, Part Number is S57–P85Z36.

NOTE: SEE PAGE B-6 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

NOMINAL PIPE SIZE (INS)	A		B		C	
	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
1/2	N/A	N/A	N/A	N/A	N/A	N/A
3/4	N/A	N/A	N/A	N/A	10	40
1	N/A	N/A	N/A	N/A	10	40
1¼	N/A	N/A	N/A	N/A	10	40
1½	N/A	N/A	N/A	N/A	10	40
2	10	40	15 + "L"	45 + "L"	10	40
2½	15	40	20 + "L"	45 + "L"	15	40
3	15	40	20 + "L"	45 + "L"	15	40
3½	15	40	20 + "L"	45 + "L"	15	40
4 TO 12	15	40	20 + "L"	45 + "L"	15	40

Figure B-1. Typical Temperature Sensor Installation For Pipe



(D) PIPE RUN TEE

(E) PIPE RUN TEE EXTENSION

(F) PIPE RUN TEE WITH REDUCER

Sensor Part Numbers:

1. – Single Element RTD Probe – S53PXXZ36
2. – Dual Element RTD Probe – S57PXXZ36
3. – Thermowell – F203U(WW)

EXAMPLE – Select a dual element RTD Probe and Thermowell for a 3½" pipe with a 1.5" (1.5" X 10 tenths/inch = 15 tenths) Extension ("L" Illustration E)

- THERMOWELL – Part Number is F203U(WW). Under "E" in Table, (WW) = (33 + L) where L = 15. Therefore part number is F203U48
- RTD PROBE – Part Number is S57–PXXZ36. Under "E" in Table, (XX) = 60 + L where L = 15. Therefore part number is S57–P75Z36

NOTE: SEE PAGE B-6 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

NOMINAL PIPE SIZE (INS)	D		E		F	
	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
1/2	6	40	12 + "L"	45 + "L"	N/A	N/A
3/4	6	40	12 + "L"	45 + "L"	N/A	N/A
1	6	40	12 + "L"	45 + "L"	10	40
1¼	10	40	15 + "L"	45 + "L"	10	40
1½	10	40	15 + "L"	45 + "L"	15	40
2	18	50	23 + "L"	55 + "L"	15	40
2½	18	50	23 + "L"	55 + "L"	15	40
3	18	50	23 + "L"	55 + "L"	15	4.0
3½	28	55	33 + "L"	60 + "L"	N/A	N/A

Figure B-1. Typical Temperature Sensor Installation For Pipe (continued)

COMMENTS:

(1) Length of extension shall be selected to allow thermowell immersion in fluid stream between wall and centerline of pipe.

(2) Weather proof head shall be oriented to minimize accidental damage. Part No. F102-4.

(3) Material selection shall be galvanically compatible to the system design.

(4) Dow Corning DC-342 heat transfer grease (9) shall be applied to the bottom of the RTD probe prior to insertion into the thermowell.

(5) Standard conduit 3/4" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit. All connections shall be watertight.

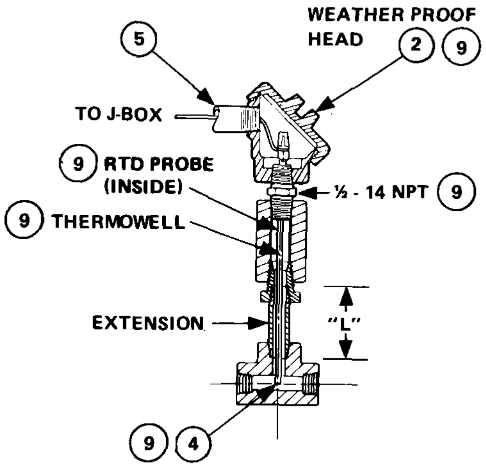
(6) If installation of thermowell(s) degrades the design or operational integrity of the fluid transport system, other methods shall be investigated for this application. ERDA shall provide and/or approve the design change.

(7) Pipe thread sealing compound may be used in accordance with local codes.

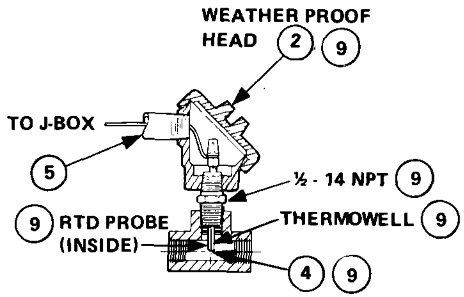
(8) In areas where mixing of fluid is necessary to provide meaningful temperature results, the RTD shall be located 10 diameters for a pipe smaller than 1" or 20 diameters for pipe greater than 11/4" from the mixing intersection.

(9) ERDA supplied part to site contractor.

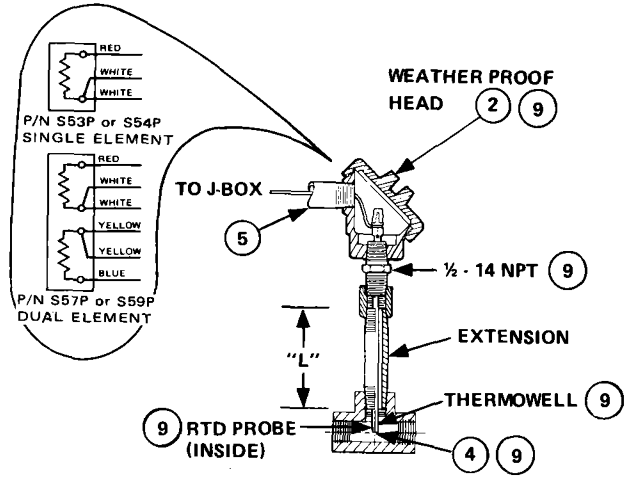
(10) Source: Minco Products, Inc., Minneapolis, Minnesota or equivalent.



(A) 3/8" PLASTIC PIPE TEE WITH EXTENSION



(B) 1/2" PLASTIC PIPE TEE



(C) 1/2" PLASTIC PIPE TEE WITH EXTENSION

Semsor Part Numbers:

1. – Single Element RTD Probe – S53–P(XX)Z36
2. – Dual Element RTD Probe – S57–P(XX)Z36
3. – Thermowell – F203U(WW)

EXAMPLE – Select a dual element RTD Probe and Thermowell for a ½" plastic pipe with a 2.0" (2.0" X 10 tenths/inch = 20 tenths) Extension("L" Illustration C)

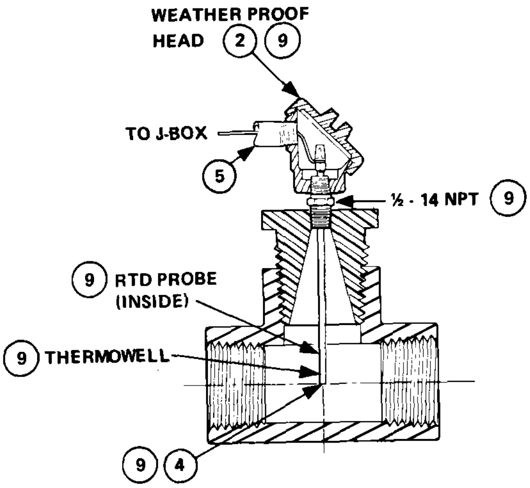
- THERMOWELL – Part Number is F203U(WW). Under "C" in Table, (WW) = 15 + L and L = 20. Therefore, part number is F203U35
- RTD PROBE – Part Number is S57–P(XX)Z36. Under "C" in Table, (XX) = 40 + L and L = 20. Therefore, part number is S57–P60Z36

NOTE: SEE PAGE B-9 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

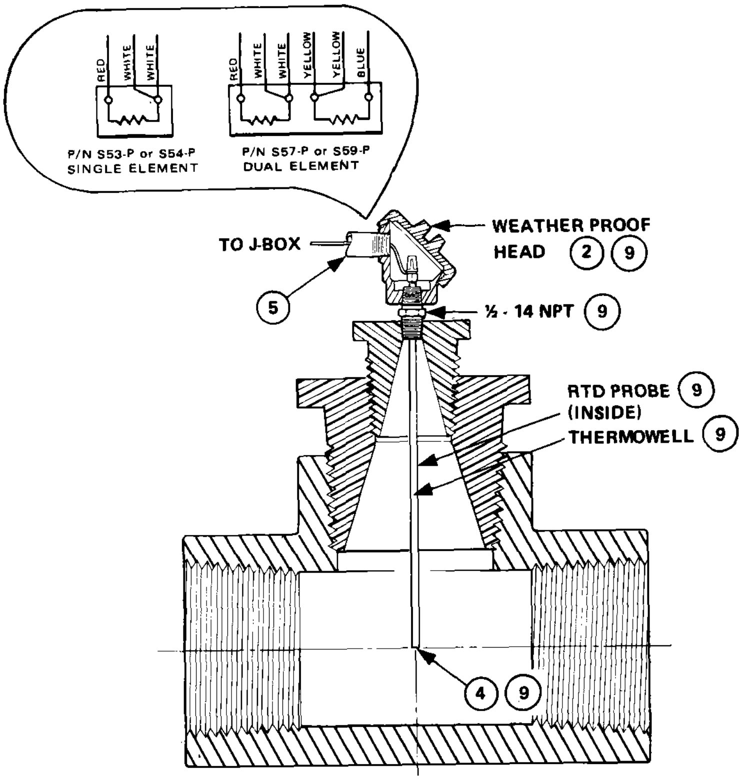
TUBING SIZE (OD INS)	A		B		C	
	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
3/8	20 + "L"	45 + "L"	N/A	N/A	N/A	N/A
1/2	N/A	N/A	6	40	15 + "L"	40 + "L"

Figure B-2. Typical Temperature Sensor Installation For Schedule 80 Plastic Pipe

NOTE: SEE PAGE B-9 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).



(D) 3/4" to 2" PLASTIC PIPE



(E) 2 1/2" to 4" PLASTIC PIPE

Sensor Part Numbers – 1. Single element RTD Probe – S53–P(XX)Z36
2. Dual element RTD Probe – S57–P(XX)Z36
3. Thermowell – F203U(WW)

EXAMPLE – Select a single element RTD Probe and Thermowell for a 4" plastic pipe. (Illustration E)

- THERMOWELL –Part Number is F203U(WW). Under "E" in Table, (WW)=70. Therefore, part number is F203U70.
- RTD PROBE – Part Number is S53–P(XX). Under "E" in Table (XX) = 95. Therefore, part number is S53–P95 Z36.

PIPE SIZE (INS)	D		E	
	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
3/4	25	50	N/A	N/A
1	25	50	N/A	N/A
1¼	30	55	N/A	N/A
1½	30	55	N/A	N/A
2	35	60	N/A	N/A
2½	N/A	N/A	50	80
3	N/A	N/A	60	85
4	N/A	N/A	70	95

Figure B-2. Typical Temperature Sensor Installation For Schedule 80 Plastic Pipe (continued)

COMMENTS:

1. Length of extension shall be selected to allow thermowell immersion in fluid stream between wall and centerline of plastic pipe.

2. Weather proof head shall be oriented to minimize accidental damage. Part No. F102-4.

3. Material selection shall be galvanically compatible to the system design.

4. Dow Corning DC-342 heat transfer grease (9) shall be applied to the bottom of the RTD probe prior to insertion into the thermowell.

5. Standard conduit 3/4" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit. All connections shall be watertight.

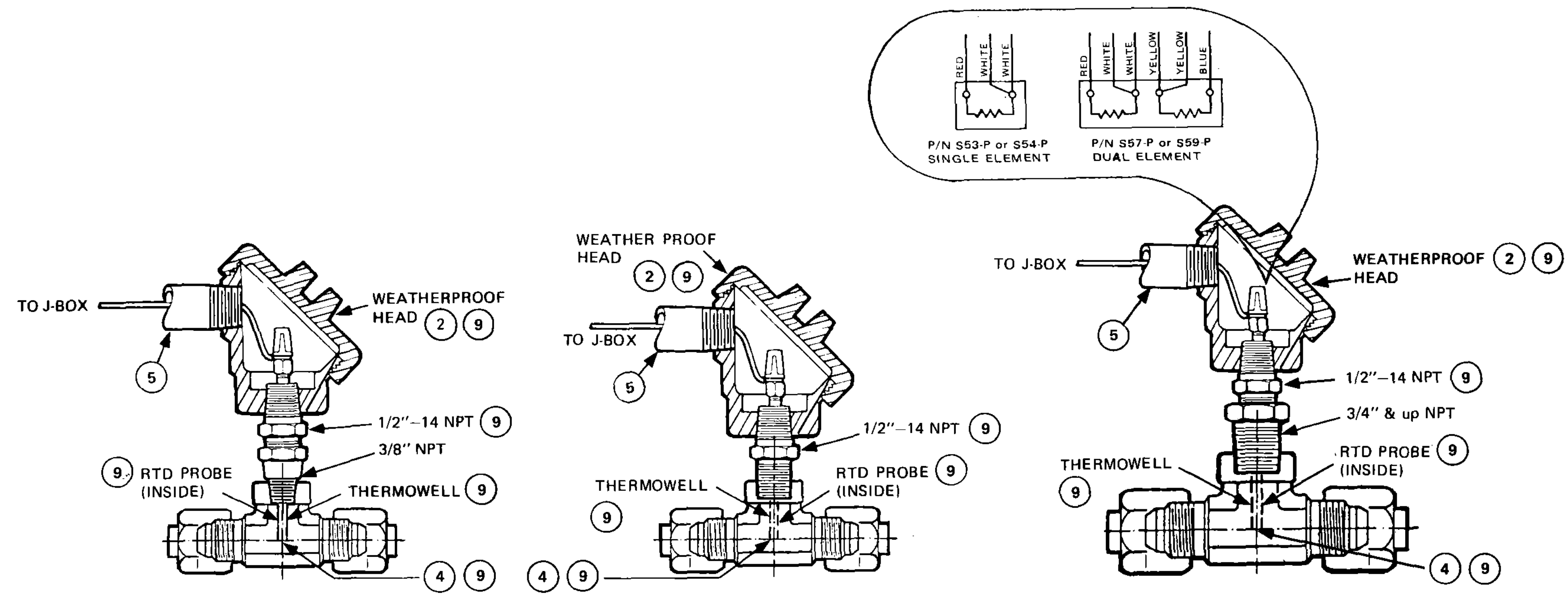
6. If installation of thermowell(s) degrades the design or operational integrity of the fluid transport system, other methods shall be investigated for this application. ERDA shall provide and/or approve the design change.

7. Pipe thread sealing compound may be used in accordance with local codes.

8. In areas where mixing of fluid is necessary to provide meaningful temperature results, the RTD shall be located 10 diameters for a pipe smaller than 1" or 20 diameters for pipe greater than 11/4" from the mixing intersection.

9. ERDA supplied part to site contractor.

10. Source: Minco Products, Inc., Minneapolis, Minnesota or equivalent.



(A) 1/2" FLARED TUBE TEE WITH REDUCING CONNECTOR

(B) 5/8" FLARED TUBE/PIPE BRANCH TEE

(C) 3/4" & UP FLARED TUBE WITH PIPE THREAD REDUCER

Sensor Part Numbers –
1. Single Element RTD Probe – S53–P(XX)Z36
2. Dual Element RTD Probe – S57–P(XX)Z36
3. Thermowell – F203U(WW)

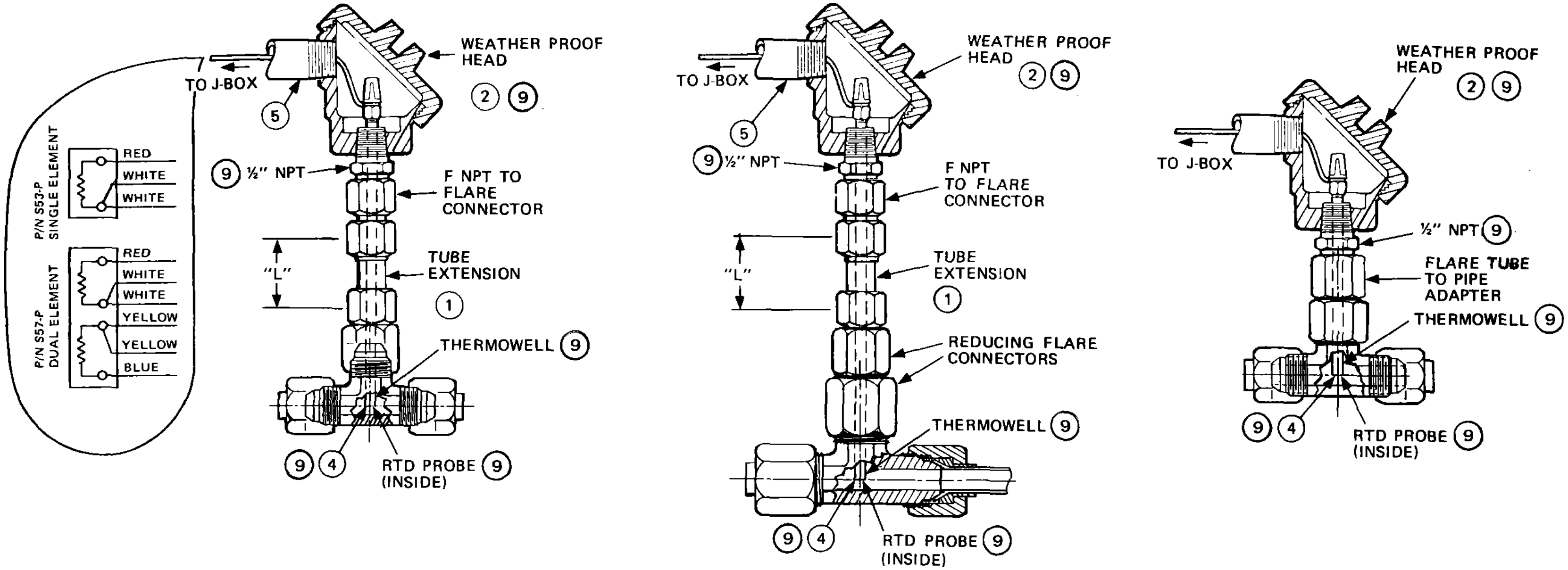
EXAMPLE – Select a single element RTD Probe and Thermowell for a 5/8" flared tube pipe thread branch tee. (Illustration B)

- THERMOWELL – Part Number is F203U(WW). Under "B" in Table, WW = 7. Therefore, part number is F203U7.
- RTD Probe – Single element part number is S53–P(XX)Z36. Under "C" in Table, XX = 40. Therefore, part number is S53–P40Z36.

NOTE: SEE PAGE B-12 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCULED (O).

TUBING SIZE (OD INS)	A		B		C	
	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
1/2 (-8)	15	40	N/A	N/A	N/A	N/A
5/8 (-10)	N/A	N/A	7	40	N/A	N/A
3/4 (-12)	N/A	N/A	N/A	N/A	15	40
1 (-16)	N/A	N/A	N/A	N/A	19	45
1¼ (-20)	N/A	N/A	N/A	N/A	19	45
1½ (-24)	N/A	N/A	N/A	N/A	19	45
2 (32)	N/A	N/A	N/A	N/A	19	45
2 (32)	N/A	N/A	N/A	N/A	19	45

Figure B-3. Typical Tubing Installation (37° and 45° Fittings)



(A) FLARED TEE ½" to 1" **(B) FLARED TUBE TEE REDUCED TO ½" EXTENSION** **(C) FLARED TUBE TEE WITH BRANCH SWIVEL NUT**

Sensor Part Numbers:

1. – Single element RTD Probe – S53–P(XX)Z36
2. – Dual element RTD Probe – S57–P(XX)Z36
3. – *Thermowell* – F203U(WW)

EXAMPLE – Select a dual element RTD Probe and Thermowell for a 1½" flared tube/tee with a 2.0" (2.0" X 10 tenths/inch = 20 tenths) *Extension ("L" Illustration B)*

- THERMOWELL – Part Number is F203U(WW). Under "B" in Table, (WW) = 45 + L and L = 20. Therefore, part number is F203U65.
- RTD PROBE – Part Number is S57–P(XX)Z36. Under "B" in Table, (XX) = 70 + L and L = 20. Therefore, part number is S57–P90Z36.

NOTE: SEE PAGE B-12 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

TUBING SIZE (OD INS)	A		B		C	
	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
1/2	25 + "L"	55 + "L"	N/A	N/A	25	55
5/8	25 + "L"	55 + "L"	N/A	N/A	28	55
3/4	25 + "L"	55 + "L"	N/A	N/A	30	55
1	N/A	N/A	40 + "L"	65 + "L"	N/A	N/A
1¼	N/A	N/A	45 + "L"	70 + "L"	N/A	N/A
1½	N/A	N/A	45 + "L"	70 + "L"	N/A	N/A

Figure B-3. Typical Tubing Installation (37^0 and 45^0 Fittings) (continued)

COMMENTS:

(1) Length of extension shall be selected to allow thermowell immersion in fluid stream between wall and centerline flared tube.

(2) Weather proof head shall be oriented to minimize accidental damage. Part No. F102-4.

(3) Material selection shall be galvanically compatible to the system design.

(4) Dow Corning DC-342 heat transfer grease (9) shall be applied to the bottom of the RTD probe prior to insertion into the thermowell.

(5) Standard conduit 3/4" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit. All connections shall be watertight.

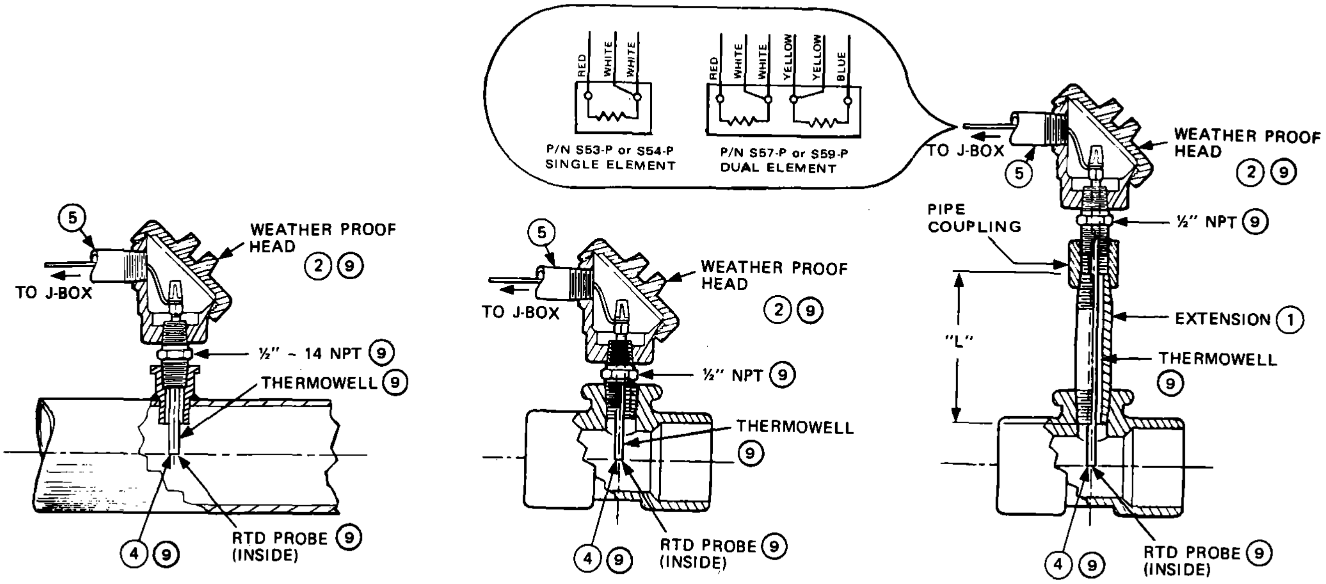
(6) If instllation of thermowell(s) degrades the design or operational integrity of the fluid transport system, other methods shall be investigated for this application. ERDA shall provide and/or approve the design change.

(7) Pipe thread sealing compound may be used in accordance with local codes.

(8) In areas where mixing of fluid is necessary to provide meaningful temperature results, the RTDs shall be located 10 diameters for a pipe smaller than 1" or 20 diameters for pipe greater than 11/4" from the mixing intersection.

(9) ERDA supplied part to site contractor.

(10) Source: Minco Products, Inc., Minneapolis, Minnesota or equivalent.



(A) SOLDER ADAPTER

(B) 3/8" to 3" RUN TEE SOLDER/PIPE ADAPTER

(C) 3/8" to 3" RUN TEE SOLDER/PIPE ADAPTER

Sensor Part Numbers:

1. – Single element RTD Probe – S53–P(XX)Z36
2. – Dual element RTD Probe – S57–P(XX)Z36
3. – Thermowell – F203U(WW)

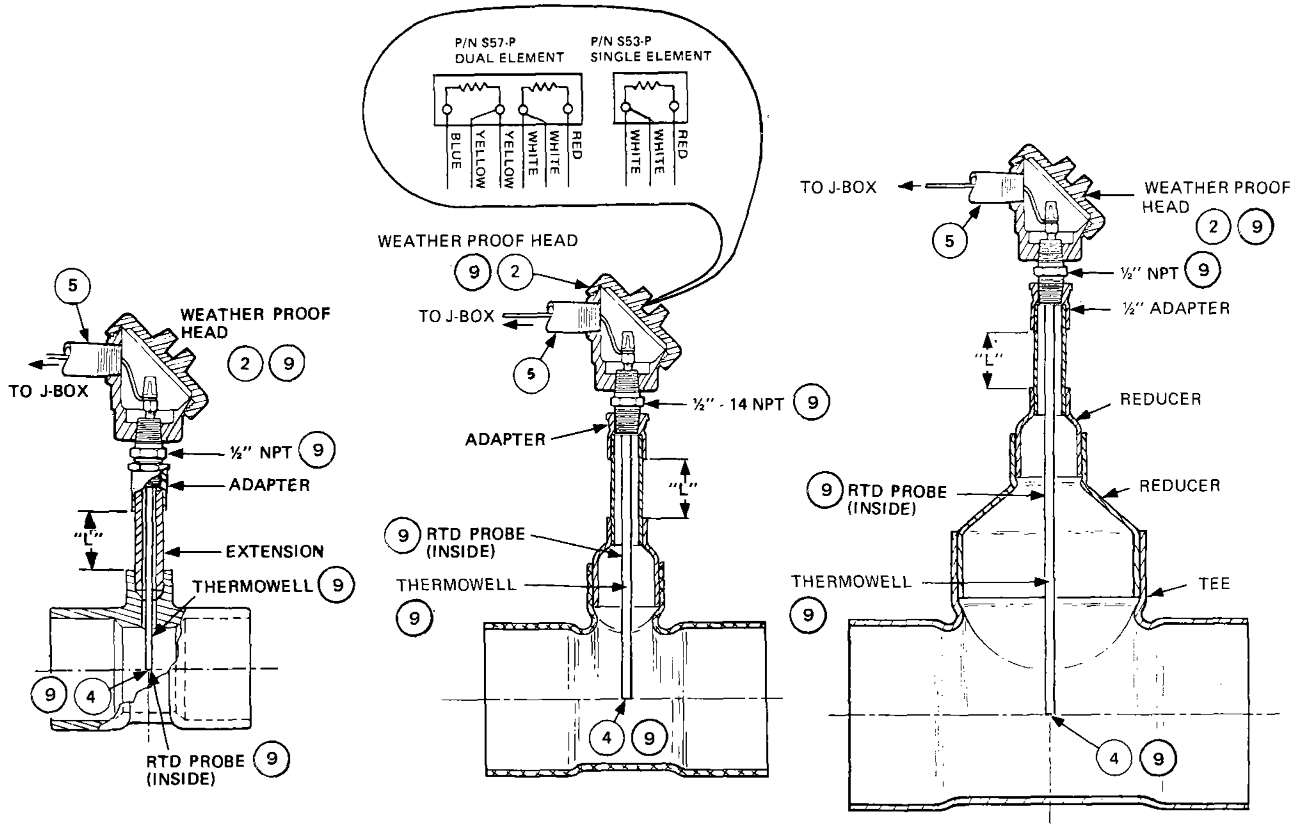
NOTE: SEE PAGE B-15 FOR COMMENTS REFERENCED TO NUMBERS CIRCLED (O).

EXAMPLE – Select a single element RTD Probe and Thermowell for a 2½" tee with a 2.0" (2.0" X 10 tenths/inch = 20 tenths) Extension ("L" Illustration C)

- THERMOWELL – Part Number is F203U(WW). Under "C" in Table, (WW) = 32 + L and L = 20. Therefore, part number is F203U52.
- RTD PROBE – Part Number is S53–P(XX)Z36. Under "C" in Table, (XX) = 60 + L and L = 20. Therefore, part number is S53–P80Z36.

PIPE SIZE NOMINAL (INS)	TUBE SIZE OD (INS)	A		B		C	
		THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
3/8	1/2	N/A	N/A	4	30	18 + "L"	45 + "L"
1/2		N/A	N/A	4	30	18 + "L"	45 + "L"
5/8	3/4	N/A	N/A	4	30	18 + "L"	45 + "L"
3/4		N/A	N/A	4	30	18 + "L"	45 + "L"
	1	N/A	N/A	4	30	23 + "L"	50 + "L"
1		15	40	6	40	23 + "L"	50 + "L"
	1¼	15	40	6	40	23 + "L"	50 + "L"
1¼		15	40	6	40	23 + "L"	50 + "L"
	1½	15	40	6	40	23 + "L"	50 + "L"
1½		15	40	6	40	23 + "L"	50 + "L"
2		15	40	10	40	27 + "L"	55 + "L"
2½		15	40	15	40	32 + "L"	60 + "L"
3		15	40	15	40	32 + "L"	60 + "L"
3½		15	40	15	40	32 + "L"	60 + "L"
4.0		15	40	N/A	N/A	N/A	N/A
5.0		15	40	N/A	N/A	N/A	N/A
6.0		15	40	N/A	N/A	N/A	N/A
7.0		15	40	N/A	N/A	N/A	N/A

Figure B-4. Typical Temperature Sensor Solder Connection



(A) REDUCING TEE WITH EXTENSION **(B) TEE WITH REDUCER AND EXTENSION** **(C) LARGE TEE WITH REDUCERS AND EXTENSION**

Sensor Part Numbers:

1. – Single Element RTD Probe – S53–P(XX)Z36
2. – Dual Element RTD Probe – S57–P(XX)Z36
3. – Thermowell – F203(WW)

NOTE: SEE PAGE B-15 FOR COMMENTS REFERENCED TO NUMBERS CIRCLED (O).

EXAMPLE – Select a single element RTD Probe and Thermowell for a 2" reducing tee with a 3.0" (3.0" X 10 tenths/inch = 30 tenths) Extension ("L" Illustration A)

- THERMOWELL – Part Number is F203U(WW) under "A" in Table, (WW) = 18 + L and L = 30. Therefore, part number is F203U48.
- RTD PROBE – Part Number is S53–P(XX)Z36 under "A" in Table, (XX) = 45 + L and L = 30. Therefore, part number is S53–P75Z36.

PIPE SIZE NOMINAL INS	TUBE SIZE OD INS	A		B		C	
		THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)	THERMOWELL (WW)	RTD PROBE (XX)
3/8	1/2	13 + "L"	40 + "L"	N/A	N/A	N/A	N/A
1/2		13 + "L"	40 + "L"	N/A	N/A		
5/8	3/4	13 + "L"	40 + "L"	20 + "L"	47 + "L"		
3/4		18 + "L"	40 + "L"	25 + "L"	55 + "L"		
	1	18 + "L"	40 + "L"	25 + "L"	55 + "L"		
1		8 + "L"	45 + "L"	25 + "L"	55 + "L"		
	1¼	18 + "L"	45 + "L"	29 + "L"	55 + "L"		
1¼		18 + "L"	45 + "L"	29 + "L"	55 + "L"		
	1½	18 + "L"	45 + "L"	29 + "L"	55 + "L"		
1½		18 + "L"	45 + "L"	29 + "L"	55 + "L"		
2		18 + "L"	45 + "L"	35 + "L"	60 + "L"		
2½		18 + "L"	45 + "L"	N/A	N/A	55 + "L"	85 + "L"
3		18 + "L"	45 + "L"	N/A	N/A	55 + "L"	85 + "L"
4		18 + "L"	45 + "L"	N/A	N/A	55 + "L"	85 + "L"
5		N/A	45 + "L"	N/A	N/A	60 + "L"	85 + "L"
6		N/A	45 + "L"	N/A	N/A	60 + "L"	85 + "L"

Figure B-4. Typical Temperature Sensor Solder Connection (continued)

COMMENTS:

1. Length of extension shall be selected to allow thermowell immersion in fluid stream between wall and centerline of tube/pipe.

2. Weather proof head shall be oriented to minimize accidental damage. Part No. F102-4.

3. Material selection shall be galvanically compatible to the system design.

4. Dow Corning DC-342 heat transfer grease shall be applied to the bottom of the RTD probe prior to insertion into the thermowell.

5. Standard conduit 3/4" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit. All connections shall be watertight.

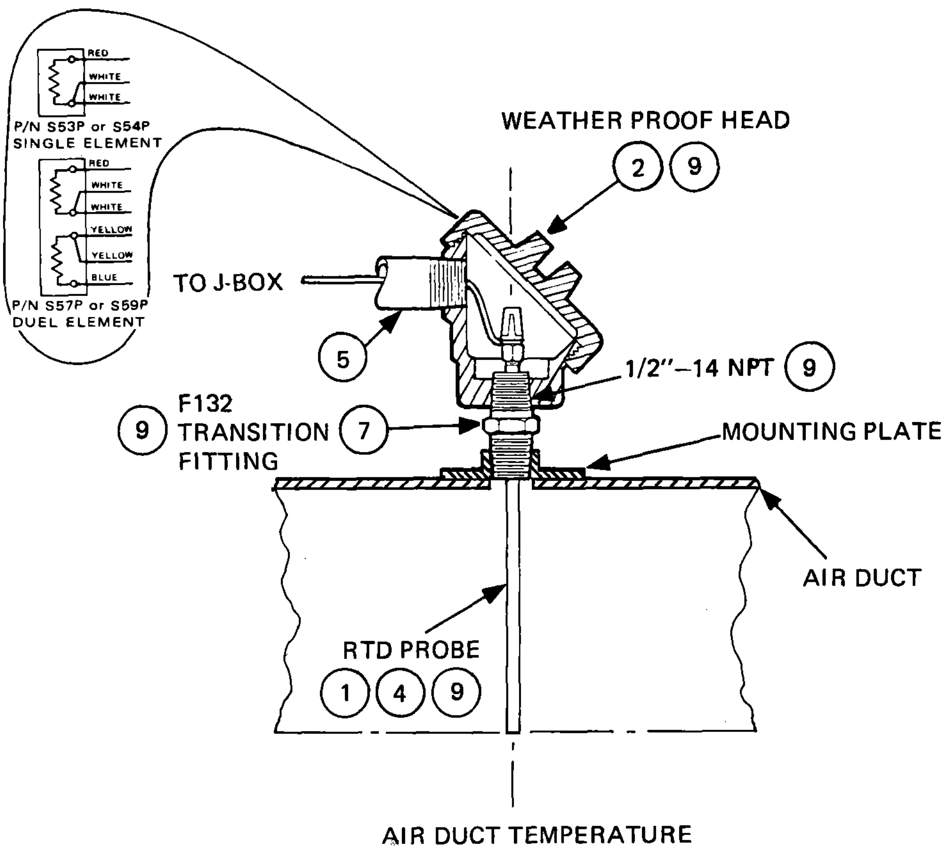
6. If installation of thermowell(s) degrades the design or operational integrity of the fluid transport system, other methods shall be investigated for this application. ERDA shall provide and/or approve the design change.

7. Pipe thread sealing compound may be used in accordance with local codes.

8. In areas where mixing of fluid is necessary to provide meaningful temperature results, the RTD shall be located 10 diameters for a pipe smaller than 1" or 20 diameters for pipe greater than 11/4" from the mixing intersection.

9. ERDA supplied part to site contractor.

10. Source: Minco Products, Inc., Minneapolis, Minnesota or equivalent.



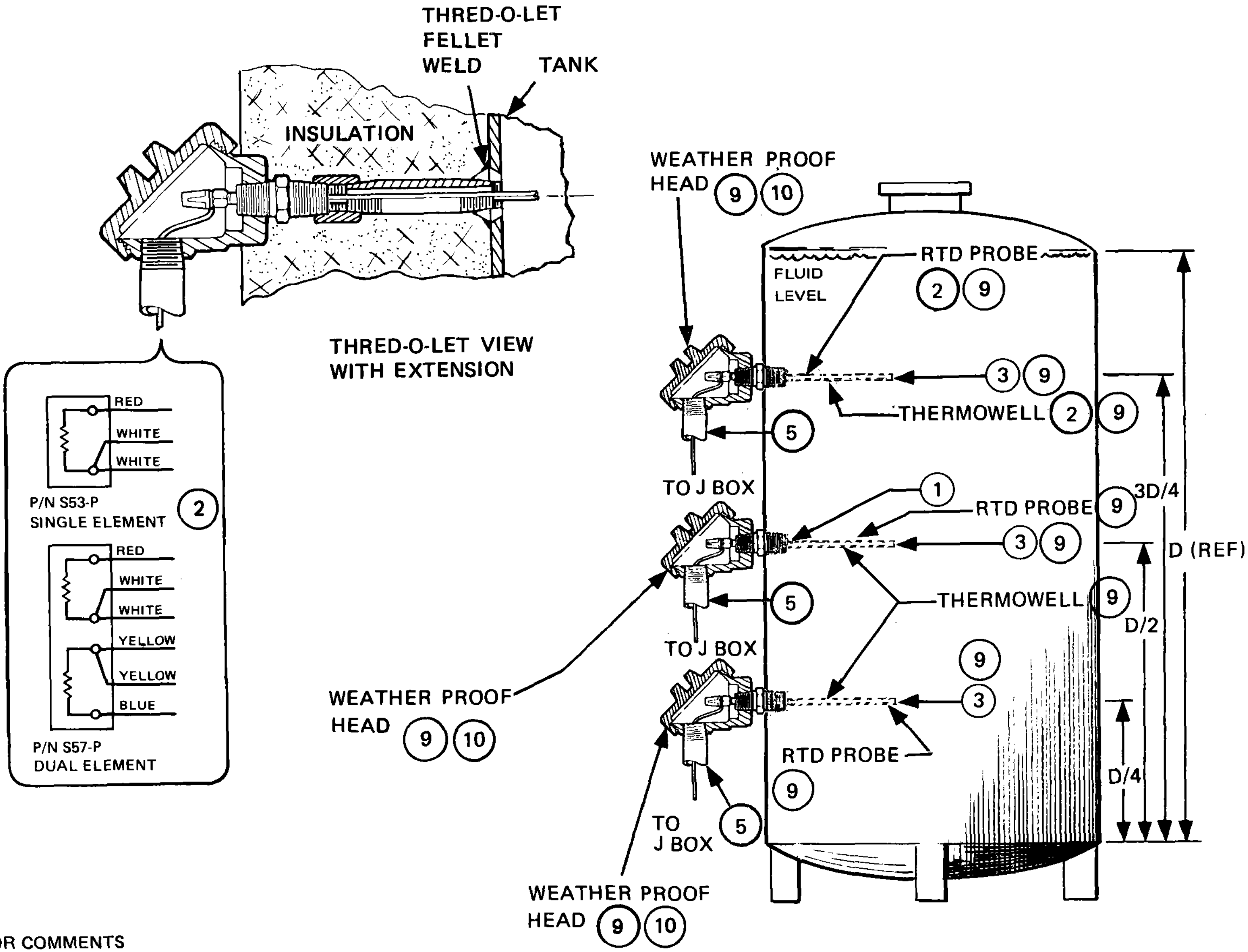
Sensor Part Numbers – Single Element RTD Probe – S53P85Z36
Dual Element RTD Probe – S57P85Z36
Transition Fitting –F132

NOTE: SEE PAGE B-17 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

Figure B-5. Typical Duct Temperature Sensor Installation

COMMENTS:

1. RTD probe length shall be selected to allow probe to enter air stream between inside wall and centerline of duct.
2. Weather proof head shall be oriented to minimize accidental damage. Part No. F102-4.
3. Material selection shall be galvanically compatible to the system design.
4. RTD probe part numbers S53-P85Z36 or S57-P85Z36.
5. Standard conduit 3/4" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit. All connections shall be watertight.
6. Pipe thread sealing compound may be used in accordance with local codes.
7. Fluid seal transition fitting, Part No. F-132.
8. In areas where mixing of fluid is necessary to provide meaningful temperature results, the RTD shall be located 10 diameters from the mixing intersection.
9. ERDA supplied part to site contractor.
10. Source: Minco Products, Inc., Minneapolis, Minnesota or equivalent.



NOTE: SEE PAGE B-22 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

Figure B-6. Typical Temperature Sensor For Vertical Tank Installation

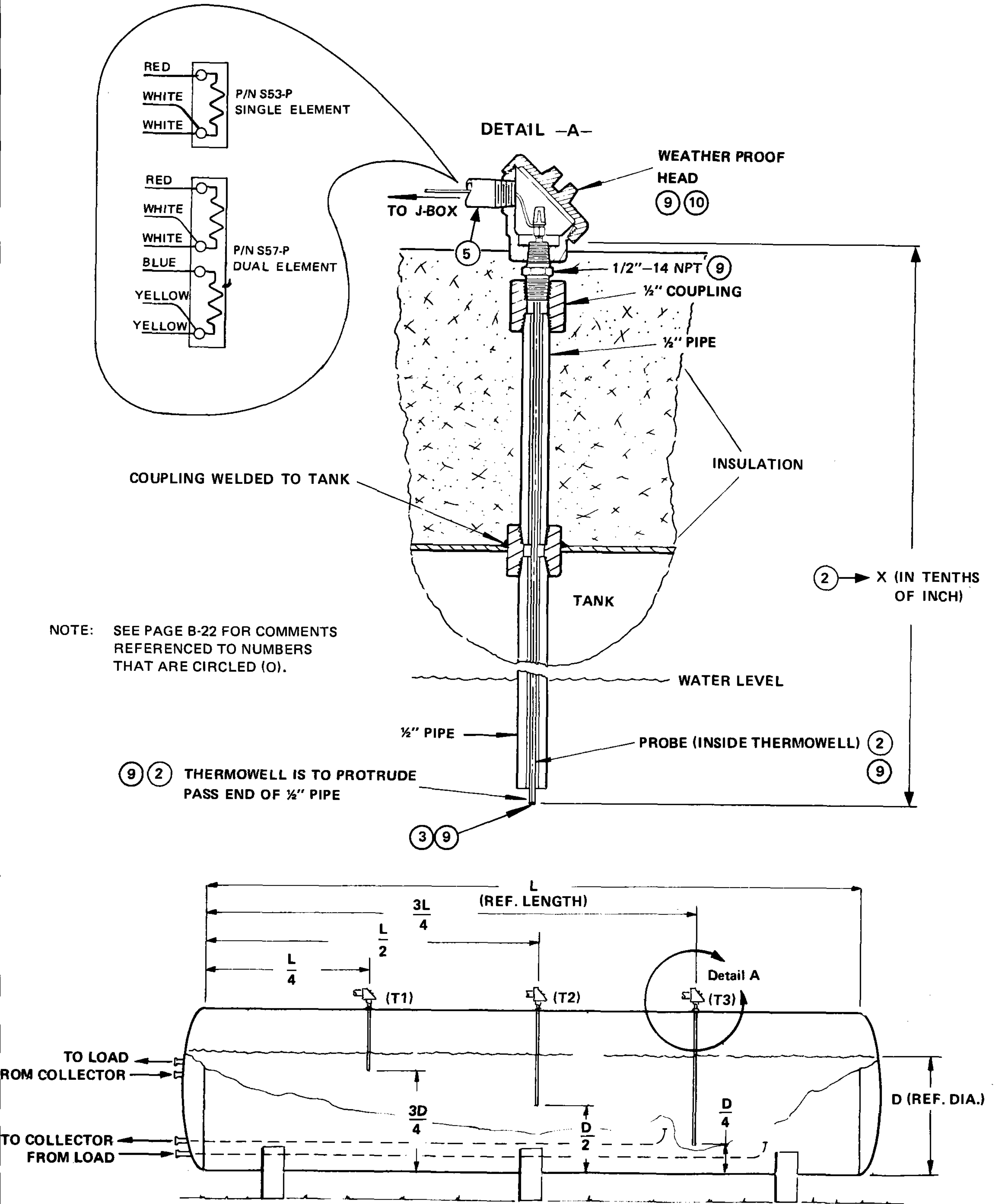


Figure B-6. Typical Horizontal Tank Sensor Installation (Top) (continued)

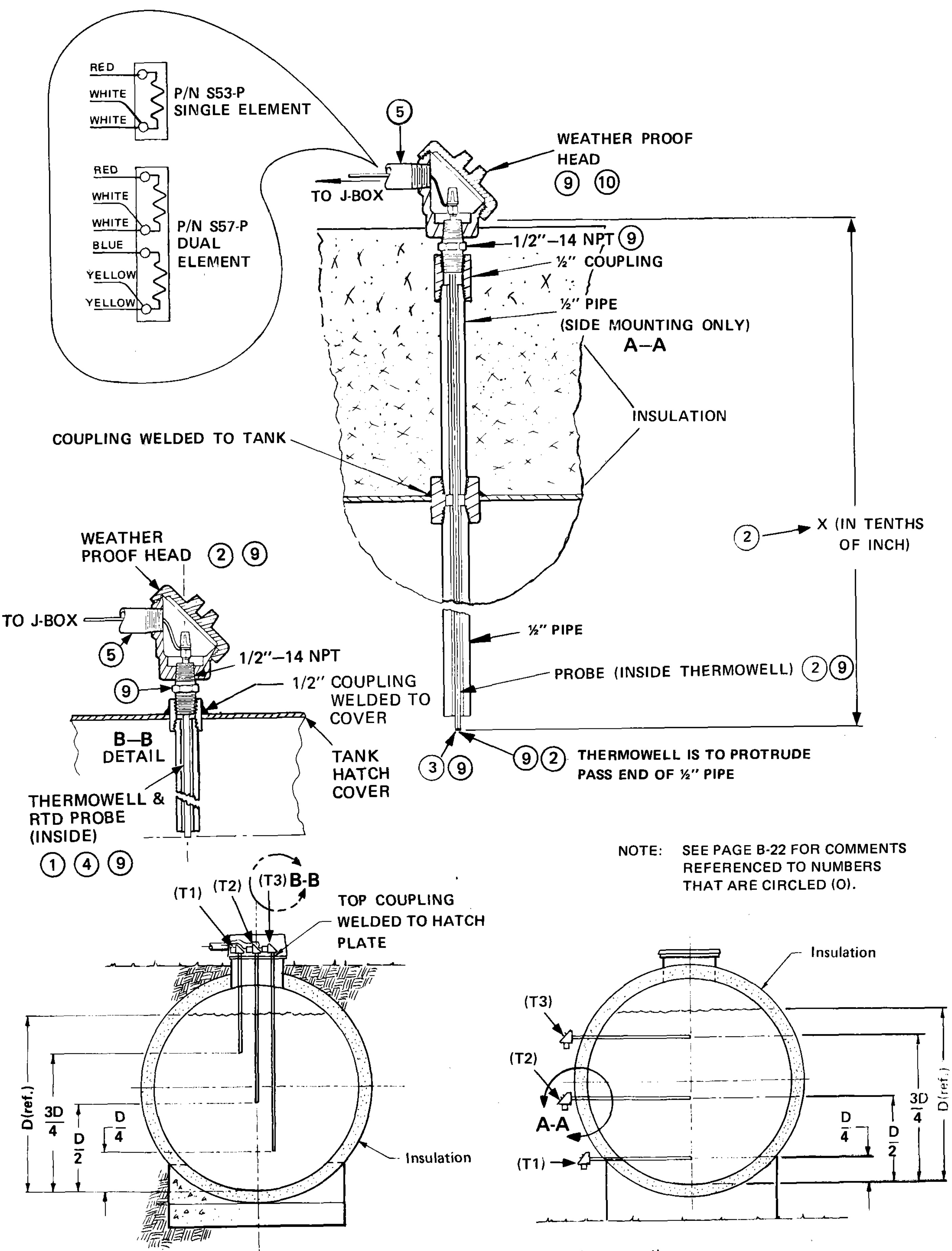
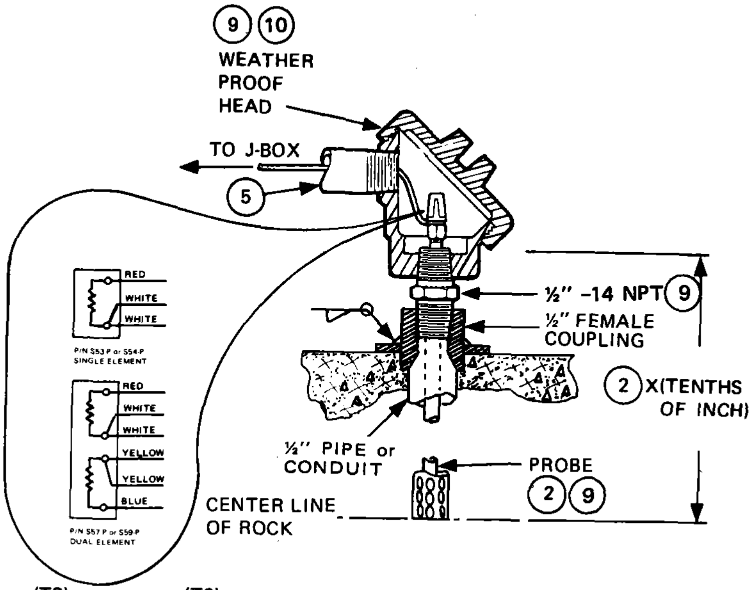


Figure B-6. Typical Horizontal Tank Sensor Manhole And Side Installation (continued)

NOTE: SEE PAGE B-22 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).



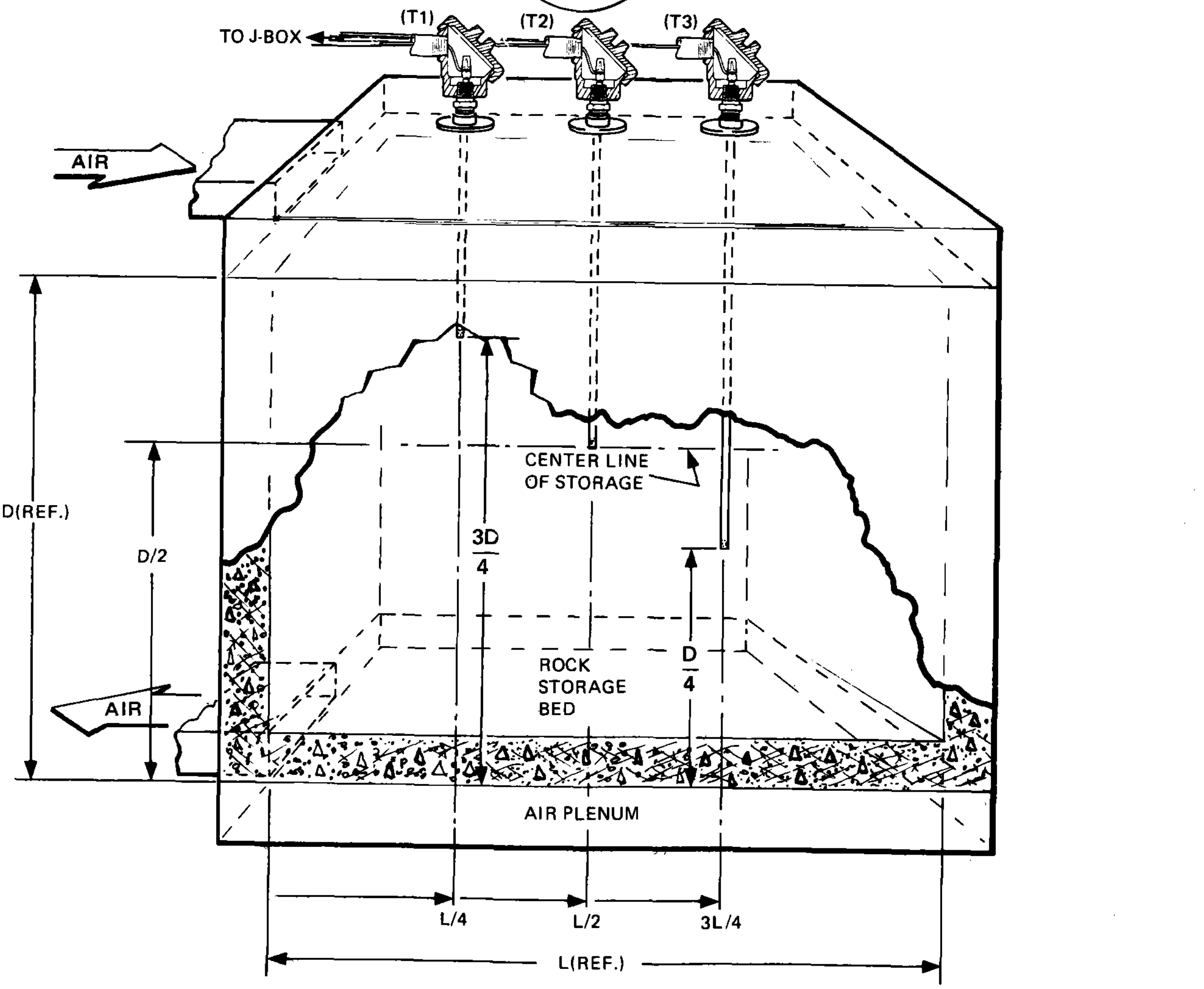


Figure B-6. Typical Air Type Storage Installation (continued)

COMMENTS:

(1) Performance requirement is to establish an average temperature for the storage media. Location and number of temperature sensors required shall depend on the design of the container, entrances, and exists in order to provide an average temperature.

(2)

(2) STORAGE SUBSYSTEM PART NUMBERS

Ref. Fig. to (Meas. No.)	VERTICAL TANK (PAGE B-18)		HORIZONIAL TANK (PAGE B-19/20)		AIR and OTHERS (PAGE B-21)	
	Thermowell	RTD Probe	Thermowell	RTD Probe	Thermowell	RTD Probe
1	F203U154	S53-P180	F203U(X-25 tenths of inch)	S53-P(X+5 tenths of inch)	F203U(X-25 tenths of inch)	S53-P(X+5 tenths of inch)
2	F203U154	S53-P180	F203U(X-25 tenths of inch)	S53-P(X+5 tenths of inch)	F203U(X-25 tenths of inch)	S53-P(X+5 tenths of inch)
3	F203U154	S53-P180	F203U(X-25 tenths of inch)	S53-P(X+5 tenths of inch)	F203U(X-25 tenths of inch)	S53-P(X+5 tenths of inch)

(3) Dow Corning DC-342 heat transfer grease 9 shall be applied to the bottom of the RTD probe prior to insertion into the thermowell.

(4) Material selection shall be galvanically compatible to the system design.

(5) Standard conduit 3/4" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit. All connections shall be watertight.

(6) If installation of thermowell(s) degrades the design or operational integrity of the fluid transport system, other methods shall be investigated for this application.

(7) Pipe thread sealing compound may be used in accordance with local codes.

(8) In areas where mixing of fluid is necessary to provide meaningful temperature results, the RTD shall be located 10 diameters for a pipe smaller than 1" or 20 diameters for pipe greater than 1-1/4" from the mixing intersection.

(9) ERDA supplied part to site contractor.

(10) Weather proof head shall be oriented to minimize accidential damage. Part Number F102-4.

(11) Source: Minco Products, Incorporated, Mineapolis, Minnesota or equivalent.

B.3 FLOW SENSORS

In selecting flowmeter locations, the site contractor shall identify those circuits critical to system operation and recommend an isolation circuit for sensor installation. Isolation valves shall be provided for each circuit if excessive loss of transport fluid during maintenance or replacement of sensors is apparent. Figure B-7 shows a typical isolation circuit. The following figures provide illustrations, part numbers, and dimensional information for typical installations of fluid sensors.

INSTALLATION TYPE	INSTALLATION FIGURE NUMBER AND LOCATION
Flared tube	B-8 (Page B-29)
Pipe flowmeter	B-9 (Page B-30)
Wafer flowmeter	B-10 (Page B-31)
Fuel oil	B-11 Page B-32)
Front mount gas meter	B-12 (Page 33/34)
Top mount gas meter	B-13 (Page B-33/34)
Air duct	B-14 (Page B-35) B-15 (Page B-36)

Flared tube flowmeters (45^{o} and 37^{o} flares) may be selected for flared tube installations to 2 inch OD (-32). All connecting parts (B-Nut, sleeves etc.) will be supplied by the site contractor. Flared tube flowmeter installation dimensions and typical part numbers are shown in Figure B-8.

Small pipe flowmeters used on pipes that are three (3) inches or less in diameter utilizes an external pipe thread. The site contractor shall provide the pipe unions shown in Figure B-9. A large pipe flowmeter is used on pipes equal or greater than two (2) inches in diameter and utilizes the wafer design for flange connections. As shown in Figure B-10, the site contractor shall provide the mating flanges, gaskets, and bolts for this installation.

Fuel oil flow sensor will require connecting with a standard MNPT connection. The meters should be placed in a fairly stable temperature environment as the operating temperature range of the installation area will be required prior to sensor selection.

Gas meters for fossil fuels are standard diaphram type meters used by various gas companies in both residential and commercial applications. This device will use standard AGA connections and will require pressure regulations only if connected to the main supply. If the sensor is placed in series or parallel to an existing meter, pressure regulation will not be required.

Air flow measurements utilize a sensor inside an air duct. The duct dimensions dictate the requirements for sizing of the sensor. Where possible the tube sensor should be located in the transverse cross sectional center of a straight duct section providing at least eight diameters upstream and two diameters downstream of the sensor free of elbows, transitions, or reductions. Since HVAC duct sizes vary due to total load and velocity gradients, the sensor selection will not be made until after the site contractor has defined the duct layout and size. In order to properly size the sensor to the HVAC duct design, the site contractor must provide to ERDA the "L" dimension, "W" dimension, and "thickness of the duct wall" as shown in Figures B-14 and B-15. As shown in Figure B-15, 120 Vac power to be supplied by the site contractor is required if the air velocity probe is used.

B.4 POWER (ALTERNATING CURRENT)

Wattmeters shall be used to measure the electrical energy required for operating the solar system, for auxiliary energy, and for energy conversion. The energy used by each circulating pump in the collector/storage loop, in the space heating and/or cooling loop, and in the domestic hot water loop will be measured. The auxiliary energy used for space heating or cooling system and the domestic hot water system will be measured. Any electrical energy used for conversion of solar energy will be measured.

The site contractor shall make recommendations for connecting electrical circuits in such a manner as to minimize the number of wattmeter sensors in providing the required measurements. For example, in a complex system it may be practical to place more than one pump on a circuit with one measurement while maintaining the desired information.

The site contractor shall assist in selecting the AC power transducers from the single or multiphase configuration shown in Figures B-16 through B-25. The site contractor shall provide the wiring and installation of each power transducer.

B.5 RELATIVE HUMIDITY

The relative humidity probe, should be placed internally near the thermostat that controls the conditioned air in the building or in the return duct and is only required for selected systems. A typical RH probe is shown in Figure B-26 and installation examples are shown in Figure B-26. Outside relative humidity will be measured for selected sites and the sensor should be mounted in an area where air can flow over the probe but protected from rain or direct sunlight.

B.6 AMBIENT TEMPERATURE

The outside ambient temperature sensor shall be housed in a radiation shield, shown in Figure B-29, to be provided by ERDA. This shield will be mounted by the site contractor in an area that is representative of the site ambient temperature but should not cast a shadow on the collector array. The sensor should be placed where air flow is evident and away from surfaces that could affect temperatures by radiated heat or air currents.

Internal ambient temperature probes for active systems shall be located near the thermostat that controls the conditioned air in the building. Normal air circulation should be allowed to flow over the sensor. Figure B-27 shows a wall mount designed to blend in with the decor of a room. Figure B28 provides an example of mounting the sensor in the HVAC return duct. This method is very effective if the blower operates continuously or other methods not acceptable.

Passive systems should have the sensor placed in an average temperature area where the normal room air currents can pass over the probe.

B-7. COLLECTOR ABSORBER SURFACE TEMPERATURE

Absorber surface temperature measurements shall be installed on selected systems. If possible this sensor should be installed on the back side of the absorber plate and bonded in place with a thin layer of Dow Corning 732 RTV adhesive or equivalent provided by ERDA. A typical installation example is shown in Figure B-30.

B-8. SOLAR RADIATION

The pyranometer(s) shall be mounted on a fixture supplied by the site contractor in the same plane as the collector array. The installed sensor should not cast a shadow on the collector surface, neither should the collectors shade the pyranometer. Precautions should always be taken to avoid subjecting the instrument to mechanical shock and vibration during the installation. Also, the sensor should not be subjected to vibration during operation of the system components. The pyranometer should be oriented so the connector is located north of the receiving surface (in northern hemisphere). This minimizes heating of the electrical connections by the sun. Figure B-30 shows a typical example of a pyranometer mount for a flat plate collector.

Care should be taken to minimize reflected energy from the solar collectors onto the pyranometer.

Concentrating type collectors will have one (1) pyranometer mounted in the collector plane for total radiation and one for diffuse radiation. The diffuse sensor includes a 3 inch shadow band to shade the element from the direct sunlight. As the seasons change periodic adjustments will be required by the site contractor to obtain accurate data. A typical adjustment schedule is provided as follows:

- daily - March, April, September, October,
- two days - August, May, November, February,
- three days - June, July, December, January.

Ideally, the shadow band adjustments should be performed at solar noon each time for best results.

B-9. ANGULAR DISPLACEMENT

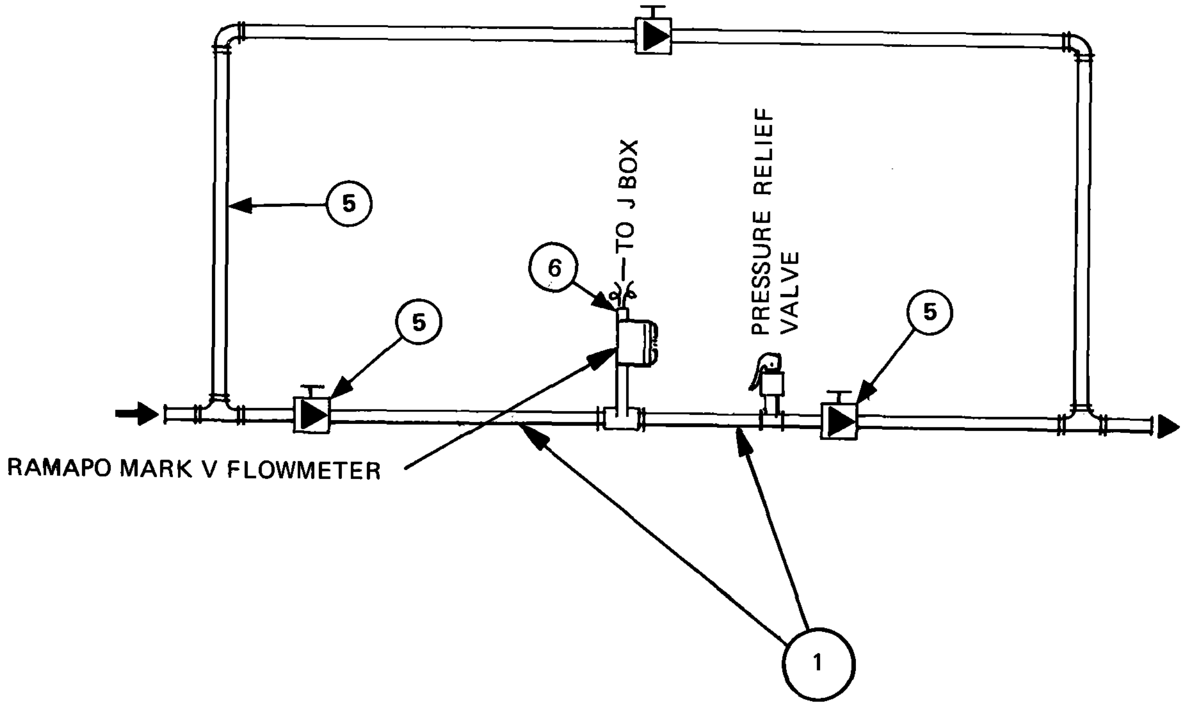
An angular displacement sensor is used on selected sites to determine tilt of the collector as the system tracks the sun. As shown in Figure B-31, the sensor is typically installed with twin "L" brackets for the illustrated tracker.

B-10. LEVEL DETECTOR

Level detector(s) will be placed on selected sites to determine the level of the media in the storage tanks. Unpressurized systems that operate for long periods without automatic level compensation are candidates for the sensor. As shown in Figure B-32, the transducer is placed with the sensing point level with the bottom of the liquid in the tank.

B-11. WIND SPEED AND DIRECTION

These measurements are required for selected solar energy systems only. When required the sensors shall be installed in an area representative of the site air flow. This sensor should not be placed where it can cast a shadow on the collector array. A typical sensor is shown in Figure B-54.



NOTE: SEE PAGE B-28 FOR COMMENTS REFERENCED TO NUMBERS THAT ARE CIRCLED (O).

Figure B-7. Typical Flowmeter Installation

COMMENTS:

1. Two inch (2") size flowmeters or less shall be preceded by a minimum of ten (10) diameters, followed by six (6) diameters of uninterrupted flow line and should not contain flexible lines.

   Two and one-half inch (2-1/2") size flowmeters or larger shall be preceded by a minimum of twenty (20) diameters and followed by ten (10) diameters of uninterupted flow line and should not contain flexible lines.

2. Flowmeters shall be located in the horizontal position if possible.

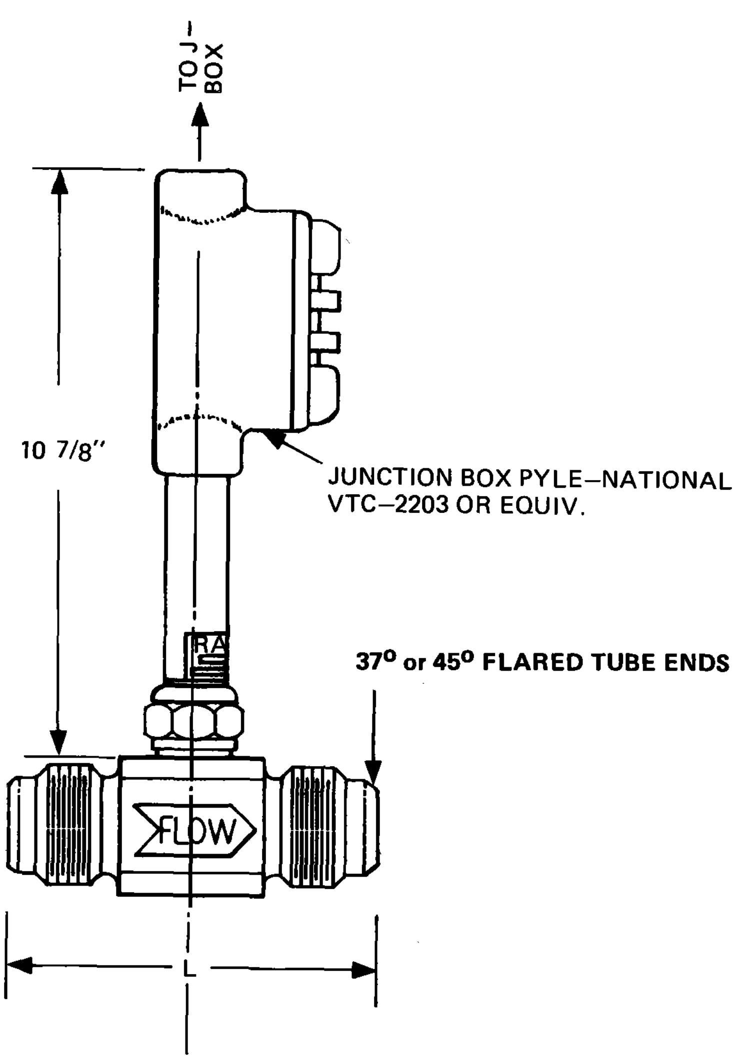
3. Material selection shall be galvanically compatible to the system design.

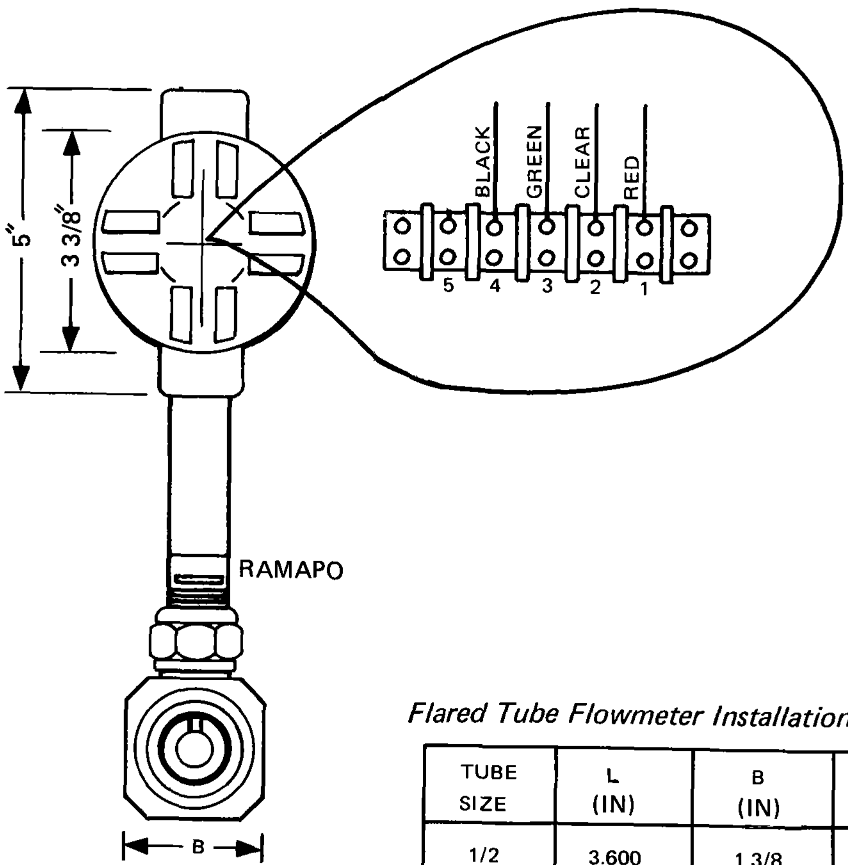
4. Pipe thread sealing compound may be used on all pipe threads in accordance with local codes.

5. Flowmeter by-pass (isolation) optional depending on the criticality of circuit and is required only if the system must be operational during flowmeter maintenance or repair. In areas where the fluid cannot be drained, isolation valves must be provided to prevent excessive loss of transport fluid.

6. Standard conduit 1/2" - 14 NPT internal pipe threads. Installation optional unless required per local codes. Rigid conduit shall be terminated at the sensor end with flexible conduit.

7. Source: Ramapo Instrument Company, Inc., Montville, New Jersey 07045.

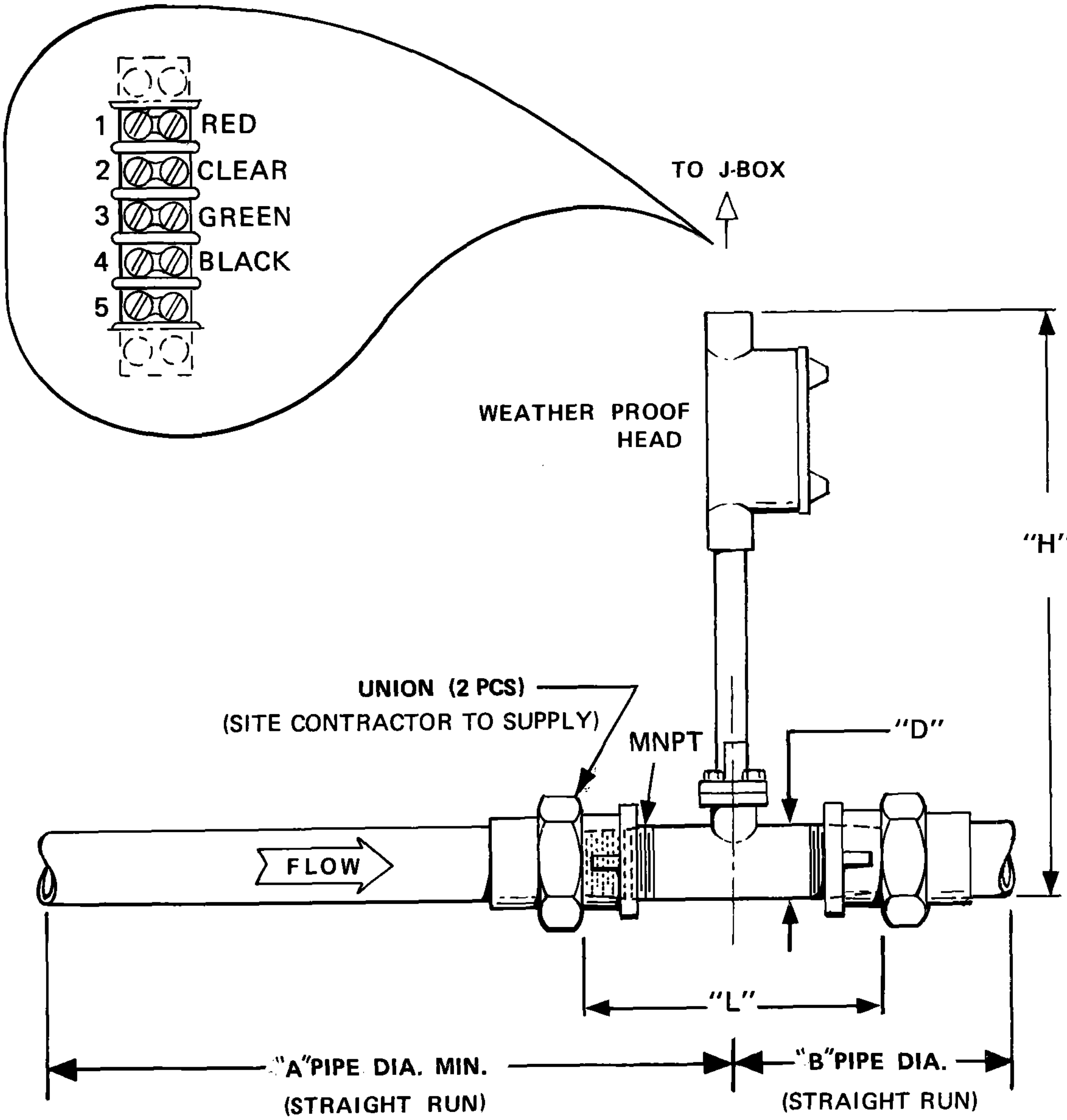




Flared Tube Flowmeter Installation Dimensions

TUBE SIZE	L (IN)	B (IN)	MODEL
1/2	3.600	1 3/8	MK V-½-
3/4	3.600	1 3/8	MK V-¾-
1	3.666	1 3/8	MK V-1-
1 1/4	3.666	1 11/16	MK V-1¼-
1 1/2	3.760	1 15/16	MK V-1½-
1 3/4	4.010	2 5/16	MK V-1¾-
2	4.260	2 9/16	MK V-2-

Figure B-8. Typical Flared Tube Flowmeter



SMALL PIPE FLOWMETER DIMENSIONS

PIPE SIZE (IN)	"D" (IN)	"L" (IN)	"H" (IN)	MODEL NUMBER	PIPE STRAIGHT RUN LENGTH (UPSTREAM) ("A")	PIPE STRAIGHT RUN LENGTH (DOWNSTREAM) ("B")
1/2	.840	4.0	11.938	MKV–1/2	10	6
3/4	1.050	4.0	12.125	MKV–3/4	10	6
1	1.315	5.0	12.438	MKV––1	10	6
1–1/4	1.66	6.0	12.750	MKV–1–1/4	10	6
1–1/2	1.9	6.0	13.0	MKV–1–1/2	10	6
2	2.375	8.0	13.5	MKV–2	10	6
2–1/2	2.875	9.0	14.0	MKV–2–1/2	20	10
3	3.500	9.0	15.125	MKV–3	20	10

Figure B-9. Typical Small Pipe Flowmeter

LARGE PIPE FLOWMETER DIMENSIONS

PIPE SIZE (IN)	"D" (IN)	"L" (IN)	"H" (IN)	"A" FLANGE BOLT HOLE ORIENTATION FROM VERTICAL (DEGREES)	NUMBER BOLTS (EA)	BOLT SIZE (IN)	MODEL NUMBER
2	4	2.5	14.313	22–1/2°	4	5/8	MKV–2
2–1/2	4–3/4	2.5	15.063	22–1/2°	4	5/8	MKV–2–1/2
3	5–1/4	2.5	15.563	22–1/2°	4	5/8	MKV–3
3–1/2	6	2.5	16.625	22–1/2°	8	5/8	MKV–3–1/2
4	6–3/4	2.5	17.125	22–1/2°	8	5/8	MKV–4
5	7–5/8	2.5	18.0	22–1/2°	8	3/4	MKV–5
6	8–5/8	2.5	19.0	22–1/2°	8	3/4	MKV–6
8	10–7/8	2.5	21.125	22–1/2°	8	3/4	MKV–8
10	13–1/4	2.5	23.063	15°	12	7/8	MKV–10
12	16	2.5	25.438	15°	12	7/8	MKV–12

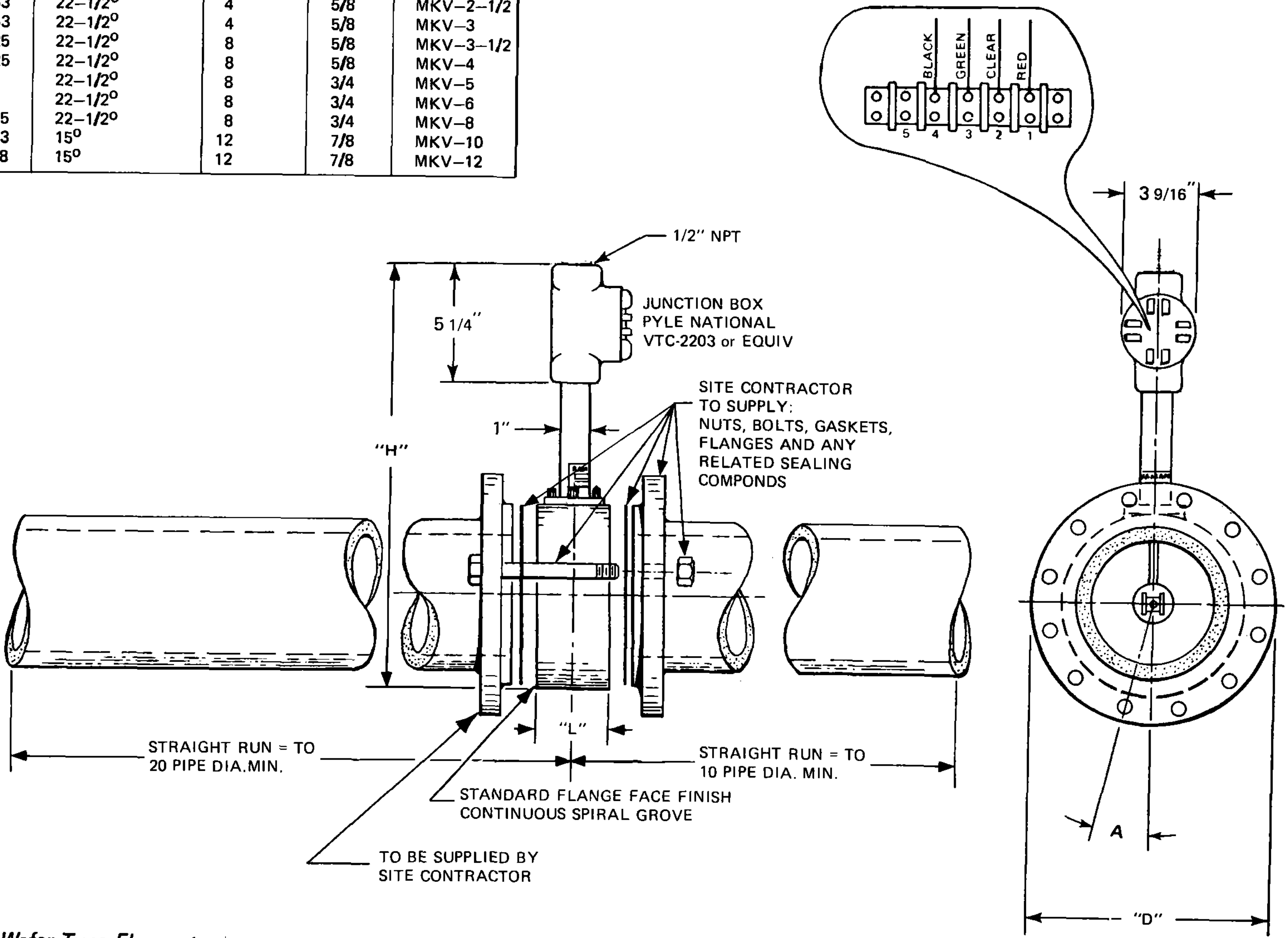
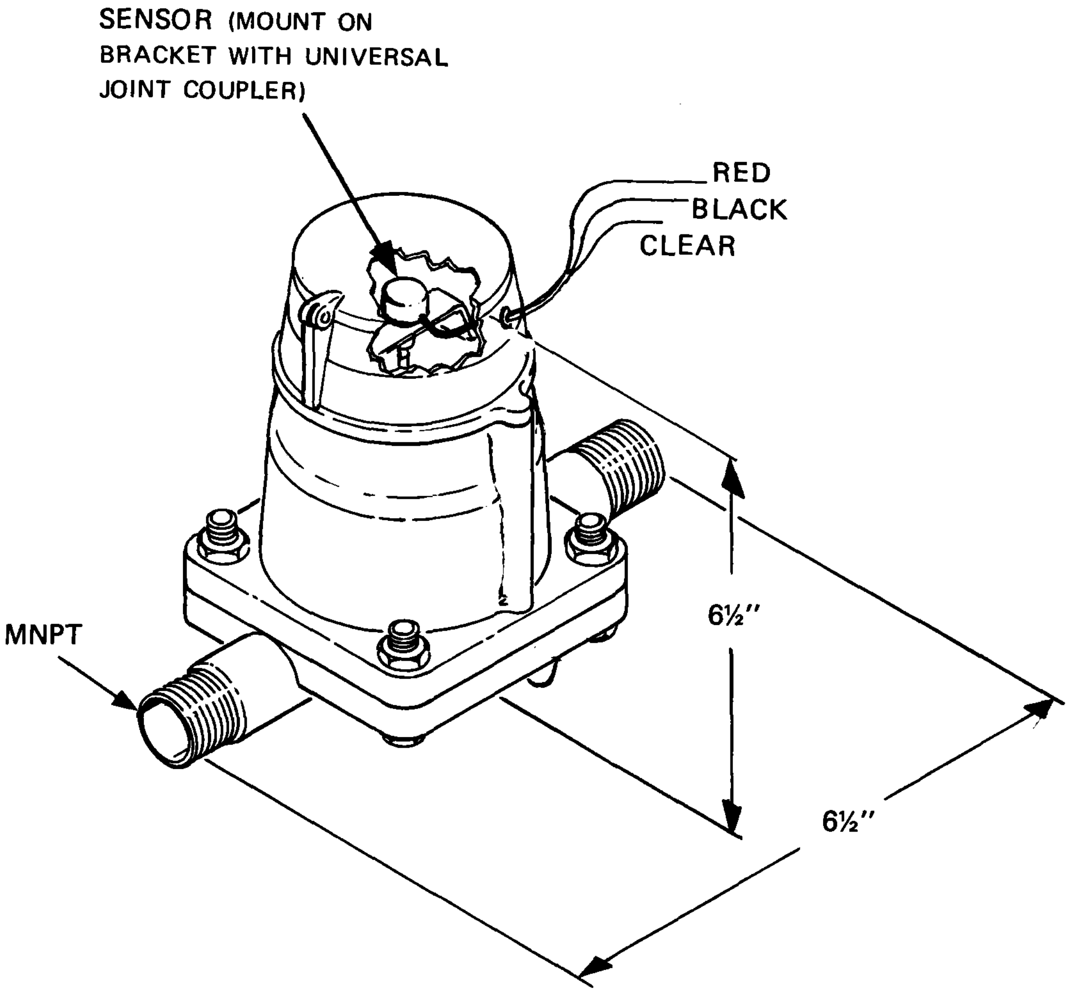
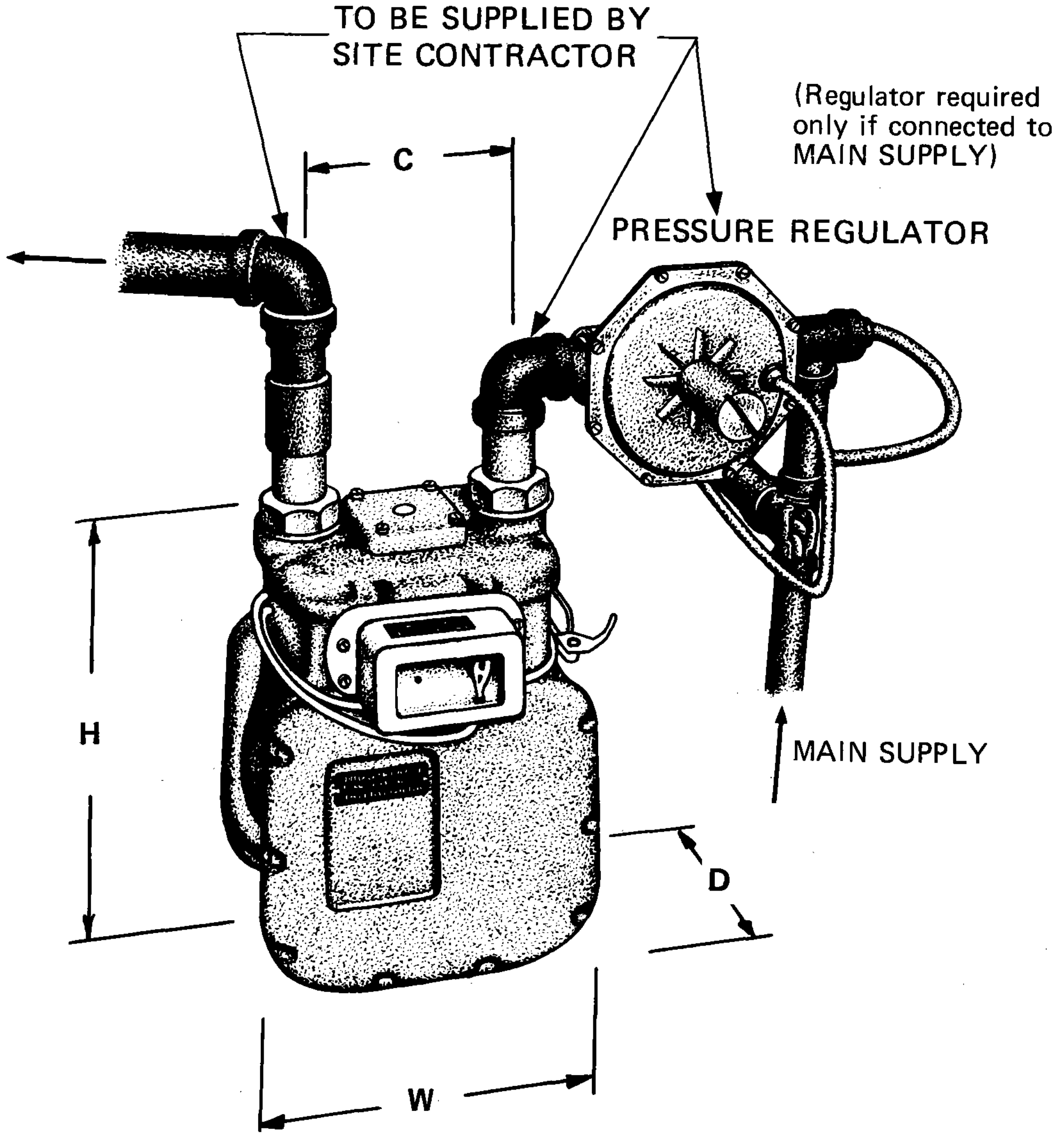


Figure B-10. Typical Large Pipe Wafer Type Flowmeter



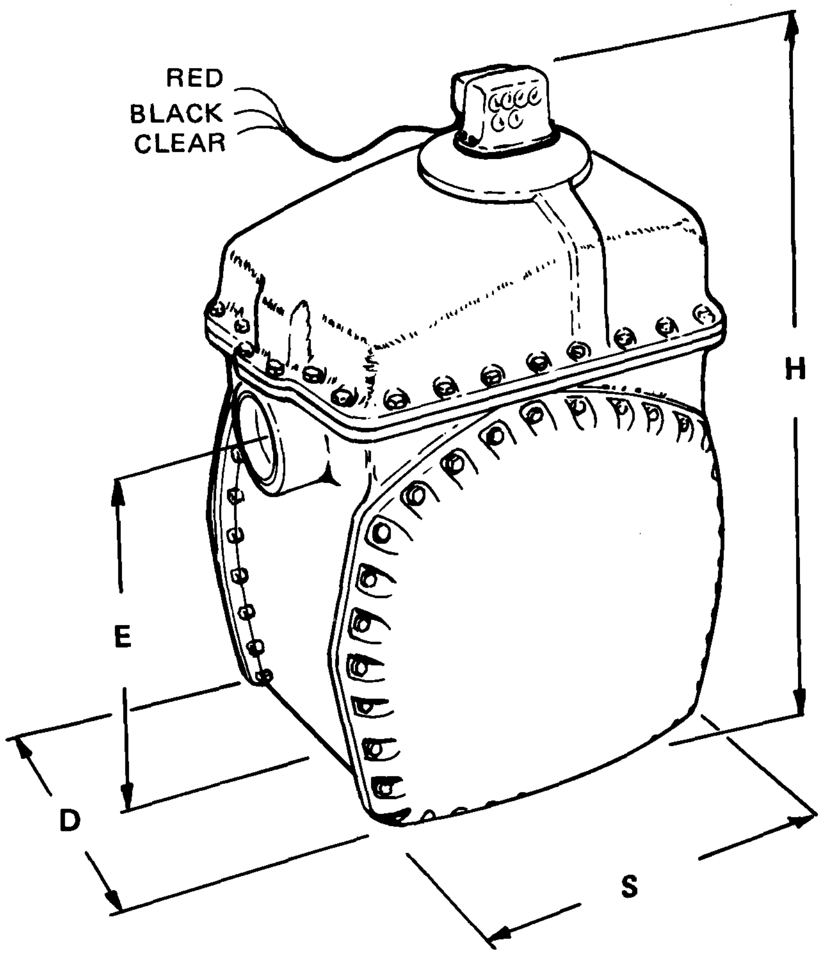
Line	Connections	Model No.
¾"	MNPT	20-11
1"	MNPT	21-11

Figure B-11. Typical Fuel Oil Meter



MODEL NO	MAX PRESS (PSIG)	CONNECTION PIPE	MC/FLG	DIMENSIONS C	D	E	H	S	W	INDEX TYPE	CAPACITY AT 1/2"H_2O (CFH)
AC-80	5	1/2		11 1/4	7	-	11	-	7/8	FRONT	80
AL175	5	3/4, 1	1 1/4 MC	6	7	-	11 3/4	-	8	FRONT	175
AC175	5	3/4,	1	6	7	-	11 3/4	-	8	FRONT	175
AL250	5	3/4, 1	1 1/4 MC	6	8 1/2	-	13 7/8	-	9 5/8	FRONT	250
AL425	10DR25		1 1/4	8 1/2	10	-	14 7/8	-	10 3/4	FRONT	425

Figure B-12. Typical Low Volume Gas Meter



MODEL NO	MAX PRESS (PSIG)	CONNECTION PIPE	MC/FLG	DIMENSIONS						INDEX TYPE	CAPACITY AT 1/2"H_2O (CFH)
				C	D	E	H	S	W		
25B(400)	350	1 1/4	-	-	15 1/2	12 1/4	22 1/2	13 1/4	13 1/8	TOP	400
AL800	100	1 1/2	-	11	16 5/8	-	24	-	14 5/8	TOP	800
AL1000	100	1 1/2, 2 MPT SWIVEL	2	11 or 13 1/8	16 5/8	-	24 3/4	-	14 5/8	TOP	1000
AL1400	100	2 / 3	3 FLG	-	15 7/8	15	29	17 3/8/13 3/4	17 1/4	TOP	1400
80B(1200)	250/350	2	-	-	20	18 1/2	30 3/4	18 1/8	18 7/8	TOP	1200
AL2300	100	4	4 FLG	-	18 3/8	17 7/8	33 3/8	21 5/8	21 5/8	TOP	2300
250B	350	4	-	-	27 1/8	22	35 3/4	21 1/4	22 1/4	TOP	3000
500B	250/350	4	-	-	24 3/4	23 3/8	41 3/8	26	28	TOP	4800
AL5000	100	4	4 FLG	-	23 1/2	23 3/8	40	32	26 1/4	TOP	5000
DU5000	250/350	4	-	-	24 3/4	23 3/8	42 3/8	26	28	TOP	5000

(CFH)

Figure B-13. Typical Large Volume Gas Meter

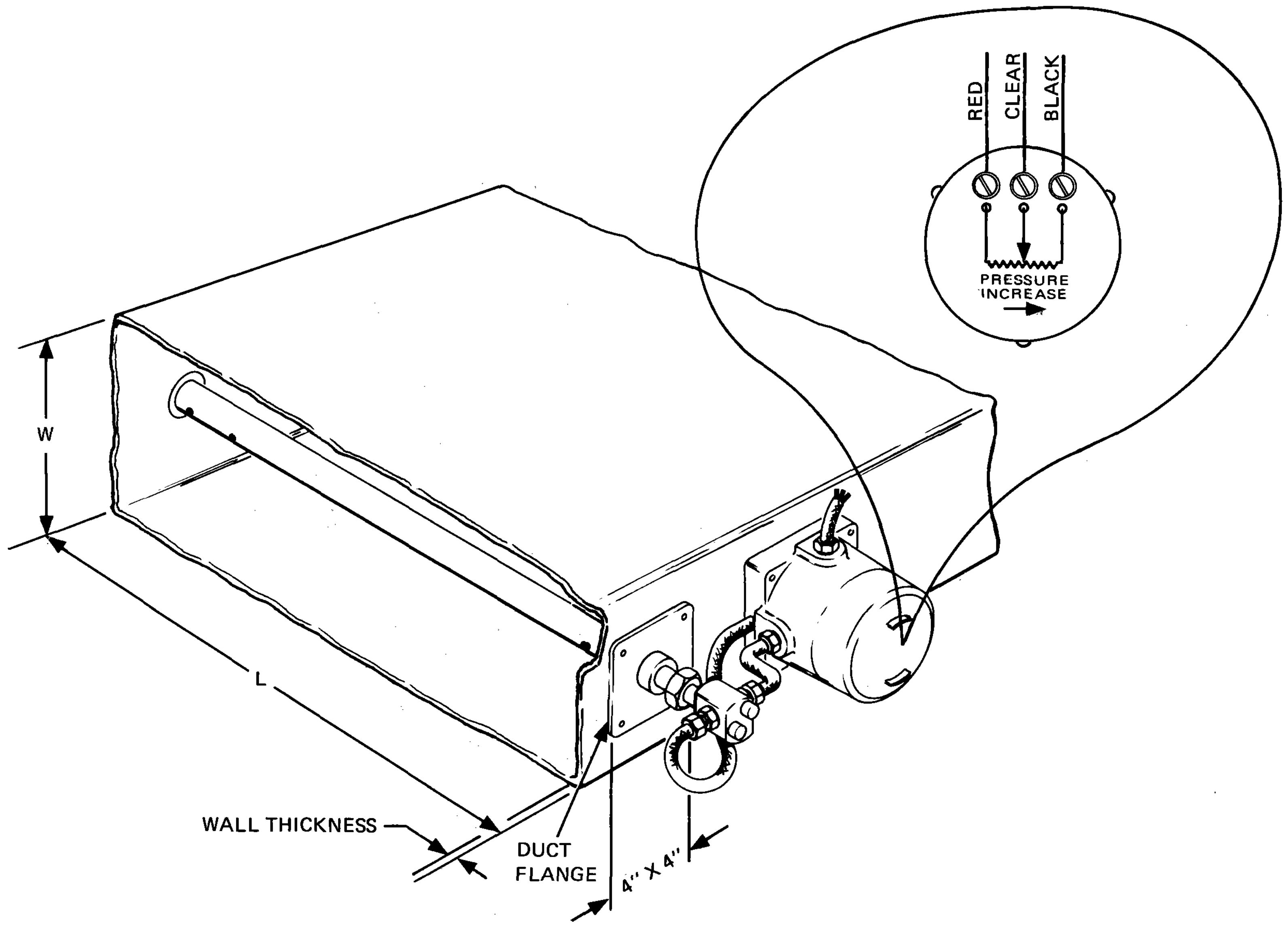
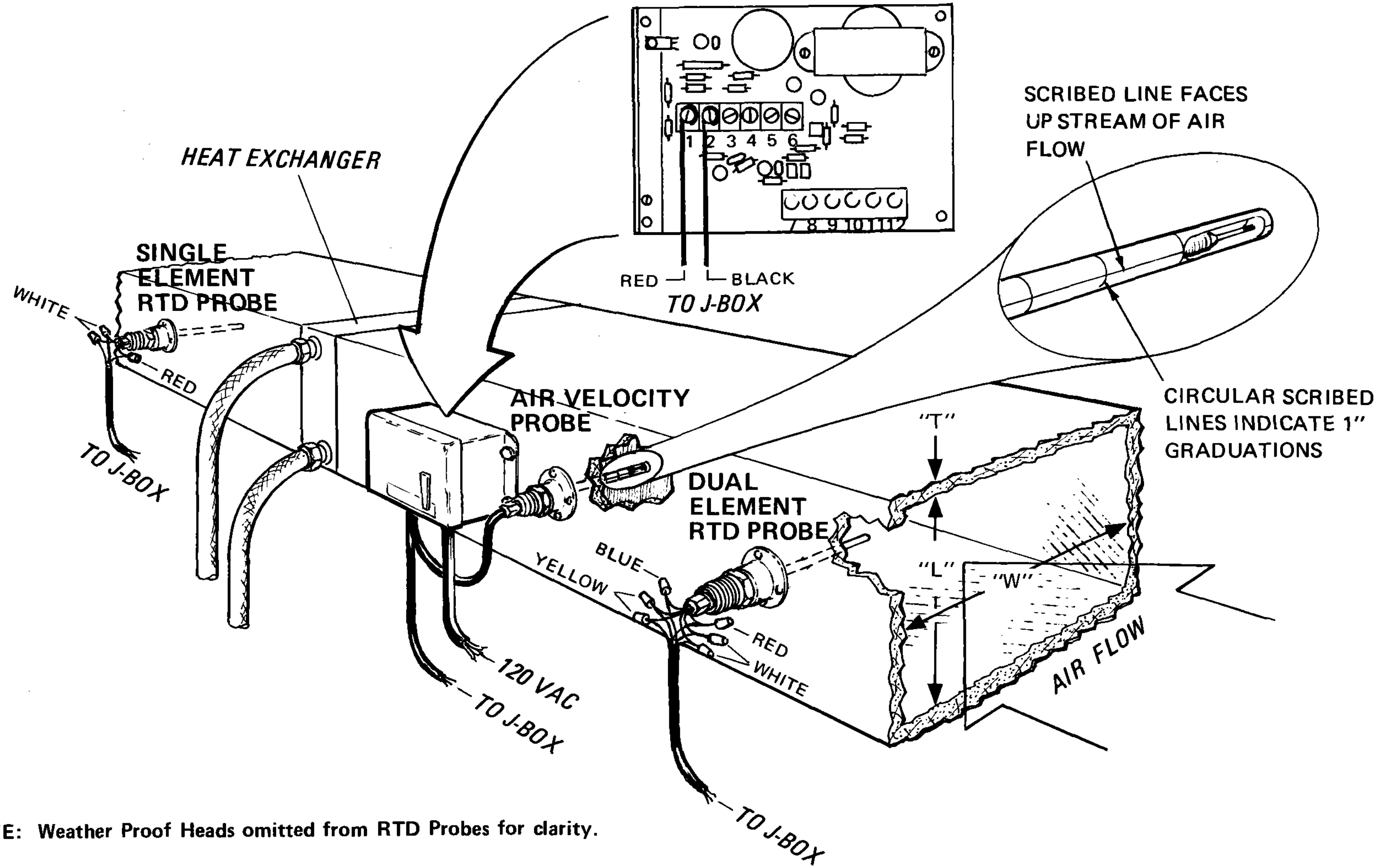


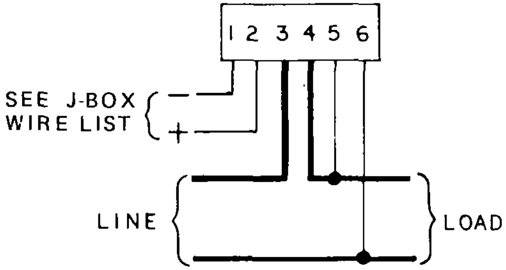
Figure B-14. Typical HVAC Duct Pitot Tube Flow Monitor Installation For High Velocity Systems



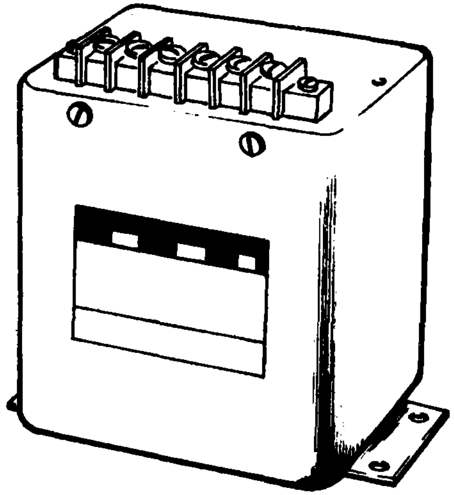
NOTE: Weather Proof Heads omitted from RTD Probes for clarity.

Figure B-15. Typical Anemometer Duct Installation.

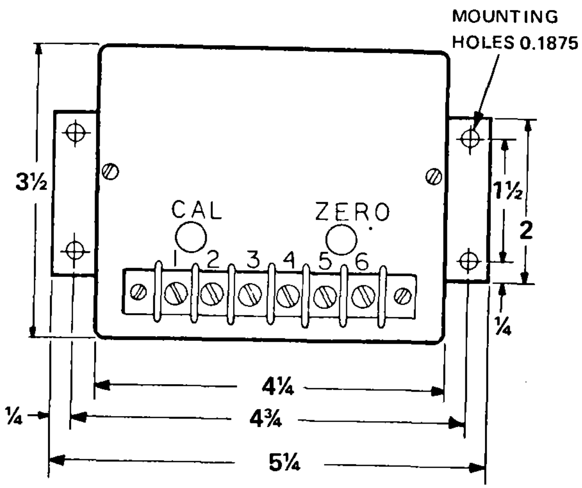
The single phase AC watt transducers used for measurement of single phase power in the system are connected as shown below. These units provide a 50 millivolt output corresponding to a specified power input for the particular model used. (Example: For the PC5-1 rated, 120 volts, 5 amperes, 600 watts; the 50 mv output indicates a power reading of 500 watts.)



Circuit showing current directly connected through terminals 3 and 4. The voltage input is applied to terminals 5 and 6 with the output appearing on terminals 1 and 2.



CASE SIZE "H"



OVERALL HEIGHT 5¼"

SINGLE PHASE 60 Hz MODELS

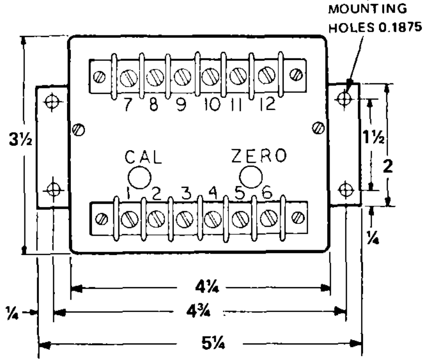
MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 50MV=	CURRENT SENSOR DRAWING
	VOLTS	AMPS	WATTS		
1	120	5	600	500W	–
2	240	5	1.2K	1KW	–
3	480	5	2.4K	2KW	–
10	120	10	1.2K	1KW	–
11	240	10	2.4K	2KW	–
12	480	10	4.8K	4KW	–
19	120	15	1.8K	1.5KW	–
20	240	15	3.6K	3KW	–
21	480	15	7.2K	6KW	–
103	120	1	120	100W	–
104	240	1	240	200W	–
105	480	1	480	500W	–
106	120	2.5	300	300W	–
107	240	2.5	600	600W	–
108	480	2.5	1200	1200W	–
	CASE SIZE DRAWING H				

Figure B-16. Typical Single Phase 60 HZ Watt Transducer

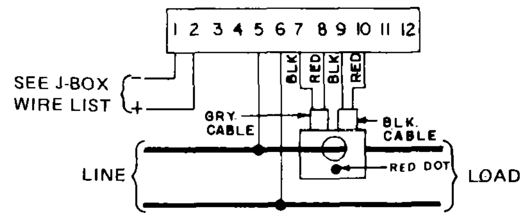
SINGLE PHASE 60 Hz MODELS

MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 50MV=	CURRENT SENSOR DRAWING
	VOLTS	AMPS	WATTS		
28	120	50	6K	5KW	* C
29	240	50	12K	10KW	* C
30	480	50	24K	20KW	* C
31	120	100	12K	10KW	C
32	240	100	24K	20KW	C
33	480	100	48K	40KW	C
34	120	200	24K	20KW	D
35	240	200	48K	40KW	D
36	480	200	96K	80KW	D
37	120	400	48K	40KW	D
38	240	400	96K	80KW	D
39	480	400	192K	160KW	D
40	120	600	72K	60KW	E
41	240	600	144K	120KW	E
42	480	600	288K	240KW	E
43	120	1000	120K	100KW	E
44	240	1000	240K	200KW	E
45	480	1000	480K	400KW	E
46	120	2000	240K	200KW	E
47	240	2000	480K	400KW	E
48	480	2000	960K	800KW	E

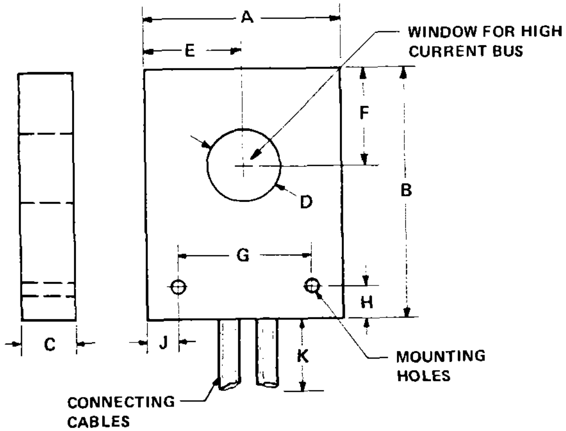
CASE SIZE "H"

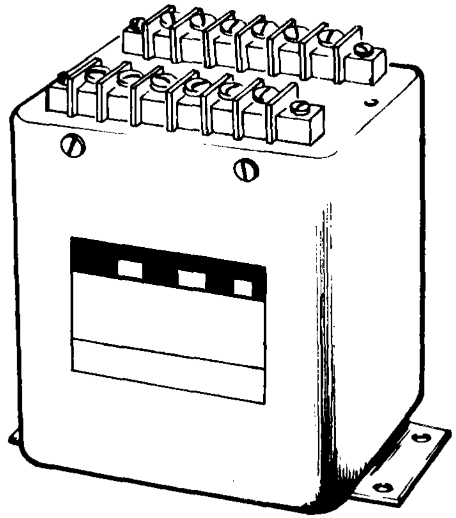


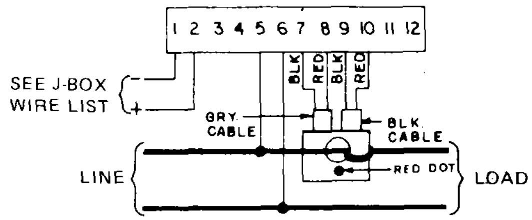
OVERALL HEIGHT 5¼"



HIGH CURRENT TRANSDUCERS







*CURRENT TRANSFORMER WITH TWO TURNS OF WIRE THROUGH WINDOW

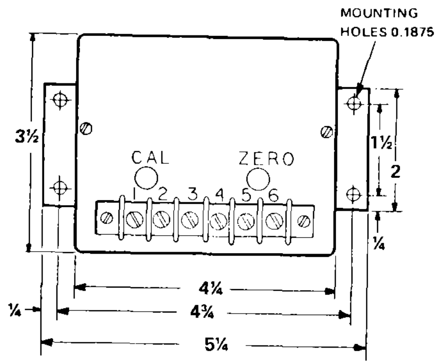
OUTLINE DIMENSION FOR C,D,E

OUT-LINE DIM.	A	B	C	D	E	F	G	H	J	K	THICK-NESS	WT. LB.	MTG. HOLE
C	2	2	¾	¾	1	⅞	1½	¼	¼	15		¾	9/64
D	3⅛	4	⅞	1⅛	1 9/16	1 9/16	2⅛	½	½	15		1	11/64
E	4⅛	5	1¼	2	2 1/16	2	3¼	7/16	7/16	15		2⅛	17/64

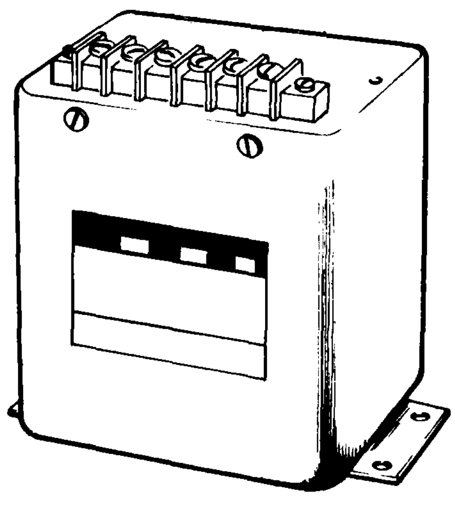
Figure B-17. Typical Single Phase 60 HZ Watt Transducer (continued)

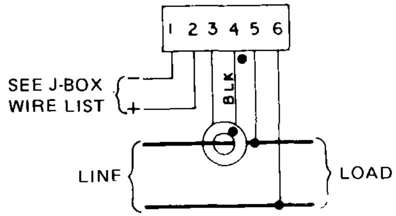
SINGLE PHASE 60 Hz MODELS					
MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 50MV=	CURRENT SENSOR DRAWING
	VOLTS	AMPS	WATTS		
49	120	50	6K	5KW	* W
50	240	50	12K	10KW	* W
51	480	50	24K	20KW	* W
58	120	100	12K	10KW	W
59	240	100	24K	20KW	W
60	480	100	48K	40KW	W
67	120	200	24K	20KW	W
68	240	200	48K	40KW	W
69	480	200	96K	80KW	W
76	120	400	48K	40KW	X
77	240	400	96K	80KW	X
78	480	400	192K	160KW	X
85	120	600	72K	60KW	X
86	240	600	144K	120KW	X
87	480	600	288K	240KW	X
94	120	1000	120K	100KW	Y
95	240	1000	240K	200KW	Y
96	480	1000	480K	400KW	Y

CASE SIZE "H"



OVERALL HEIGHT 5¼"

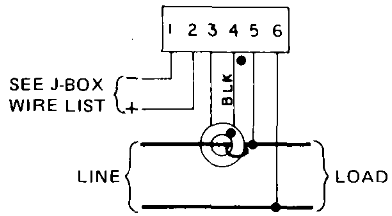




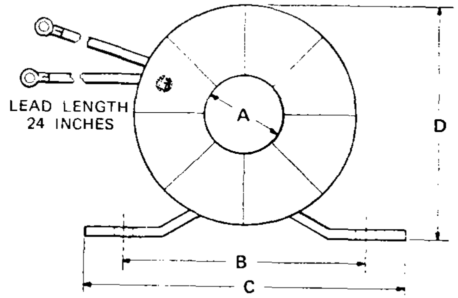
HIGH CURRENT TRANSFORMERS

OUTLINE DIM.	A	B	C	D	THICKNESS	WT. LB.	MTG. HOLE
W	1¼	3⅞	5⅛	3⅞	1⅝	2	9/32
X	2¼	5¾	7⅛	5⅛	1½	3	9/32
Y	2¾	5¾	7⅛	5¼	1½	2¼	9/32

Note: ALL DIMENSIONS ARE IN INCHES



*CURRENT TRANSFORMER WITH TWO TURNS OF WIRE THROUGH WINDOW



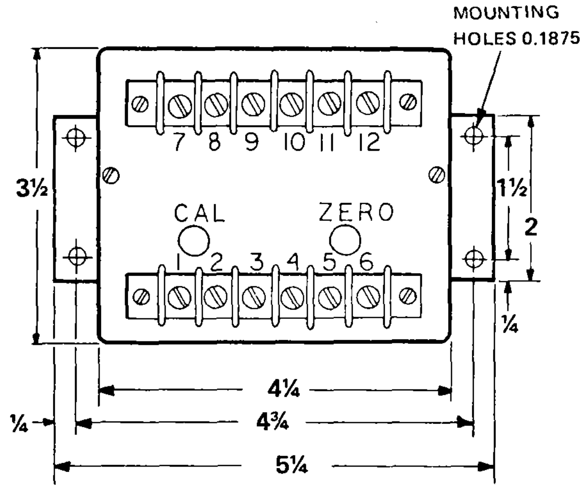
OUTLINE DIMENSIONS FOR W,X,&Y

Figure B-18. Typical Single Phase 60 HZ Watt Transducer (continued)

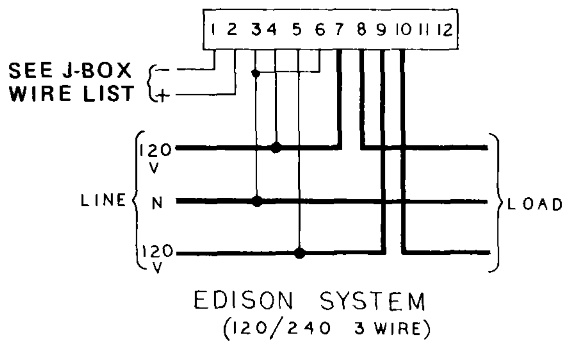
SINGLE PHASE 3 WIRE 60Hz MODELS

MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 100MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
4	120	5	1.04K	1KW	–	–
13	120	10	2.08K	2KW	–	–
22	120	15	3.12K	3KW	–	–

CASE SIZE "H"



OVERALL HEIGHT 5¼"



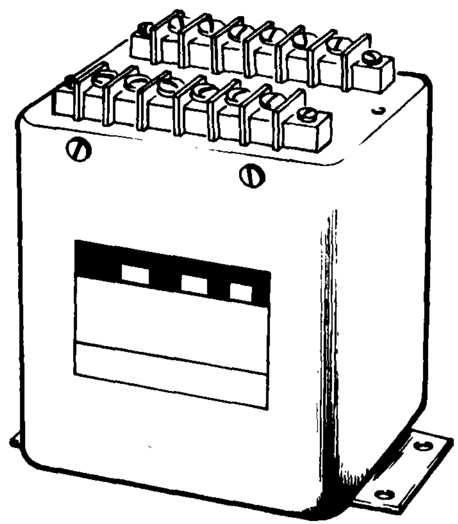
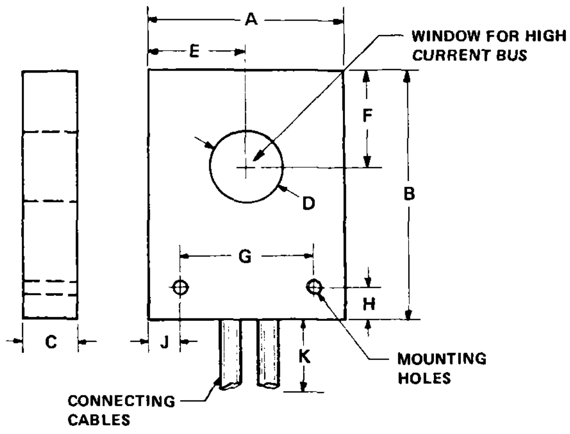


Figure B-19. Typical Single Phase 3-Wire 60 HZ Watt Transducer

SINGLE PHASE 3 WIRE 60Hz MODELS

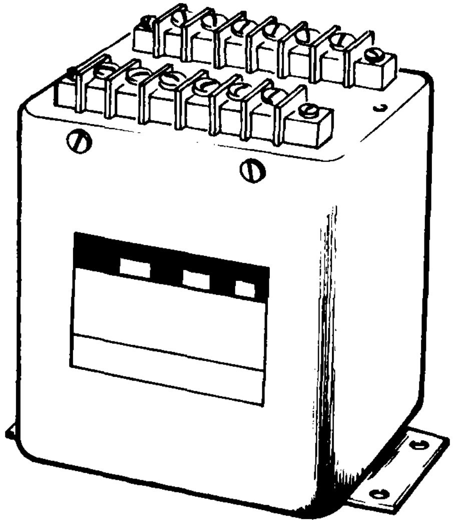
MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 100MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
31-2	120	100	20.8	20KW	C	2

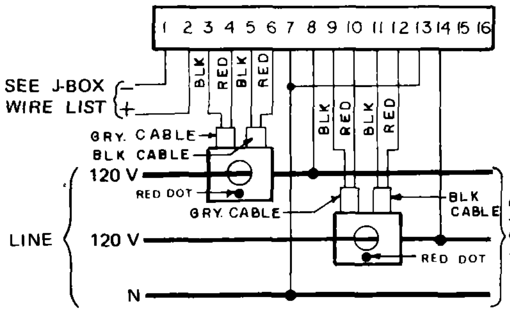


OUTLINE DIMINSIONS FOR C

OUT-LINE DIM.	A	B	C	D	E	F	G	H	J	K	THICK-NESS	WT. LB.	MTG. HOLE
C	2	2	¾	¾	1	⅞	1½	¼	¼	15		¾	9/64

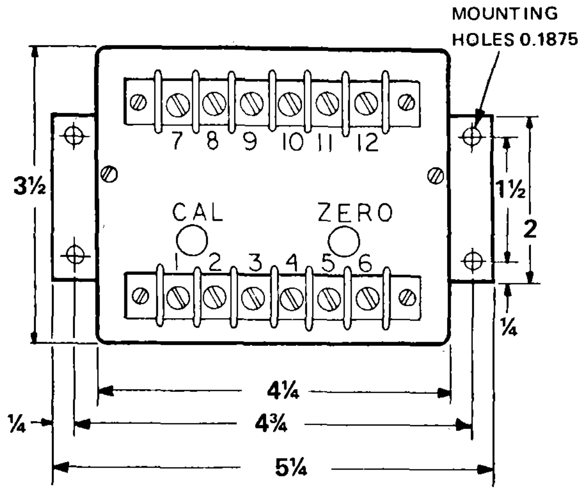
ALL DEMENSIONS ARE IN INCHES





CURRENT TRANSDUCERS
(240 VOLT 3-WIRE)

CASE SIZE "H"



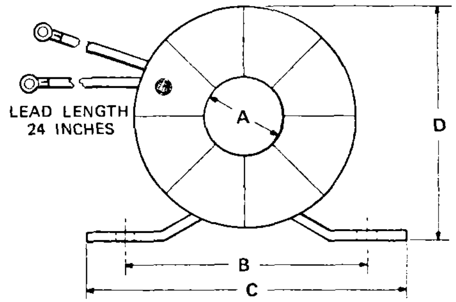
OVERALL HEIGHT 5¼"

Figure B-20. Typical Single Phase 3-Wire 60 HZ Watt Transducer (continued)

SINGLE PHASE 3 WIRE 60Hz MODELS

MODEL NUMBER PC5-	FULL SCALE IMPUTS			OUTPUT CALIB. 150MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
52	120	50	10.4K	10KW	W	* 2
61	120	100	20.8K	20KW	W	2
70	120	200	41.6K	40KW	W	2
79	120	400	83.1K	80KW	X	2
88	120	600	125K	120KW	X	2
97	120	1000	208K	200KW	Y	2
CASE SIZE DRAWING H						

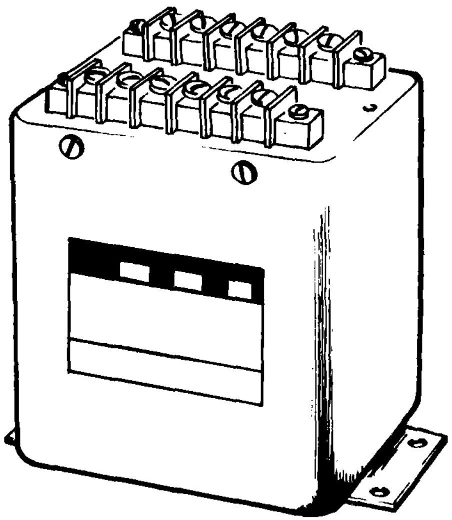
* Indicates 2 turns thru the external transducer or transformer window.



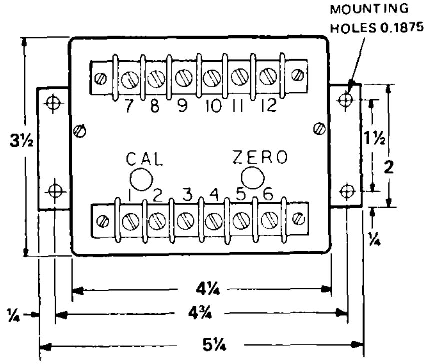
OUTLINE DIMENSIONS FOR W,X,&Y

OUT-LINE DIM.	A	B	C	D	THICK-NESS	WT. LB.	MTG. HOLE
W	1¼	3⅞	5⅛	3⅞	1⅝	2	9/32
X	2¼	5¾	7⅛	5⅛	1½	3	9/32
Y	2¾	5¾	7⅛	5¼	1½	2¼	9/32

Note: ALL DIMENSIONS ARE IN INCHES

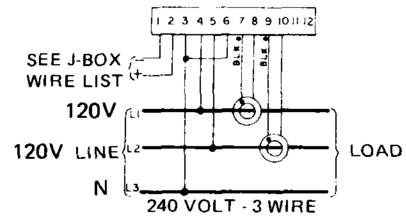


CASE SIZE "H"

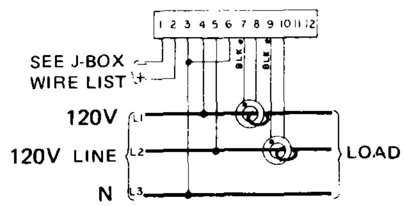


OVERALL HEIGHT 5¼"

DIRECT CONNECTION FOR 3 - WIRE



HIGH CURRENT TRANSFORMERS



*CURRENT TRANSFORMER WITH TWO TURNS OF WIRE THROUGH WINDOW

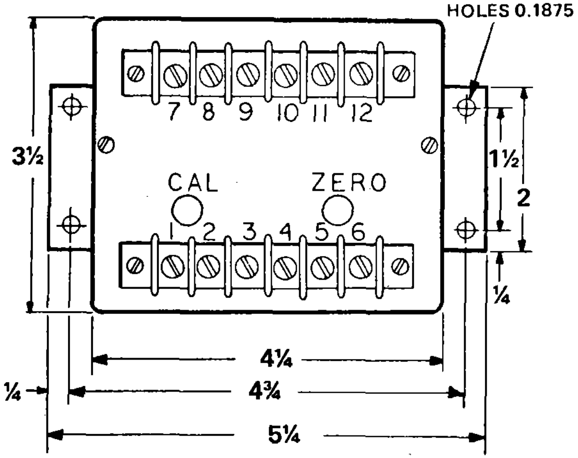
Figure B-21. Typical Single Phase 3-Wire 60 HZ Watt Transducer (continued)

The three phase AC watt transducers used for measurement of three phase power in the system are connected as shown below. These units provide a 100 millivolt output corresponding to a calibrated power rating. (Example: For the PC5 4 rated 120 volts, 5 amperes, 1040 watts; the 100 mv output indicates a power reading of 1000 watts.)

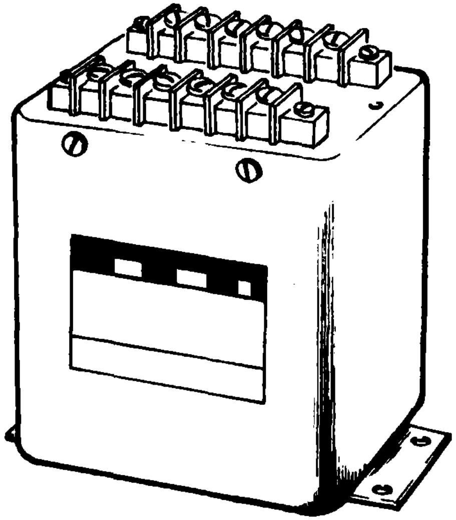
3 PHASE 3 WIRE 60Hz MODELS

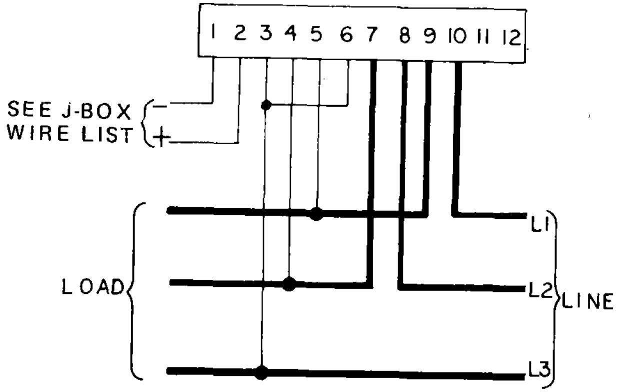
MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 100MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
4	120	5	1.04K	1KW	–	–
5	240	5	2.08K	2KW	–	–
6	480	5	4.16K	4KW	–	–
13	120	10	2.08K	2KW	–	–
14	240	10	4.16K	4KW	–	–
15	480	10	8.31K	8KW	–	–
22	120	15	3.12K	3KW	–	–
23	240	15	6.24K	6KW	–	–
24	480	15	12.5K	12KW	–	–
CASE SIZE DRAWING H						

CASE SIZE "H"



OVERALL HEIGHT 5¼"

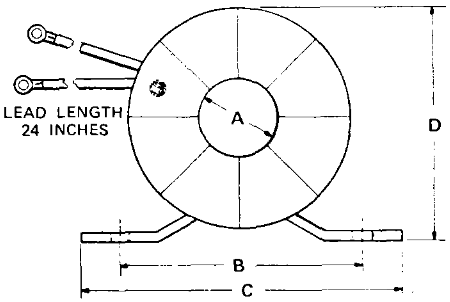




Circuit used for balanced or unbalanced networks by algebraically summing the EI Cos - product from two phases.

Figure B-22. Typical 3-Phase 3-Wire 60 HZ Watt Transducer

3 PHASE 3 WIRE 60Hz MODELS



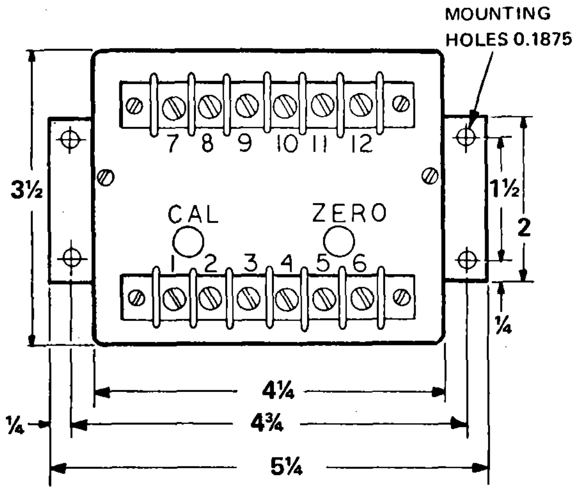
OUTLINE DIMENSIONS FOR W,X,&Y

OUT-LINE DIM.	A	B	C	D	THICK-NESS	WT. LB.	MTG. HOLE
W	1¼	3⅞	5⅛	3⅞	1⅝	2	9/32
X	2¼	5¾	7⅛	5⅛	1½	3	9/32
Y	2¾	5¾	7⅛	5¼	1½	2¼	9/32

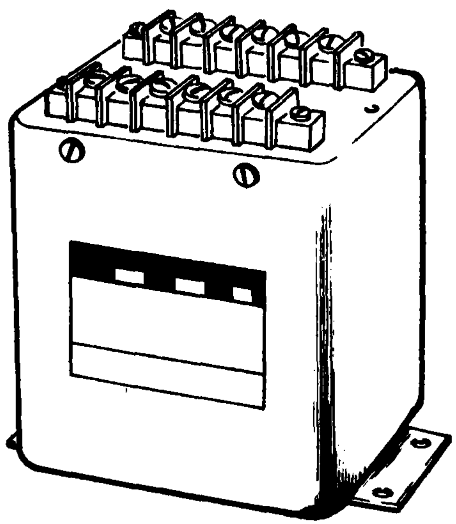
Note: ALL DIMENSIONS ARE IN INCHES

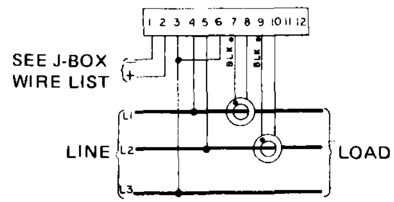
MODEL NUMBER PC5-	FULL SCALE INPUTS			OUTPUT CALIB. 100MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
52	120	50	10.4K	10KW	W	* 2
53	240	50	20.8K	20KW	W	* 2
54	480	50	41.6K	40KW	W	* 2
61	120	100	20.8K	20KW	W	2
62	240	100	41.6K	40KW	W	2
63	480	100	83.1K	80KW	W	2
70	120	200	41.6K	40KW	W	2
71	240	200	83.1K	80KW	W	2
72	480	200	166K	160KW	W	2
79	120	400	83.1K	80KW	X	2
80	240	400	166K	160KW	X	2
81	480	400	332K	320KW	X	2
88	120	600	125K	120KW	X	2
89	240	600	249K	240KW	X	2
90	480	600	499K	480KW	X	2
97	120	1000	208K	200KW	Y	2
98	240	1000	416K	400KW	Y	2
99	480	1000	831K	800KW	Y	2
CASE SIZE DRAWING H						

CASE SIZE "H"

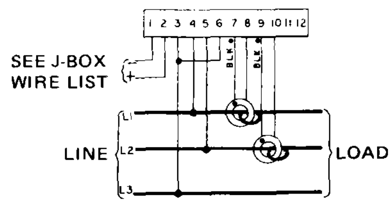


OVERALL HEIGHT 5¼"





CURRENT TRANSFORMERS



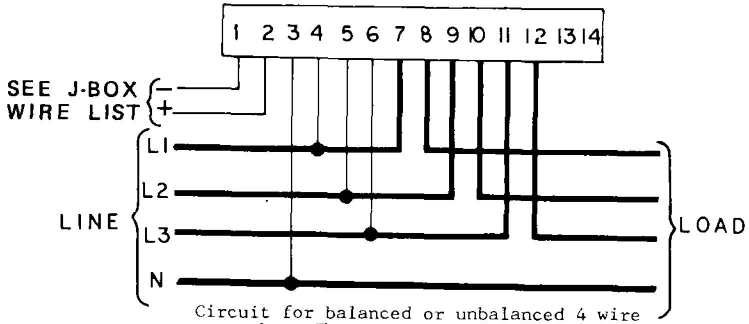
*CURRENT TRANSFORMER WITH TWO TURNS OF WIRE THROUGH WINDOW

Figure B-23. Typical 3-Phase 3-Wire 60 HZ Watt Transducer (continued)

The three phase AC watt transducers used for measurement of three phase power in the system are connected as shown below. These units provide a 100 millivolt output corresponding to a calibrated power rating. (Example: For the PC5 7 rated 120 volts, 5 amperes, 1040 watts; the 100 mv output indicates a power reading of 1000 watts.)

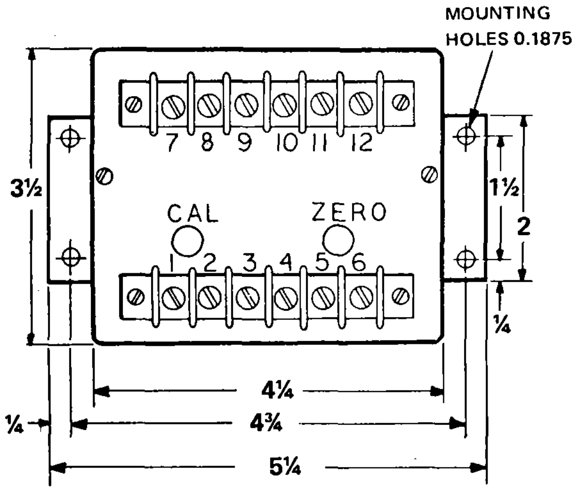
3 PHASE 4 WIRE 60Hz MODELS

MODEL NUMBER PC5-	FULL SCALE IMPUTS			OUTPUT CALIB. 150MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
7	120	5	1.80K	1.5KW	–	–
8	240	5	3.60K	3KW	–	–
9	480	5	7.2K	6KW	–	–
16	120	10	3.6K	3KW	–	–
17	240	10	7.2K	6KW	–	–
18	480	10	14.4K	12KW	–	–
25	120	15	5.4K	4.5KW	–	–
26	240	15	10.8K	9KW	–	–
27	480	15	21.6K	18KW	–	–
CASE SIZE DWG. H (BASE UNIT)						



Circuit for balanced or unbalanced 4 wire networks. The output from all three phases are algebraically summed to obtain the total true power.

CASE SIZE "H"



OVERALL HEIGHT 5¼"

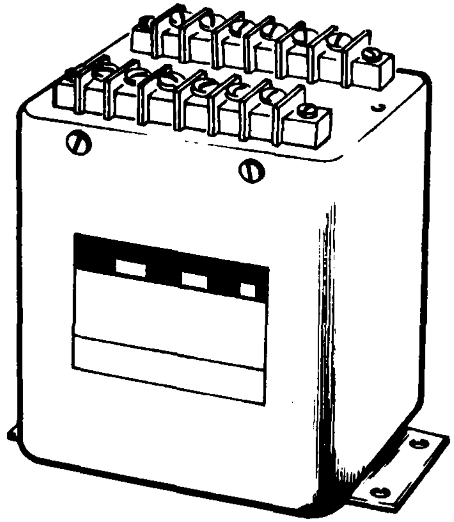
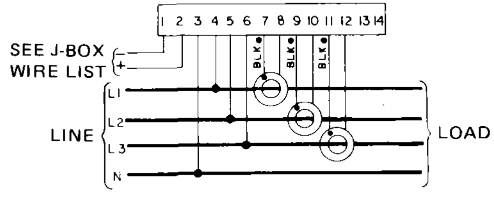


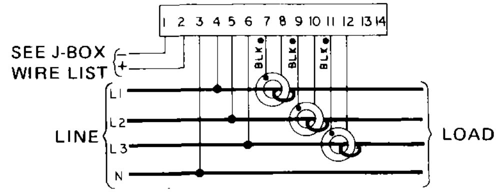
Figure B-24. Typical 3-Phase 4-Wire 60 HZ Watt Transducer

3 PHASE 4 WIRE 60Hz MODELS

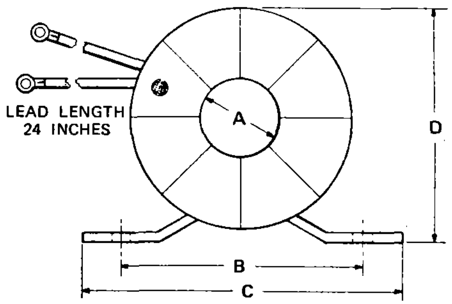
MODEL NUMBER PC5-	FULL SCALE IMPUTS			OUTPUT CALIB. 150MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
	VOLTS	AMPS	WATTS			
55	120	50	18K	15KW	W	* 3
56	240	50	36K	30KW	W	* 3
57	480	50	72K	60KW	W	* 3
64	120	100	36K	30KW	W	3
65	240	100	72K	60KW	W	3
66	480	100	144K	120KW	W	3
73	120	200	72K	60KW	W	3
74	240	200	144K	120KW	W	3
75	480	200	288K	240KW	W	3
82	120	400	144K	120KW	X	3
83	240	400	288K	240KW	X	3
84	480	400	576K	480KW	X	3
91	120	600	216K	180KW	X	3
92	240	600	432K	360KW	X	3
93	480	600	864K	720KW	X	3
100	120	1000	360K	300KW	Y	3
101	240	1000	720K	600KW	Y	3
102	480	1000	1.44M	1.2MW	Y	3
CASE SIZE DWG. H (BASE UNIT)						



CURRENT TRANSFORMERS



*CURRENT TRANSFORMER WITH TWO TURNS OF WIRE THROUGH WINDOW

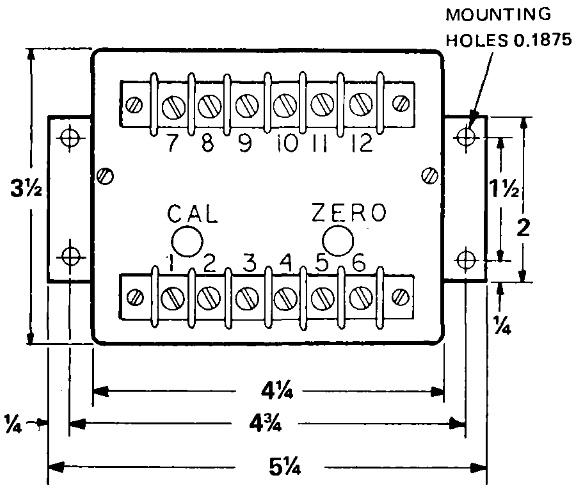


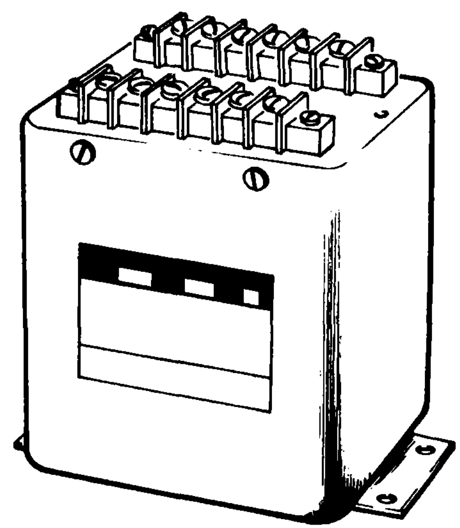
OUTLINE DIMENSIONS FOR W,X,&Y

OUT-LINE DIM.	A	B	C	D	THICK-NESS	WT. LB.	MTG. HOLE
W	1¼	3⅞	5⅛	3⅞	1⅝	2	9/32
X	2¼	5¾	7⅛	5⅛	1½	3	9/32
Y	2¾	5¾	7⅛	5¼	1½	2¼	9/32

Note: ALL DIMENSIONS ARE IN INCHES

CASE SIZE "H"





OVERALL HEIGHT 5¼"

Figure B-25. Typical 3-Phase 4-Wire 60 HZ Watt Transducer (continued)

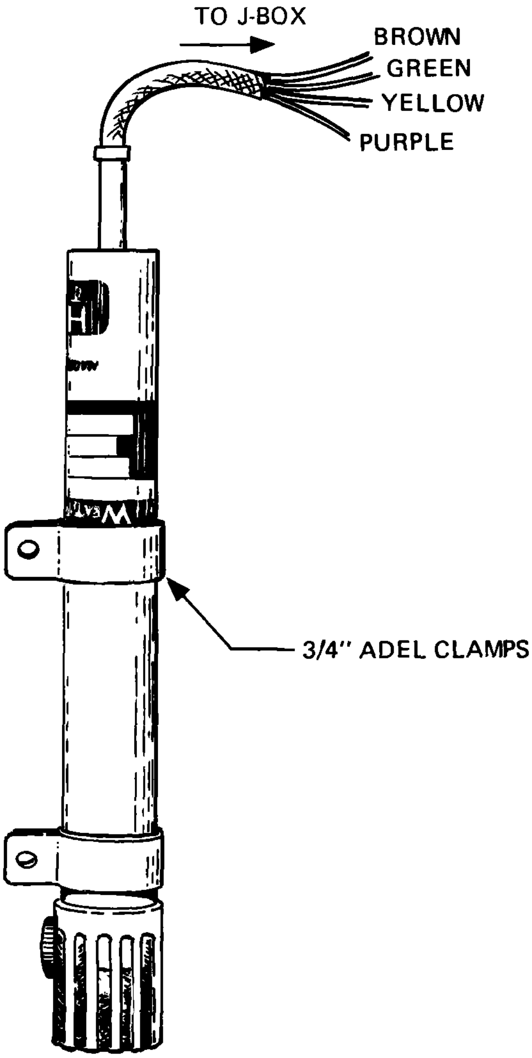


Figure B-26. Typical Relative Humidity Sensor

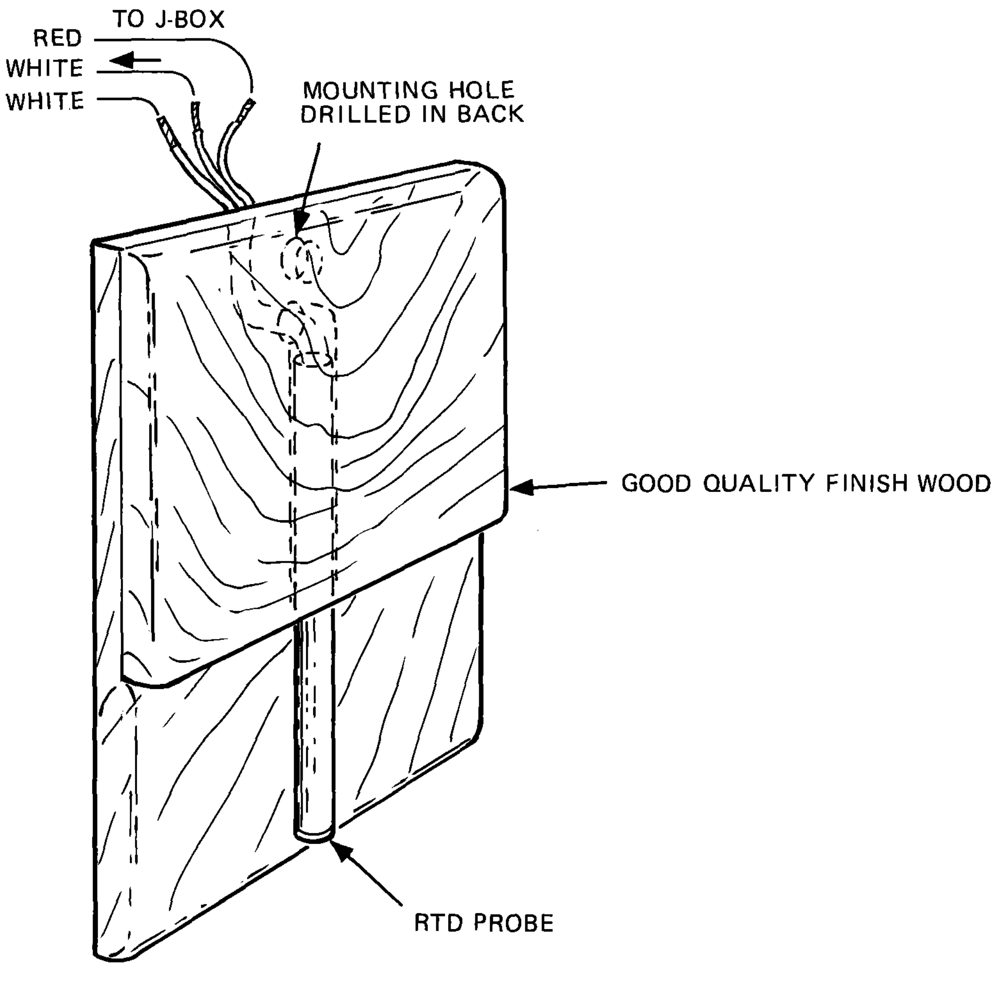


Figure B-27. Typical Internal Ambient Temperature Probe.

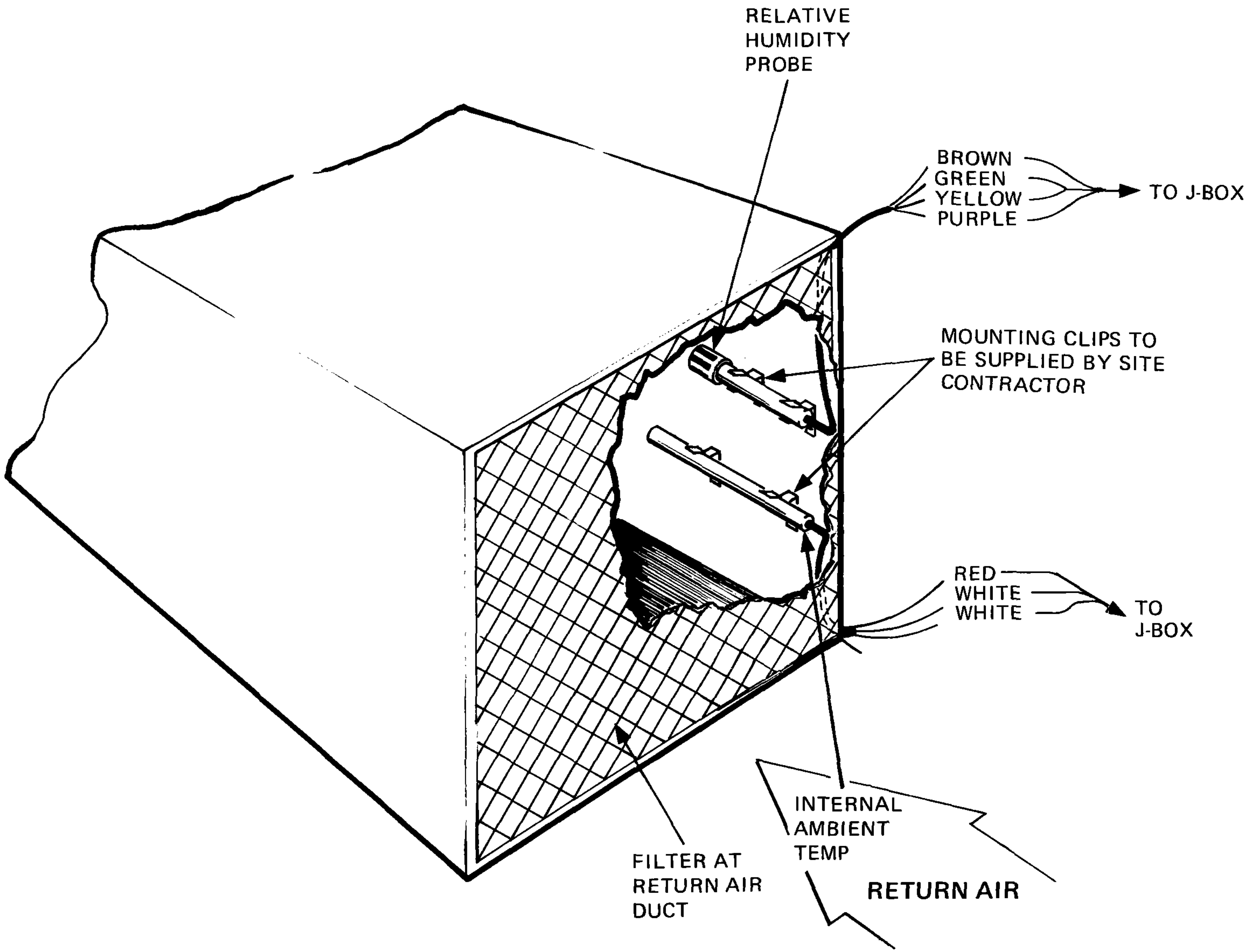


Figure B-28. Typical Internal Ambient Temperature Probe And Relative Humidity Duct Mount

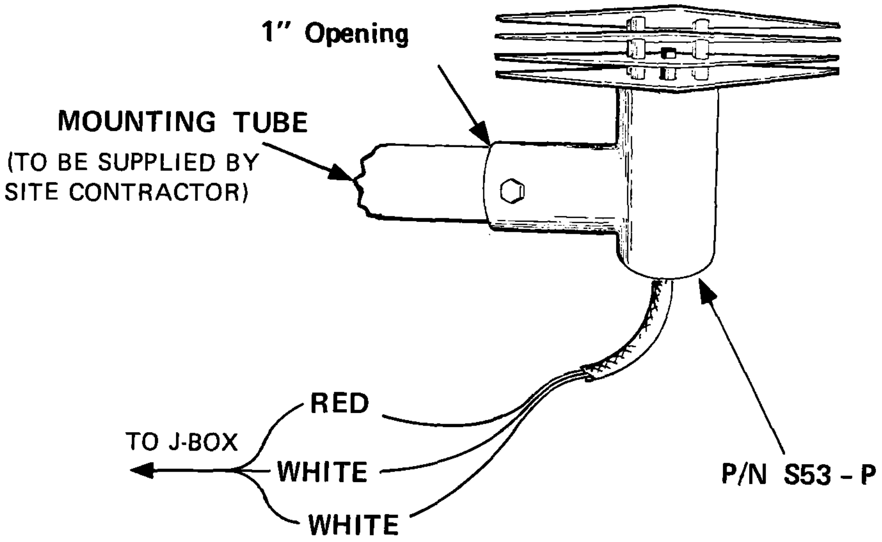


Figure B-29. Typical Outside Ambient Temperature Sensor

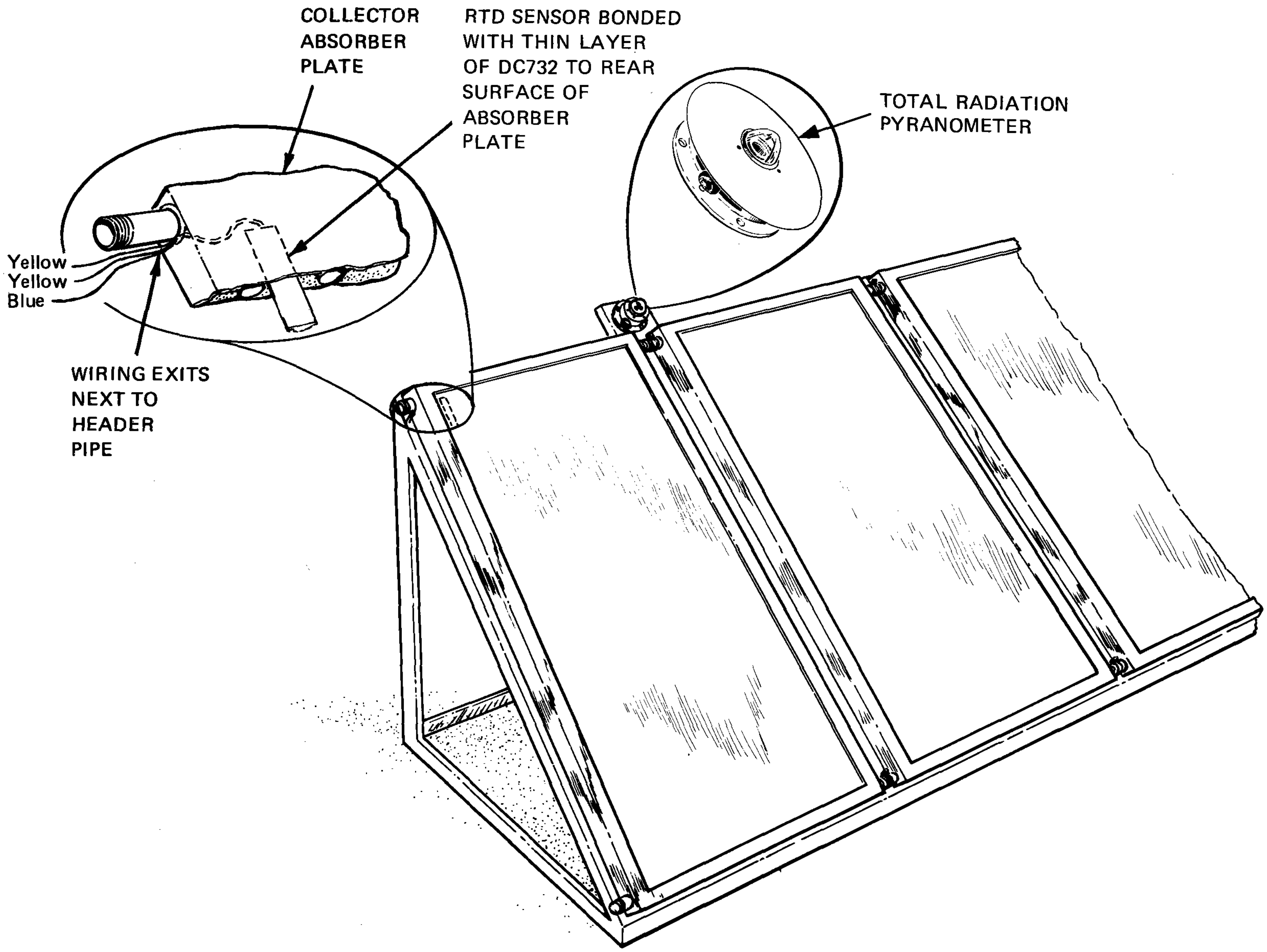


Figure B-30. Typical Flat Plate Collector With Absorber Surface Temperature Sensor And Insolation Sensor Installation

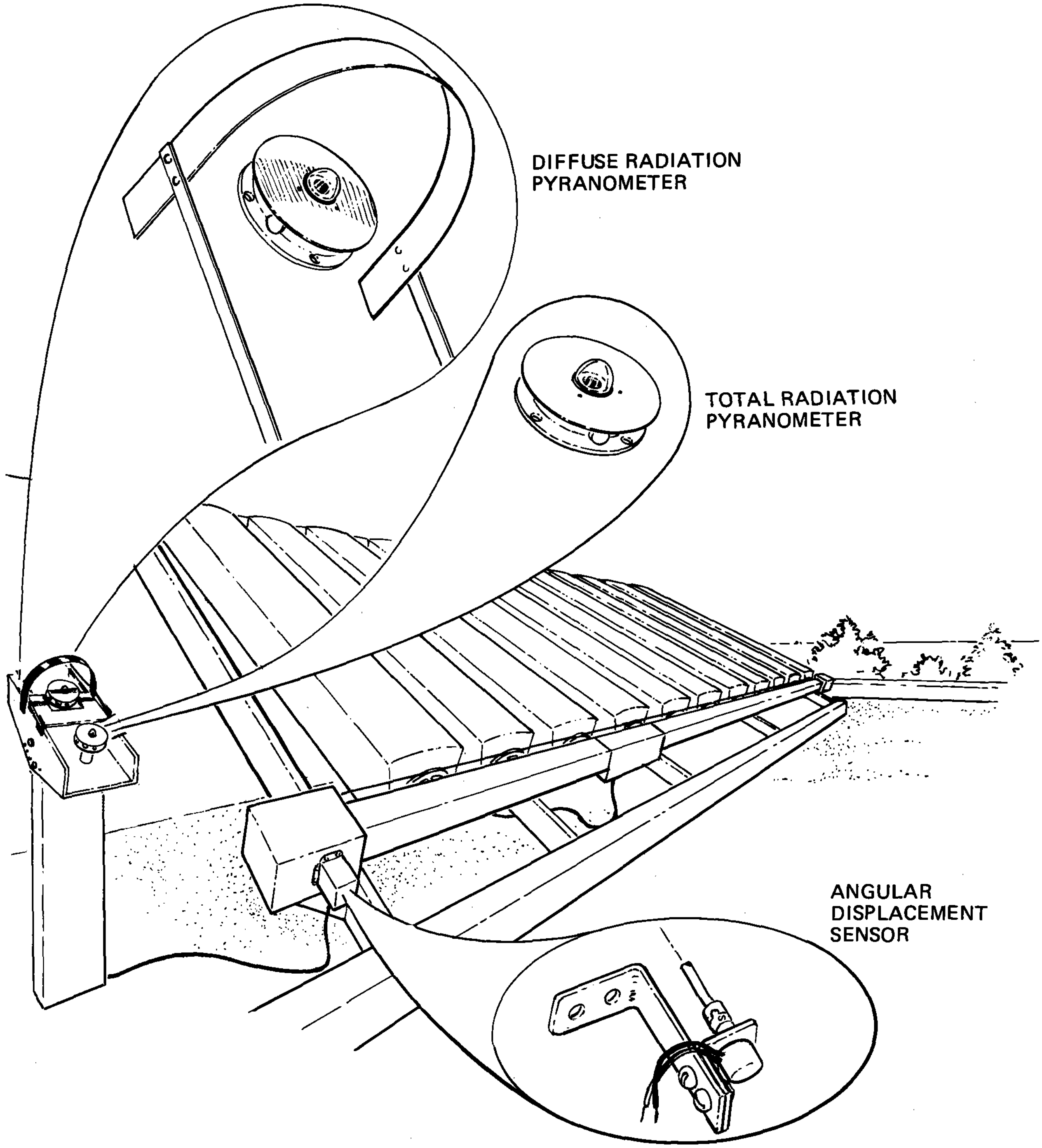


Figure B-31. Typical Concentrating Collectors with Insolation and Angular Displacement Sensor Installations.

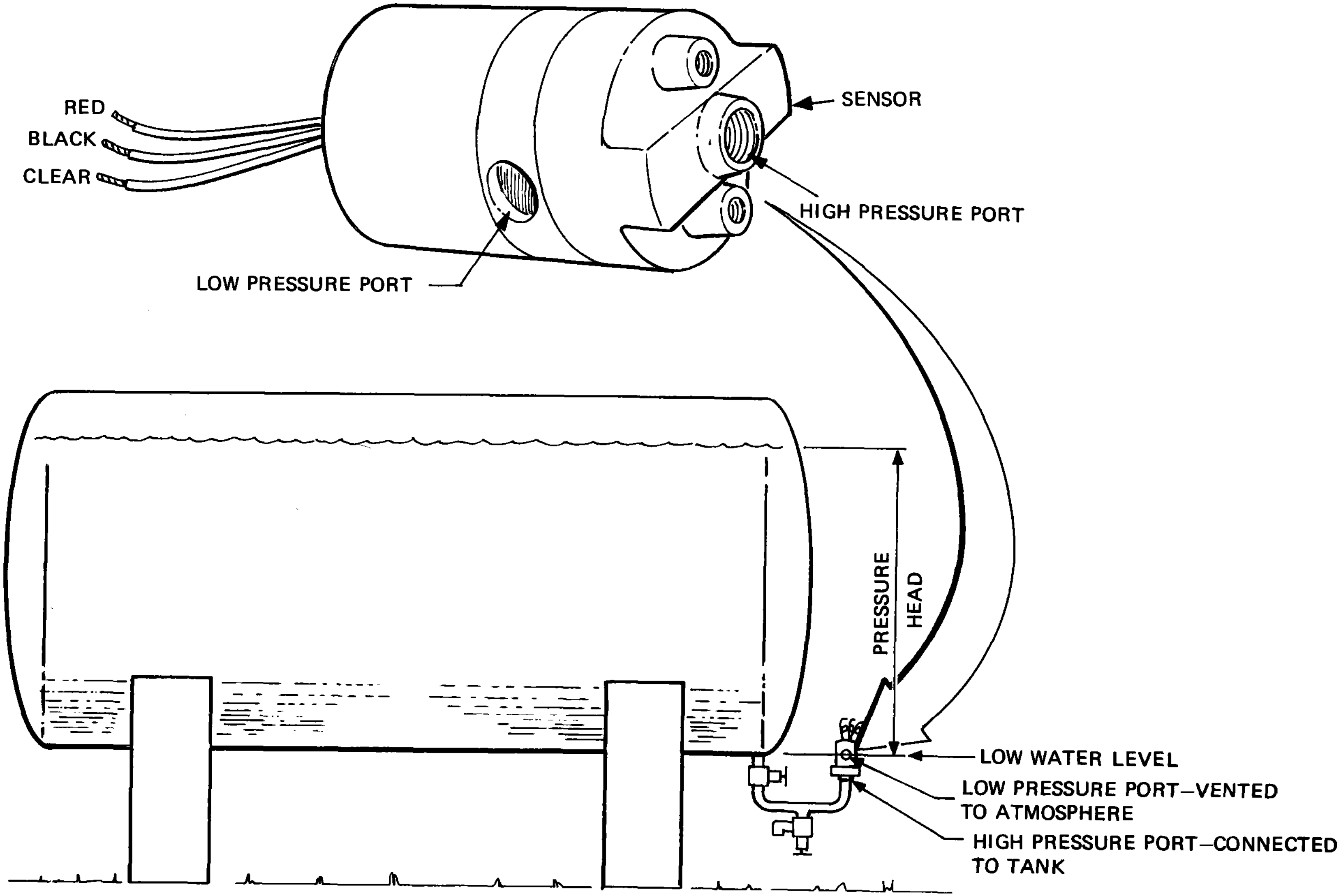


Figure B-32. Typical Storage Tank Level Indicator Installation.

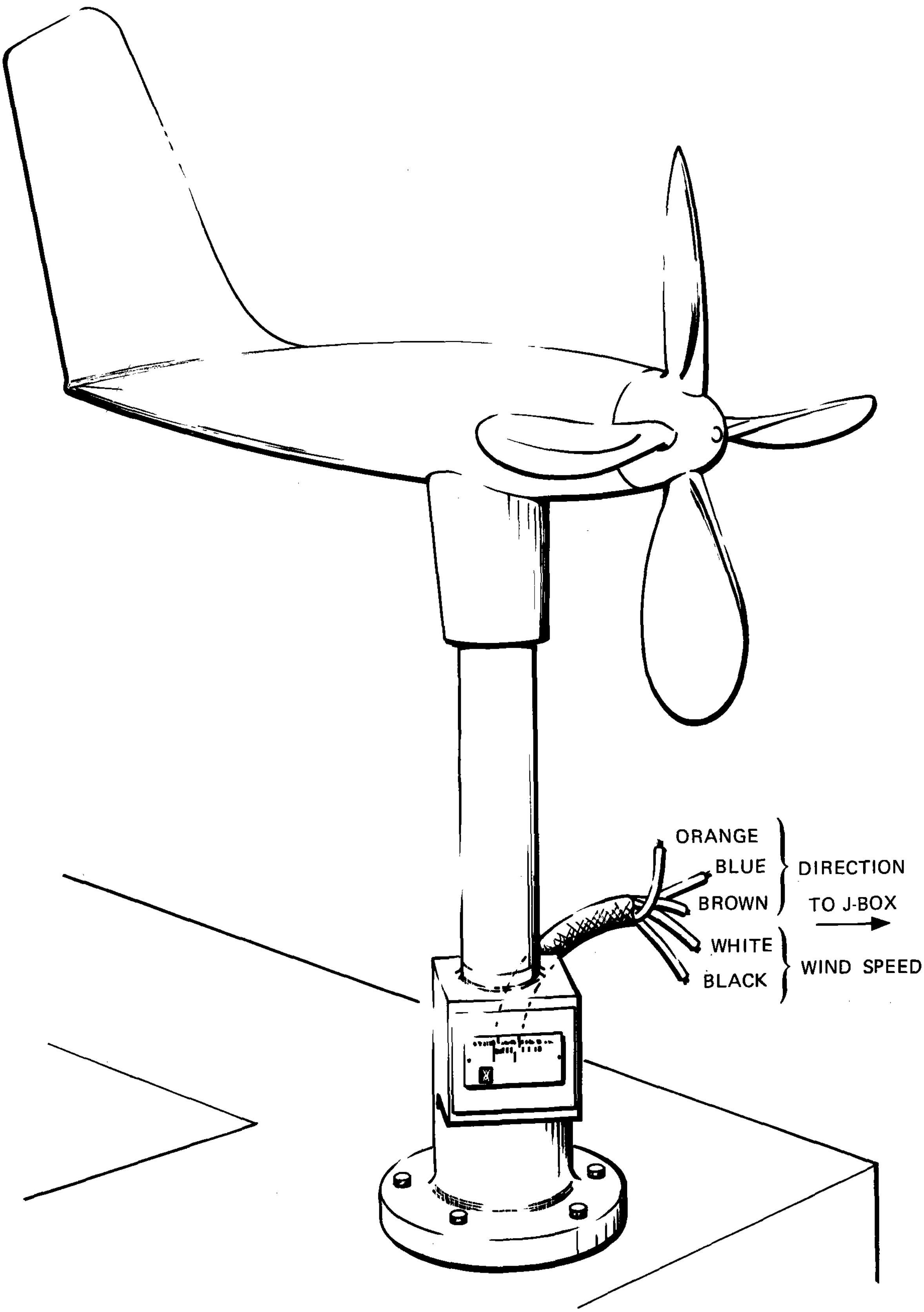


Figure B-33. Typical Wind Speed/Direction Indicator Installation.