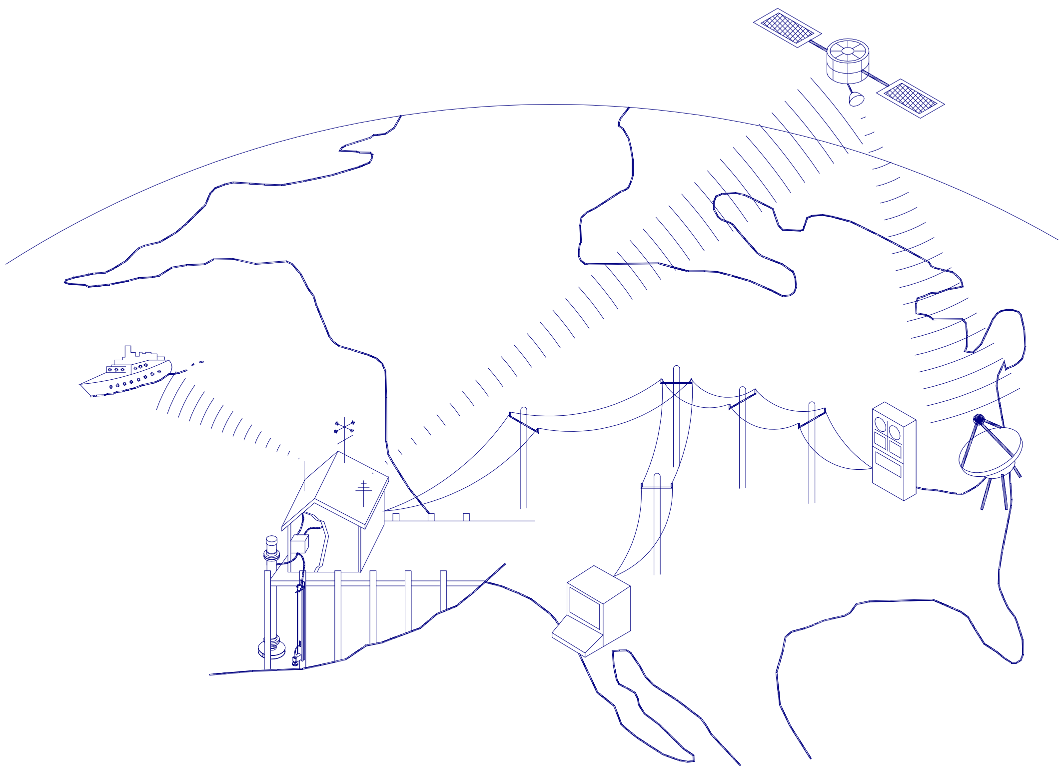
NEXT GENERATION WATER LEVEL MEASUREMENT SYSTEM (NGWLMS)
SITE DESIGN, PREPARATION, AND INSTALLATION MANUAL



January 1991

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Oceanography and Marine Assessment
Rockville, MD

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This manual supercedes prior editions dated: July 1989

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ACRONYMS

AC	- Alternating current
ADR	- Analog-to-digital recorder
COE	- Corps of Engineers
DC	- Direct current
ETG	- Electric tape gage
GOES	- Geostationary Operational Environmental Satellite
GT	- Great diurnal range
MHHW	- Mean higher high water
MLLW	- Mean lower low water
NEMA	- National Electrical Manufacturers Association
NGWLMS	- Next Generation Water Level Measurement System
NOAA	- National Oceanic and Atmospheric Administration
NOS	- National Ocean Service
NWLON	- National Water Level Observation Network
NWS	- National Weather Service
PBM	- Primary bench mark
PVC	- Polyvinyl chloride
RTU	- Remote terminal unit
SRM	- Sensor reference mark
TBM	- Temporary bench mark

1 INTRODUCTION

1.1 BACKGROUND

The Sea and Lake Levels Branch, of the Office of Oceanography and Marine Assessment (OMA), is responsible for the management of a national water level measurement program. The foundation of this program is the operation and maintenance of the National Water Level Observation Network (NWLON), a network of approximately 200 continuously operating data collection stations in the U.S. coastal oceans, the Great Lakes and connecting waterways, and in U.S. Trust Territories and Possessions. The data and information from this network represent one of the most unique and valuable geophysical data sets available. The network provides for the determination and maintenance of vertical reference datums used for surveying and mapping, dredging, coastal construction, water level regulation, marine boundary determinations, tide prediction, and for determination of long term water level variations (e.g. trends). The station platforms and telemetered data are used to support major U.S. Government programs such as the NWS Tsunami Warning System, the NWS storm surge monitoring programs, the U.S. Army Corps of Engineers (COE) national dredging program, the COE/Canadian Great Lakes regulation program, and the NOAA Climate and Global Change Program.

The Next Generation Water Level Measurement System (NGWLMS) field unit is a stand alone data acquisition and data transmission unit. The field unit includes a data collection platform with an acoustic water level measurement sensor, and a backup system with a pressure sensor. The field unit can support up to 11 additional ancillary sensors. The primary link by which data are transmitted from the field unit to NOS for data processing and analysis is once every three hours via Geostationary Operational Environmental Satellite (GOES). Data may also be transmitted by line of sight radio, over telephone lines where available, or downloaded by personal computer on site.

The implementation of the NGWLMS in the NWLON and other data collection program networks, represents a fundamental change in how the Branch accomplishes its functions. The NGWLMS, when fully implemented, replaces the predecessor technologies for data collection, data transmission, data quality control, data processing and analysis, data dissemination, and data base management with state-of-the-art systems.

1.2 PURPOSE

This document contains the procedures and guidelines required to establish a standard NGWLMS site. This document focuses mainly on establishing a NGWLMS at existing NWLON locations, however, the procedures and guidelines can be easily adapted to new locations.

A standard NGWLMS site (see Figure 1-1) is defined as encompassing the following;

- Support structure (pier, platform, wharf, etc.).
- Instrument shelter.
- Standard production field unit with primary and backup water level sensors (see Figure 1-2).
- Auxiliary support components (protective well, brackets, etc.).
- Utilities.
- Bench mark network.

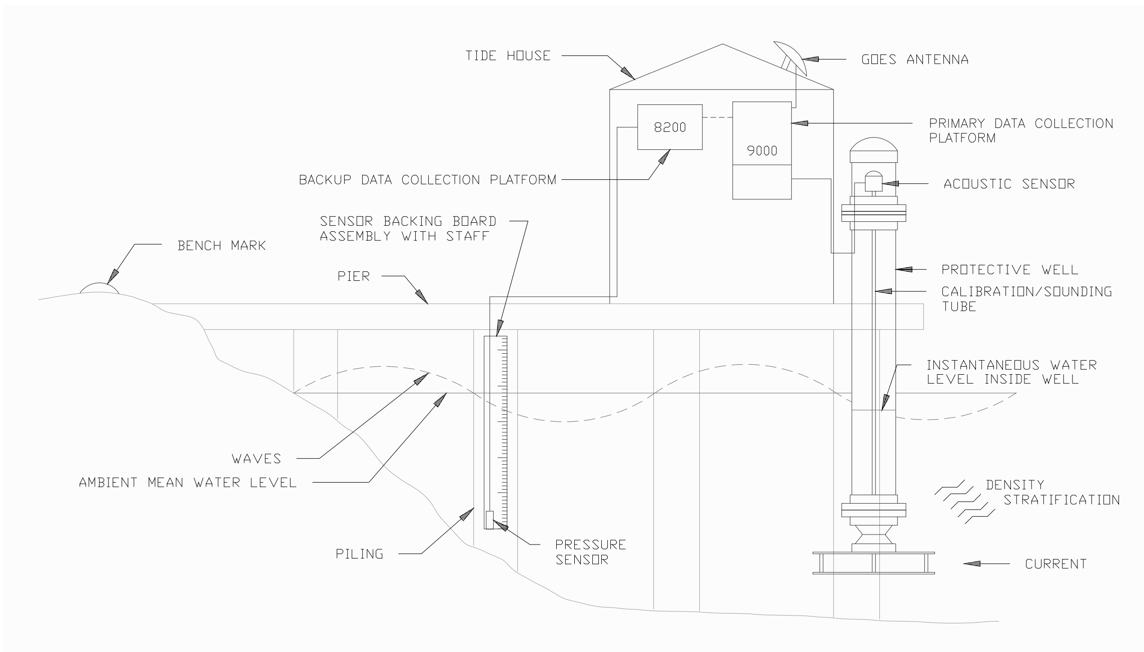


Figure 1-1
Typical NGWLMS Site

A NGWLMS site is established in three phases. First, the NGWLMS site must be designed. This can be done primarily at the office if enough information is available, but a site reconnaissance is usually necessary and recommended. Chapter 2 addresses designing the NGWLMS installation.

Next, the NGWLMS site must be prepared before the actual instrumentation is installed. This may include obtaining permission, constructing an instrument shelter, installing auxiliary support components, arranging for utility service, etc.. This is typically the most difficult part. Chapter 3 addresses site preparation.

Third, the NGWLMS field unit and any ancillary sensors are installed and initialized. The NGWLMS field unit is the instrumentation (see Appendix A) provided by the manufacturer. Auxilary components provided are the commercially available or government designed and fabricated components required to install the field unit. Chapter 4 addresses installing the NGWLMS field unit and initializing the system.

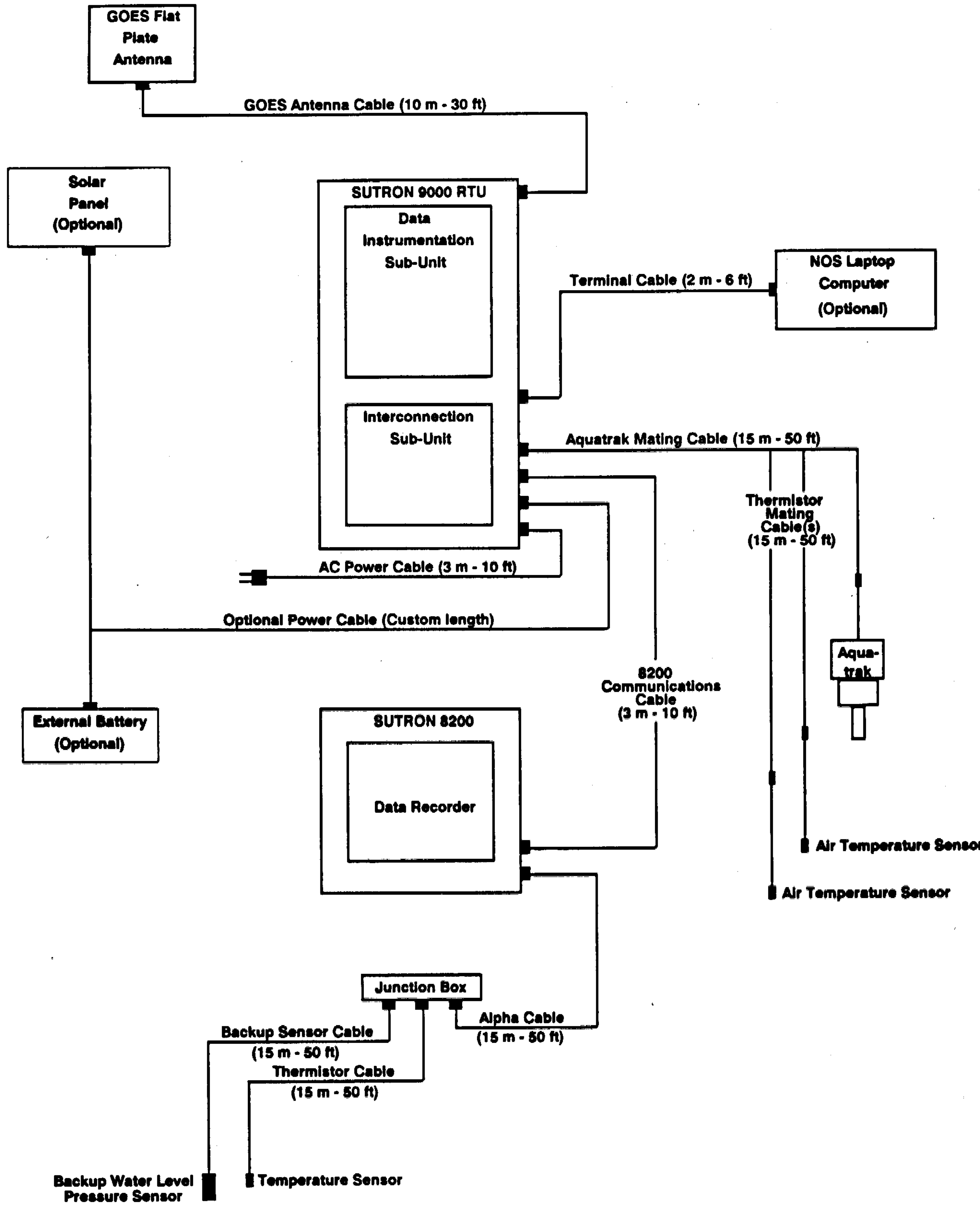


FIGURE 1-2
STANDARD NGWLMS FIELD UNIT CONFIGURATION

Drawing not to scale

The NGWLMS field unit can support up to eleven ancillary sensors in addition to the standard two water level sensors. Site design/preparation guidelines and installation procedures are addressed in Chapter 5.

The three phases may be accomplished in rapid succession or may be separated by long time periods. It is essential that proper documentation be maintained throughout all three phases to ensure that no critical information is lost along the way. Chapter 6 addresses documentation requirements and provides standard forms.

Appendices provide information, drawings, and specifications.

Units of measure provided in the manual are primarily in metric with English units following in parentheses. The English units are rounded and are not the precise metric equivalent.

Mention of trade names or commericial products does not constitute NOS endorsement or recommendation for use.

2 SITE DESIGN

The proper design of a NGWLMS site is critical to ensuring the collection of valid, high quality data. If the site is not designed or configured in accordance with the requirements, the data may be biased or degraded in some manner. Proper design will also ensure a smooth, efficient, installation. The designer must not only be aware of the requirements, but must understand the reasons behind them. Situations will arise where some of the requirements may conflict with other, and the designer must make a choice. The best choice can only be made if the underlying reasons and consequences are well understood.

2.1 OFFICE INFORMATION

The first step in designing a NGWLMS site is to gather the relevant information. In most cases, the site is an existing or historic water level station, and office files can be consulted for much of the information. Program requirements may also provide some direction. Assemble as much of the following information as possible.

- Tidal datums and bench mark elevations.
- Support structure and harbor bottom elevations.
- Support structure plan and sun transit.
- Environmental data.
- Instrument shelter and utilities description.
- GOES transmission information (azimuth and elevation).
- Ancillary sensor(s) requirements.

Tidal datums are required to determine the length and elevation of the protective well. Observed highest/lowest water levels shall be used at long term control stations. Estimated highest/lowest water levels shall be used at short term stations. Ensure that the tidal datums are based on the 1960-78 tidal epoch. Use of this information is discussed in detail in Section 2.3.2.

Support structure and harbor bottom elevations are required as they may impose physical constraints on the protective well and backup sensor mounting board assembly elevations and lengths. These elevations typically have been documented for existing NWLON stations and can be determined at historic sites through levels to the bench mark network.

Information on the support structure's orientation and the path of the sun's transit is critical for locating a thermally acceptable site for the protective well.

Descriptions of the instrument shelter and utilities are typically available for NWLON sites and can be used to determine if adequate space and utilities exist for the NGWLMS field units. The GOES satellite antenna azimuth and elevation angles are required to select an antenna site free of obstructions that may interfere with the transmission. GOES satellite azimuths are referenced in true degrees. If a compass is used to position the antenna, the local magnetic declination must be applied.

Requirements for ancillary sensors should be determined in advance to allow adequate lead time for site preparation design and installation.

Site specific environmental data, particularly on wave climate, is important. Wave data are used in determining well length and elevation. Other types of environmental data may also be useful for design or validation processes.

A preliminary design can usually be done in the office. One, or several options, should be planned for so that potential problem areas can be identified and investigated. Application of the office information, as well as information derived from a reconnaissance, is discussed in detail in the following sections as it is important to understand the applications when assembling the information.

2.2 SITE RECONNAISSANCE

The best and most thorough method of assembling all the design information required is a reconnaissance. The primary objective of the reconnaissance is to determine the optimal location and configuration for the 9000 Remote Terminal Unit (RTU), 8200 data recorder, antenna, sensors, and support components. The reconnaissance consists of personnel visiting the site sufficiently far in advance of site preparation to:

- Locate an acceptable site.
- Obtain measurements and information necessary to design the station.
- Arrange for any permits/license agreements required.
- Arrange for utilities.
- Prepare a cost estimate and work schedule.
- Allow time for the procurement and fabrication of special support components (if necessary).

Property owners should be contacted well in advance to obtain oral or written permission to use or modify the site. An advance letter of permission, permit, security clearance, or some other written instrument may be required by the owner. A license agreement may have to be executed before any work can be done. Even if the site is an existing NWLON station, some advance notice may be required or appreciated by the owner.

Accurate measurements and information can best be obtained onsite. The locale can be investigated to determine which particular site will best accommodate the preliminary design and all the other NGWLMS site requirements. Any special installation requirements, such as explosion proof conduit on fuel piers, can also be determined through discussions with local authorities.

Once a design is finalized, a cost estimate and schedule can be determined. The costs and schedule can vary significantly depending upon how extensive the site preparation work is.

The NGWLMS site establishment schedule must take into account the design and procurement/fabrication of any special support components needed.

Equipment and worksheets recommended for use during the site reconnaissance are listed in Table 1. Photographs and/or videotaping are recommended.

Camera/Videotape Recorder	Published Bench Mark Sheet
Steel tape	Sample License Agreement
Weighted tape	Engineering sketch pad
Inclinometer	Plumb bob
Compass	Chart section
NGWLMS Well/Sounding Tube Worksheet	

Table 1
Recommended Reconnaissance Equipment

2.3 DESIGN PARAMETERS

There are five main areas to consider when designing the NGWLMS site;

- The instrument shelter.
- The protective well.
- The backup sensor.
- The antenna.
- Ancillary sensors

Each area has specific requirements which must be considered. The objective is to satisfy every requirement for each area, however, this may not always be possible. Guidance will be provided as to which requirements have a higher priority than others.
Appendix A contains specifications for the field unit and commercially available or government designed and fabricated auxilary components. Appendix A should be consulted for dimensions, cable lengths, material types, and any other information that may be required for the reconnaissance (and site preparation).

2.3.1 INSTRUMENT SHELTER

An instrument shelter is required to house the instrumentation, although the system is protected against the environment and vandalism by the NEMA enclosures. The shelter provides additional protection against the environment and vandalism, a sheltered work environment for field personnel, and utilities service. The instrument shelter can be a small room or area in a an existing structure or a wood frame, masonary, or fiberglass building specifically designed, built, or purchased for a water level shelter.

Antenna and sensor distances from the 9000 RTU and 8200 data recorder are constrained by the standard cable lengths, although some cables can be lengthened within certain limitations. Utilities (power and telephone) should be nearby or easily accessible. Solar panels should be utilized in appropriate areas. If utilities are not available, cost estimates for supplying the utilities shall be obtained.

The desired mounting configuration for the NEMA enclosures is on the wall, although the enclosures can stand on a table or the floor, if adequate wall space is not available. The NEMA enclosures shall be mounted so that there is sufficient clearance in front and to the sides for installation and maintenance access. Ample clearance on the cable entry side of the enclosures is particularly advised. The distance the two enclosures can separated is limited by a 3 m (10 ft) communication cable length.

Grounding, either by single point AC or by a localized grounding system is required. Guidelines for grounding are provided in Section 3.1.

2.3.2 PROTECTIVE WELL

The protective well is comprised of four functional assemblies; the top hat, the acoustic sensor mounting plate, the well, and the orifice assemblies.

- The top hat assembly is defined as the cap, slip flange, short pipe section, vent screens, and lock.
- The acoustic sensor mounting plate assembly is defined as the two piece anodized aluminum plate, mounting clamp, and associated hardware.
- The well assembly is a white, 15 cm (6 inch) diameter schedule 80 PVC pipe with vent holes. Larger diameter or different materials may be used if already suitably installed. The well assembly shall have vent hole screens, a copper sheet insert, and a flange at each end. Slip-to-slip couplers may be required for joining sections.
- The orifice assembly is a threaded flange and double cone orifice with parallel plates. A slip-to-thread coupler with double cone orifice and shroud section may be used in areas where bottom support for the well is required or physical constraints prevent the use of parallel plates.

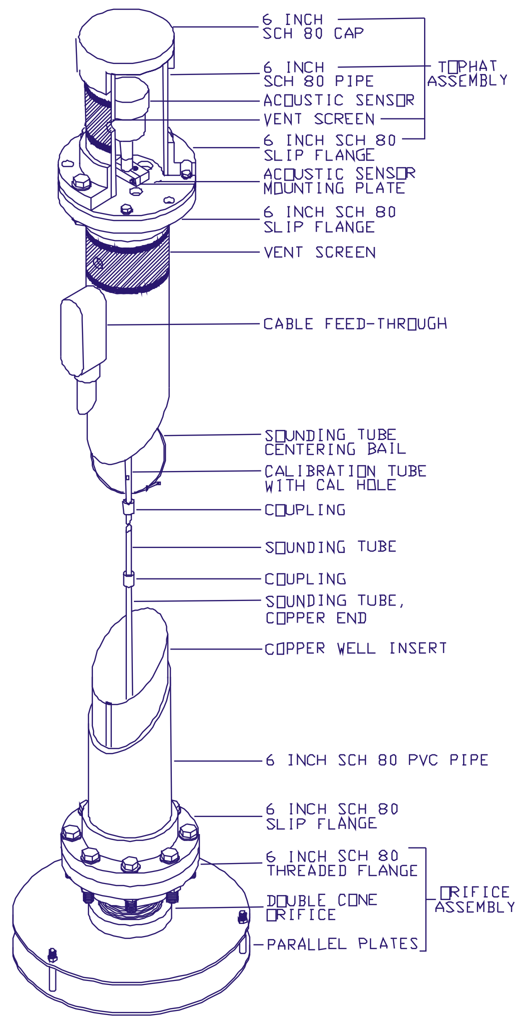


Figure 2-1
Primary Water Level Sensor
Protective Well Configuration

The design of the protective well is probably the most complex part of the installation. There are many variables to consider, some of which may conflict with each other. The well design is discussed in two parts; location and elevation. Thermistor elevations are not a part of the well location and elevation design process, but should be determined at this time. They are discussed under a third section.

2.3.2-A Protective well location

The well location is primarily constrained by the availability of support structures to which braces can be fastened. This consideration is no different than with analog-to-digital (ADR) stilling wells. The protective well shall be plumb to within 1 cm/m (1/8 inch/ft) and adequately braced to withstand expected local sea state conditions. The location can be either inside or outside (see next paragraph for considerations) of the instrument shelter, but distance from the 9000 RTU is limited by the standard 15 m (50 ft) sensor cable lengths. Longer sensor cables can be provided up to 30 m (100 ft), but distances greater than this shall be avoided, and require prior approval from headquarters.

The thermal environment of the above water portion of the well must be carefully considered. The upper 1.1 m (3.6 ft) of the well, which houses the calibration (cal) tube section, must be exposed to the same temperature regime that the rest of the above water well is. Since the transducer calibrates by calculating the speed of sound, based on the temperature regime in the cal tube, a much different temperature regime below will affect the accuracy. The two thermistors placed in the well are to measure any temperature differential. The temperature data can then be used, if necessary, to correct the water level data; but, configurations allowing large differentials are to be avoided. <u>Every reasonable effort must be made to avoid temperature differentials large enough to necessitate correcting the raw water level data.</u>

Avoid the configuration where the top 1.1 m (3.6 ft) of the well extends into a heated instrument shelter while the rest of the well passes through colder air under the pier. Also avoid the configuration where a well is installed outside of an instrument shelter and is oriented alongside a pier, or other structure, so that as the sun transits the sky, the upper section of well is in direct sunlight, while the lower section is shaded. Both can cause undesirable temperature differentials as discussed above.

Other well location considerations are accessibility of the well and security. The well should not be so difficult to access that maintenance is arduous. In areas where vandalism may be a problem, exposure of the well to public access should be avoided.

2.3.2-B Protective well elevation

Complex requirements govern the upper and lower well elevations. The highest/lowest water level elevations, coupled with the wave allowance, are critical determinants. Constraints imposed by the sounding tube also must be considered. Ideal top and bottom elevations are calculated using these determinants, and then modified as necessary by the physical constraints of the site. The *NGWLMS Well/Sounding Tube Worksheet*, described in Chapter 6, is used to design and document the well/sounding tube elevations. The following discussions will refer to it.

The top flange of the well shall be at least 1.5 m (5.0 ft) above the highest water level (plus wave allowance) elevation to ensure that extreme high water levels are measured. The acoustic sensor measures water level starting from a point near the cal hole, which is about 1.0 m (3.5 ft) below the top flange. In addition, there is a 0.5 m (1.5 ft) "blanking zone" or blind area immediately below the cal hole, that the acoustic sensor cannot measure water level in. This 1.5 m (5.0 ft) section is shown as length A on the worksheet.

Length B on the worksheet is determined by the physical relationship of the pier deck (or other structure) and the highest water level (plus wave allowance) elevation. It may be that the top of the well has to be extended some additional length over the 1.5 m (5.0 ft) minimum elevation requirement in order to reach the pier deck. Length B also acts as a safety factor as it essentially raises the highest possible water level elevation.

Ideally, the maximum top flange height above deck level should be about 1 m (3 ft) to facilitate leveling and maintenance. However, the top flange can be higher if necessary, and a downshot leveling fixture utilized. It may be that at some sites the 1.5 m (5.0 ft) requirement is not attainable. This can occur when the highest water level (plus wave allowance) elevation is above the pier deck and the resulting top flange elevation is either too high for practical reasons or physical constraints prevent it. A shorter 0.5 m (1.6 ft) calibration tube has been developed that can help in situations such as this, but it should only be considered a last resort as the shorter calibration length means lessened accuracy.

Length C on the worksheet is the difference between the highest and lowest water level (plus wave allowances) elevations. The highest and lowest water level elevations are elevations that the water level is expected to either never, or rarely, exceed. The highest and lowest water level elevations used will either be observed or estimated values. Typically, observed values will be used at long term control stations because they have been operating long enough to have experienced infrequent extreme levels. Estimated values will be used at shorter term stations because they have not been operating long enough to experience the extremes.

A wave allowance is added onto the water level extremes due to the fact that the large diameter orifice used in the protective well does not totally filter out waves. Therefore, even though an extreme water level may be within the observed/estimated water level elevation limits, the crest or trough of a wave may cause the water to momentarily exceed the limits. This can have several undesirable results. The lower thermistor may get wet, thus biasing the air temperature readings, or the water level may rise into the blanking zone and therefore not be measured. At the bottom end of the well, water level falling below the sounding tube will not be measured. The brass/cpvc tube connection is another concern. It is preferred that this connection be kept below the lowest water level (plus wave allowance) limit because of its potential to cause a false reflection, and therefore bad data. Extreme water level elevations are critical for many applications and must be measured.

The wave climate at each location is site specific, depending largely on local topography, exposure to prevailing winds, and other variables. The wave allowance for each site will be determined primarily by local knowledge as applied to average wave height. Table 2 lists average wave heights for sites in the continental United States. Other sources can be consulted for more localized wave data and for stations outside the continental United States. Table 2 can be used to estimate average wave heights for a station, which are then adjusted up or down by knowledge of local conditions, particularly how exposed the well location is to wave action. If the station is oriented so that it is exposed to prevailing winds crossing a long stretch of water, heavy wave action is likely. The average wave height determined for a location shall be used as the wave allowance at each end of the well. In general, doubling the average wave height reduces the frequency of occurrence from 50% to approximately 10% or less. The well orifice will further reduce wave height in the well by about another 20%. This method of determining the wave allowance value should provide adequate elevation in all but the worst cases. If the wave allowance length can be increased at either end of the well without compromising other requirements, it shall be done as a safety factor. Lengths B and D essentially accomplish this.

Length D on the worksheet represents a length added onto the lowest water level elevation as a safety factor. Again, an improperly installed brass/cpvc junction may give a erroneous reading if the water level should fall below it. Therefore, if there is still ample water depth after calculating the lowest well elevation (including the orifice assembly), an extra amount of well length might be added as a safety factor. Exact guidelines cannot be given on how to determine how much extra, without detailed current and wave information at a specific location, but in general the lower a well orifice is, the less effect waves and currents will have. At sites located in, or near, the surf zone, the orifice should be placed as deep as is practical.

There cannot be a standard minimum elevation off the harbor bottom specified for the well orifice. Personal judgement, based upon experience and the local bottom type, must be exercised. In general, however, for areas with hard, rocky bottoms which will experience little change, a minimum 0.5 m (1.5 ft) clearance is desirable. In areas where the bottom is sandy, or the beach profile is subject to substantial seasonal change, the orifice should be kept much higher off the bottom.

The brass antifouling tube section is typically 0.9 m (3.0 ft) in length but may be shortened if the water depth is shallow. This is shown as length F on the worksheet. There is also a requirement that the sounding tube be offset from the orifice by one well diameter. Since the typical well has a 0.2 m (0.5 ft) diameter, and the orifice is recessed down into the orifice assembly, a value of 0.1 m (0.3 ft) is used. This is shown as length G on the worksheet. Therefore, the lower section of the well (below the lowest water level plus wave allowance) will typically be at least 1.0 m (3.3 ft), unless the brass antifouling tube must be shortened due to water depth limitations.

In some cases the lowest water level elevation (plus well allowance) will be too close to the harbor bottom for the above requirements to be met. This will require that Length D be minimal or eliminated. In such cases, the antifouling tube may be shortened, or the brass/cpvc junction carefully tested and installed above the lowest water level (plus wave allowance).

Location	Mean Annual Wave Height	Location	Mean Annual Wave Height
ATLANTIC COAST			
Maine		**New Jersey (cont)**	
Moose Peak	0.5 m (1.5')	Ludlam Island^	0.6 m (1.9')
New Hampshire		**Maryland**	
Hampton Beach	0.4 m (1.4')	Ocean City	0.6 m (1.8')
Massachucetts		**Virginia**	
Nauset	0.6 m (1.8')	Assateague^	0.8 m (2.6')
Cape Cod^	0.8 m (2.5')	Virginia Beach*	0.6 m (1.8')
Rhode Island		Virginia Beach	0.6 m (2.0')
Point Judith	0.6 m (1.8')	**North Carolina**	
Misquamicut^	0.4 m (1.4')	Nags Head*	0.9 m (3.0')
New York		Nags Head	1.2 m (3.9')
Southampton^	0.6 m (1.9')	Wrightsville^	0.7 m (2.3')
Westhampton^	0.8 m (2.6')	Oak Island	0.4 m (1.2')
Jones Beach^	0.8 m (2.6')	Holden Beach^	0.5 m (1.7')
Short Beach	0.5 m (1.7')	**Georgia**	
New Jersey		St. Simon Is.	0.1 m (0.4')
Monmouth	0.5 m (1.7')	**Florida**	
Deal^	0.7 m (2.3')	Daytona Beach*	0.6 m (1.9')
Toms River	0.6 m (2.0')	Ponce deLeon	0.7 m (2.2')
Brigatine^	0.7 m (2.2')	Lake Worth*	0.7 m (2.3')
Atlantic City*	0.8 m (2.8')	Palm Beach*	0.7 m (2.3')
Atlantic City (BEP)	0.4 m (1.3')	Boca Raton^	0.6 m (1.9')
Atlantic City USCG	0.6 m (1.9')	Hillsboro	0.4 m (1.3')
GULF COAST			
Florida		**(cont)**	
Naples*	0.3 m (1.0')	Navarre Bch+	0.7 m (2.3')
Cape San Blas	0.2 m (0.7')	Santa Rosa	0.4 m (1.4')
Panama City+	0.5 m (1.7')	**Louisiana**	
Greyton Beach+	0.5 m (1.7')	Grand Island	0.4 m (1.4')
Crystal Beach+	0.5 m (1.7')	**Texas**	
Beasley Park+	0.6 m (1.8')	Galveston*	0.4 m (1.4')
PACIFIC COAST			
California		**California (cont)**	
Point Loma	0.6 m (2.1')	Point Arguello	0.8 m (2.5')
South Carlsbad+	0.8 m (2.7')	Natural Brdges+	0.9 m (2.9')
Carlsbad+	0.9 m (2.9')	Thornton+	1.2 m (4.1')
Huntington Beach*	0.5 m (1.7')	Goat Rock+	1.4 m (4.6')
Huntington+	0.8 m (2.6')	Point Arena	0.8 m (2.6')
Bolsa Chica+	0.7 m (2.2')	Prairie Creek+	1.1 m (3.7')
Leo Carrillo+	0.7 m (2.3')	**Oregon**	
Pt Mugu (PEG)+	0.9 m (3.0')	Umpqua River	1.0 m (3.3')
Pt Mugu*	0.8 m (2.7')	Yaquina Bay	1.6 m (5.1')
McGrath+	1.1 m (3.5')	**Washington**	
Carpinteria+	0.6 m (1.8')	Willapa Bay	0.6 m (1.8')
Point Conception	0.8 m (2.8')	Cape Flattery	0.5 m (1.7')
El Capitan+	0.6 m (2.0')		

^ CERC Beach Evaluation Program * CERC Wave Gage Records
+ CERC Littoral Environmental Observation Program

Table 2
Mean Wave Height at Coastal Localities
of the Conterminous United States

2.3.2-C Protective well thermistor elevations

The purpose of the two temperature sensors is to monitor any temperature differentials in the protective well. It is desirable to have the lower temperature sensor as low as possible in the well so as to obtain a representative measurement for the entire length of the well. However, it is also important to minimize the chances of the sensor from getting wet, as this will result in a false air temperature value. Use the following procedure to compute an elevation that will result in the lower temperature sensor getting wet only a small percentage of the time. Tidal datums for the site are required. Compute this elevation as follows:

- Determine the Great Diurnal Range (Gt) for the site. Gt is equal to MHHW - MLLW.
- If the Gt is less than or equal to 0.3 m (1.0 ft), place the lower temperature sensor above MHHW by 2 x Gt. The formula, therefore is; t_2 elevation = MHHW + (2 x Gt).
- If the Gt is greater than 0.3 m (1.0 ft), place the lower temperature sensor above MHHW by 30% of the Gt. The formula, therefore is; t_2 elevation = MHHW + (0.3 x Gt).
- If the value turns out to be above the highest observed/estimated water level, place the sensor at the highest observed/estimated water level.

2.3.3 BACKUP PRESSURE SENSOR ASSEMBLY

The backup sensor assembly consists of the 8200 data recorder, mounting board assembly, pressure sensor, temperature sensor, junction box, and cables.

The pressure sensor shall be installed on a separate pile from the protective well and at the same elevation, within +/- 0.2 m (0.5 ft), as the protective well orifice. The temperature sensor shall be installed immediately adjacent to the pressure sensor as its data is required to adjust the water level data.

There are two different configurations that may be employed when installing the backup pressure sensor. Each one has different advantages and disadvantages. Select the configuration most suitable for the site and available logistical support.

2.3.3-A Direct (in water) measurement configuration

The first configuration is where the pressure and temperature sensors are installed directly in the water. The first configuration is advantageous in that it does not require the addition of the gas purged system. It also allows the temperature sensor to double as a water temperature sensor. Disadvantages are that the exposed strain gauge of the pressure sensor can be affected by marine fouling and that the sensor is subject to galvanic corrosion (dis-similar metals). Unless the sensor can be cleaned regularly in areas having marine growth, or protected in some other way, the second configuration may be required. If deployed directly in the water, it may be advantageous to use a mounting board assembly. The mounting board assembly is designed to allow the sensor to be removed from the water, cleaned and/or serviced, and replaced back to the same elevation without using divers.

2.3.3-B Indirect (out of water) measurement configuration

The second configuration is where the pressure sensor is teed into a gas purged line, terminating in an underwater brass orifice, and monitors the pressure variations. The pressure and temperature sensor are installed above water in the instrument shelter. The main advantage to the second configuration is that the fouling and corrosion are avoided. The brass orifice with nitrogen gas bubbling out of it is very resistant to marine growth and does not corrode. The main disadvantage is that another system (nitrogen gas tank, regulator, manifold, tubing, and orifice) is introduced that requires maintenance and periodic nitrogen gas resupply. This configuration also eliminates water temperature data as the temperature sensor must be installed with the pressure sensor.

2.3.3-C Junction box

The 8200 data recorder junction box allows venting of the pressure sensor to atmospheric pressure, merging of the pressure sensor and thermistor cables (alpha cable), and facilitates maintenance by providing a break point for the cables between the sensors and the 8200 data recorder. The junction box requires a protected, yet reasonably accessible, location convenient to the servicing of the pressure sensor. Typically this will be immediately above where the pressure sensor is installed. The junction box's distance from the 8200 data recorder is limited by an alpha cable length of 15 m (50 ft). 15 m (50 ft) of cable is also provided between the junction box and the sensors, however, much of this must be used as a service coil.

2.3.4 ANTENNA ASSEMBLY

The antenna assembly consists of the antenna, cable, mounting bracket, and antenna mast. The antenna shall be installed so that it is pointing in the specified direction and angle with no obstructions to interfere with the transmission. The flat plate antenna has a very wide (96° @ 3db) beam path so obstructions that are some distance from the antenna, and partially obstruct the line of sight path, should not usually cause a problem. Use trigonometry to determine if a tall structure some distance away may substantially block the signal path, since the structure height, distance, and pointing angle are known.

Precautions with regard to nearby objects must be observed to insure optimum performance from the antenna. Objects in the near transmission field will distort the antenna radiation pattern. Particular precaution should be exercised if the object is another GOES antenna which may be operating on or near the same frequency as the NGWLMS. In addition to keeping any objects out of the direct line of sight path of the antenna, maintain at least a 1 m (3 ft) clearance on each side. This represents approximately 1 wavelength for the frequency in use. If the object is another antenna, a distance of more than 1 m (3 ft) is advised. A 0.6 m (2.0 ft) minimum roof clearance is recommended. If the instrument shelter is a fiberglass house, the antenna may be mounted inside, and will transmit through the wall/roof. This may be advisable in areas of vandalism or heavy ice problems.

The standard antenna cable length is 10 m (30 ft). If this is not long enough, a continuous length (no connectors) of low loss cable shall be used. It is important to determine the length of antenna cable required during the reconnaissance as the low loss cable length must be made specifically for each site.

The antenna may require a support mast. The antenna has a mounting bracket that attaches to a 5 cm (2 inch) diameter pipe. A short pipe mast may be attached to the roof, or a longer mast may be attached to the pier deck, and extend up above the roof. The antenna may be secured to a meteorological tower if one has been installed to support ancillary sensors.

2.3.5 SOLAR PANELS

If AC power is not available at a site, a solar panel must be used for the 9000 RTU. If AC power is available, the use of a solar panel is recommended, but not required, for most NGWLMS installations. The ideal configuration is to have the 9000 RTU connected to AC and also have a solar panel connected. The 9000 RTU can accept a variety of power sources simultaneously and the solar panel provides insurance against power failures. Long term power outages are not uncommon on some piers and at remote locations.

A separate solar panel is recommended for the 8200 data recorder. The 8200 data recorder is supplied by the manufacturer with dry cell batteries with an estimated operational life of one year. Replacing the dry cell batteries with a 12 volt gel cell and solar panel is encouraged for remote sites where regular maintenance intervals are a year or over.

The size of the solar panels required to keep the 9000 RTU and 8200 data recorder batteries charged is determined by the average power consumption for each unit and the site location. The average power consumption for a standard 9000 RTU field unit is about 65 ma. This value can increase considerably, however, if ancillary sensors, different types of board, or non-standard devices are connected to the 9000 RTU. Even different versions of software can change the power consumption if sampling schemes for sensors are changed. The average power consumption for a 8200 data recorder is 45 ma. The *Sutron 9000 RTU Operations and Maintenance Manual* has procedures on how to compute the power consumption for various 9000 RTU configurations. The site location is important as it determines how much sunlight the panel receives, and therefore how much power is available. The Sutron manual also provides a simple procedure with graphs, figures, and an example on how to compute the size of solar panel required. NOS typically uses a 30 watt panel for the 9000 RTU and a 5 watt panel for the 8200 data recorder.

The solar panel(s) may require a support mast. Solar panels are typically supplied with a bracket capable of mounting to both 5 cm (2 inch) diameter pipes and flat surfaces. The same mast installed for the GOES antenna may be used, or a meteorological tower.

2.3.6 ANCILLARY SENSORS

Different types of ancillary sensors may be required at a site, depending upon program requirements. Some of the ancillary sensors require much more site preparation than others. In some cases, a tower may be erected to support meteorological sensors that require minimum height elevations in order to collect meaningful data. Ancillary sensor design and installation requirements are discussed in detail in Chapter 5, as they are not considered part of a standard NGWLMS station.

2.3.7 ENVIRONMENTAL PARAMETERS

Environmental conditions specific to the site can affect site preparation requirements and should be taken into account. Some parameters which should always be evaluated are marine fouling, waves, currents, and freezing/ice cover potential.

2.3.7-A Marine fouling

Marine fouling can significantly impair high quality data collection by clogging the protective well and the pressure sensor. It is therefore important to assess beforehand how severe marine fouling may be so that it can be considered in the design and in preventive maintenance procedures. Marine fouling should be evaluated against a standard scale. A general rating system is provided in Table 3. Each station shall be rated as having a light, medium, or heavy fouling potential. Document this on the *NGWLMS Site Report* (see Chapter 6).

RATING	DEFINITION
LIGHT:	Clean or slight growth, components may be covered by a light covering of slime type growth. Infrequent cleaning required.
MEDIUM:	Components are partially to completely covered by light plant and/or animal life with scattered small shellfish (barnacles, limpets, mussels, oysters, etc.). Thickness of growth is limited to about 3 cm (1 inch). Annual cleaning is sufficient.
HEAVY:	Components are completely covered by heavy plant and/or animal life. Large clusters of shellfish or other large organisms. Thickness of growth may be considerable. Frequent cleaning is required. Note if growth is constant or varies seasonally.

Table 3
Marine Fouling Scale

2.3.7-B Currents and waves

Current and wave conditions can affect the site design. Current velocities greater than 0.3 m/s (0.5 knot), and wave heights greater than 0.6 m (2.0 ft), can cause significant draw down in the protective well and pressure sensor if not properly guarded against with parallel plates. Parallel plates are required on all protective well installations, where there is the possibility of current and wave conditions nearing or exceeding the limits, except those where the shroud configuration must be used. "Mini" parallel plates are required on all pressure sensors deployed directly in the water.

Current conditions can also affect the orientation of the protective well with respect to the pile and current direction. In areas of strong currents, the preferred orientation of the well is on the side of the pile relative to the flow, i.e., with the flow perpendicular to the axis connecting the centers of the cylindrical piling and well (see *Water Level Measurement Errors Caused by Tide Gage Stilling Wells, Part III*, prepared by H. Shih, dated March 1, 1983).

2.3.7-C Other

Any other environmental conditions, such as seasonal ice formation, pollution, wind direction and speed, that affects data collection should be noted and appropriate provisions implemented.

2.4 DESIGN DATA DOCUMENTATION

Thorough documentation of the office information, reconnaissance findings, and design is critical to an efficient installation. The *NGWLMS Site Report, NGWLMS Well/Sounding Tube Worksheet*, site drawings, photographs, etc., ensure thorough documentation.

The following items shall have been documented during the design phase:

<u>SITE</u>

Owner (address & phone no.)
Contact (address & phone no.)
Permit/license
Shipping address
Special Requirements

<u>SUPPORT STRUCTURE</u>

Type (pier, bulkhead, etc.)
Elevations and measurements
Water depth and bottom type
Access

<u>PROTECTIVE WELL</u>

Well location
Well elevation and length
Cable lengths
Brackets
Potential temperature problems

<u>ANTENNA</u>

GOES azimuth and elevation
Antenna location
Mounting mast and bracket
Cable type and length

INSTRUMENT SHELTER

Existing vs. new
Utilities/Solar Panel

BACKUP SENSOR

Configuration
Mounting board assembly length
Junction box location
Cable length

ANCILLARY SENSORS

Type
Location(s)
Cable length(s)

DIVING

Safety assessment
Physical constraints
Equipment availability

BENCH MARKS

Recovered marks
Additional marks

ENVIRONMENTAL DATA

Waves, wind & currents
Marine fouling
Lightning potential
Freezing

TOWER

Type
Location
Anchor design

MISCELLANEOUS

Tool and equipment list
Preliminary design/drawings
Cost estimate and schedule

A complete list of components, hardware, tools, and any other gear required to perform the installation should be compiled before mobilization. Appendix B lists common tools and equipment used in NGWLMS installations and can be used as a starting point.

3 SITE PREPARATION

Site preparation is the work that must be performed at the site to prepare the site for a NGWLMS field unit installation. This chapter will cover all requirements up to installing and initializing the field unit. Many site preparation requirements have been discussed in the design chapter. These, and other requirements, will be covered in more detail in this chapter.

Appendix A lists those items which will be delivered with each field unit and auxilary components required for installations. The auxilary components do not include special components dependent upon specific site requirements.

3.1 INSTRUMENT SHELTER

If a small room, or area, in an existing building is not available as an instrument shelter, a wood frame, masonry, or fiberglass building specifically designed, built, or purchased for the shelter is required. A 2x2 m (6x6 ft) prefabricated fiberglass shelter is usually of sufficient size and the most cost effective. The shelter should be secured to a suitable structure or foundation in accordance with accepted engineering practices.

Utility connections are required where feasible. Arrange for hookup while on site if this was not done previously. 110/120 volt, 50-60 HZ, AC power shall be provided where cost effective or directed. Solar panels are alternate power sources.

A voice grade RJ-11S telephone jack switched telephone line connection shall be provided where cost effective or directed. The 9000 RTU will be wired directly to the telephone jack. No telephone line may necessitate periodic synchronization (specifications are 6 months) of the GOES satellite transmission clock by an onsite terminal. Also, any change in station parameters will have to be accomplished onsite.
Select where the 9000 RTU and 8200 data recorder are to be located in the shelter. If hung on the wall, they should be fastened to support members, or to a backing board to distribute their weight. Bolts are preferred over lags. There should be at least 0.2 m (0.5 ft) of clearance between the cable entry side of the enclosures and anything which may interfere with running the various cables into them. Sufficient front and side clearance for opening the enclosure doors should also be available.

Grounding is required at all stations. Grounding shall be provided by a single point AC ground. This is best accomplished by installing an electrode underwater and running a copper wire (#8 or heavier) up into the shelter. The electrode shall be a copper rod, minimum 1 cm (1/2 inch) diameter by 2.4 m (8.0 ft) long, or a copper plate, minimum 0.2 m^2 (2.0 ft^2) of 20 gauge sheet. Acceptable alternatives are using the ETG ground wire or the ground lug in the shelter's power box <u>if</u> it can be determined that the power box ground is properly grounded. If the station is considered to be at risk from a lightning strike, then a lightning protection system shall be required. Appendix C provides guidelines on determining lightning risk and protection system specifications.

3.2 PROTECTIVE WELL ASSEMBLY

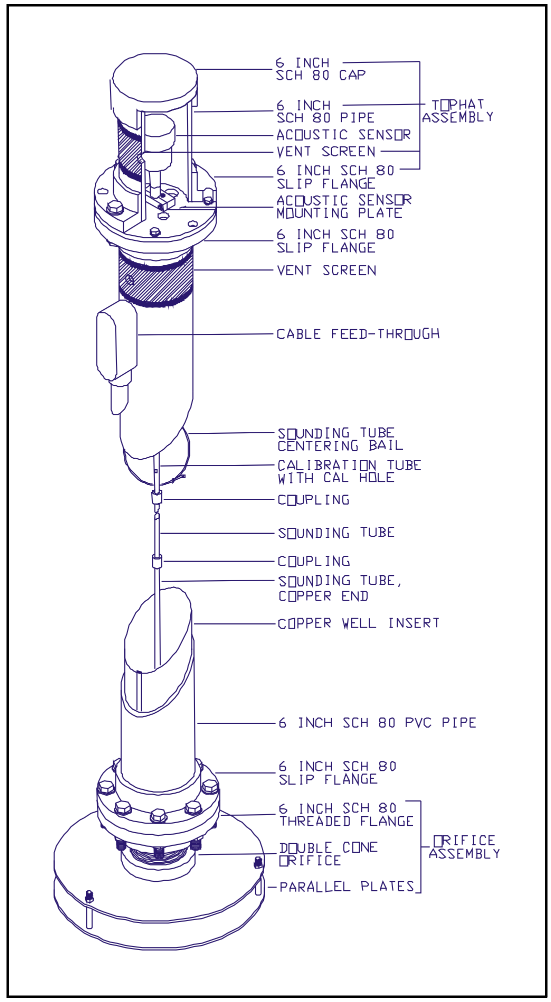


Figure 3-1
Protective Well Configuration

The protective well shall be white, 15 cm (6 inch) diameter, schedule 80 PVC pipe. Schedule 40 pipe may be used in sheltered locations where damage by waves, debris, or vessels is not a concern. Larger diameter or different materials may be used if already installed and conformance to other requirements are met.

Schedule 80 slip flanges shall be cemented on each end of the well. The top hat and mounting plate assembly attach to the upper flange and the orifice assembly attaches to the lower flange. All top well flanges shall be machined down to a smooth surface. It is important that the upper flange have a smooth, level surface, otherwise the mounting plate assembly may not seat flush on the flange.

The well shall be ventilated by two sets of four 4 cm (1.5 inch) diameter holes drilled at 90 degrees. The upper set shall be drilled 0.3 m (1.0 ft) above the upper thermistor, typically 0.2 m (0.5 ft) below the top of the upper flange. The lower set of venting holes shall be located 0.3 m (1.0 ft) above the lower thermistor. The vent hole elevations may be adjusted up or down if they conflict with bracketing locations. The vent holes shall be covered with modified stainless steel screen mesh NO HUB "M" couplers to prevent debris and insects from entering the well. It may be necessary at stations where thermal gradients are a problem, to adjust the elevations of the vent holes to more suitable elevations, or to install extra sets of vent holes. Be sure to document any nonstandard vent hole configurations.

The copper well insert is a 0.6 m (2.0 ft) long piece of copper sheet rolled into a cylinder and joined with a pipe seam. The copper insert shall be placed inside the well bottom so that the well bottom receives protection from marine fouling.

Well location and elevation requirements are discussed in Section 2.3.2. Table 4 summarizes the requirements, but refer to the other sections for detailed explanations. The *NGWLMS Well/Sounding Tube Worksheet* will provide guidance and a format to document the installation.

Location Requirements:

- Within 15 m (45 ft) of the 9000 RTU, although up to 30 m (100 ft) can be accomodated.
- Secure, accessible location.
- Proper thermal environment.
- Stable support structure.
- Vertical mounting, plumb within 1 cm/m (1/8 inch/ft).

Elevation Requirements:

- Top of well a minimum of 1.5 m (5.0 ft) above the highest water level (plus wave allowance) elevation.
- Bottom of well a minimum of 1.0 m (3.3 ft) below the lowest water level (plus wave allowance) elevation.
- Total length of well determined by summing the distance between highest and lowest water level (plus wave allowance), plus top and bottom well minimums, plus safety factor lengths, and adjusted for physical constraints.

Table 4
Protective Well Requirements Summary

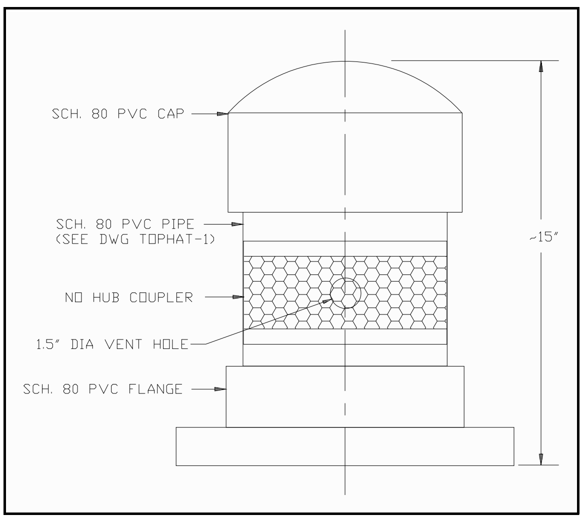


Figure 3-2
Top Hat Assembly

3.3 TOP HAT ASSEMBLY

The assembly consists of a schedule 80 slip flange, a short 0.3 m (1.0 ft) piece of schedule 80 pipe, a vent hole screen, and a slip cap, all 15 cm (6 inch) diameter.

Drill four 4 cm (1.5 inch) diameter vent holes 90 degrees apart around the midpoint of the pipe. Protect the vent holes with the same NO HUM "M" stainless steel mesh screen used on the protective well.

Use PVC primer and glue to cement the cap and flange onto the pipe. The overall length of the assembly is about 0.4 m (1.3 ft).

3.4 ACOUSTIC SENSOR MOUNTING PLATE ASSEMBLY

The acoustic sensor mounting plate assembly consists of a flat, split, aluminum plate with bolt and vent holes, an aluminum tube stop clamp, and associated hardware. The aluminum has an anodized protective coating.

3.5 ORIFICE ASSEMBLY

The orifice assembly consists of a schedule 80 threaded flange, a double cone orifice, and parallel plates. The orifice diameter shall meet the requirement D/3, where D is the well diameter. A schedule 80 slip-to-thread coupler, double cone orifice, and shroud may be substituted at shallow sites, with currents less 0.3 m/s (0.5 knot) and waves less than 0.6 m (2.0 ft), where bottom support for the well may be required or parallel plates cannot be installed due to physical constraints. An installation procedure for a standard orifice assembly is described as follows.

<u>Orifice Assembly Installation Procedure</u>

The following procedure facilitates the installation (or replacement) of a standard orifice assembly at sites where it may be difficult for divers to maneuver the assembly. It is assumed that the protective well with bottom flange is already in place.

1. Surface personnel lower the copper sheet insert to the divers, who then install it.

2. Surface personnel lower a weighted rope down the well, approximately 3 m (10 ft) past the well bottom, and tie it off up top.

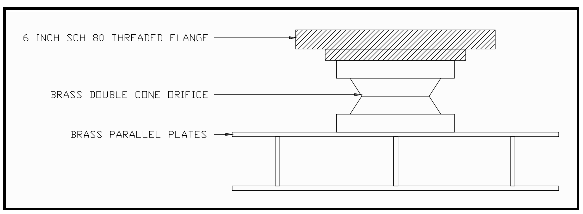


Figure 3-3
Orifice Assembly

3. Surface personnel lower the parallel plate on a second rope down next to the well. If this is not feasible, the parallel plate will have to be lowered over the side of the pier, and transported underneath. Lift bags are recommended to accomplish this.

4. Divers remove the weight from the first rope. Divers thread the rope down through the orifice and tie it off on the parallel plate standoffs. The rope may also be tied off to a short piece timber, pipe, or something similar, that is placed lengthwise between the plates.

5. Divers disconnect the parallel plate from the second rope or lift bag, while signaling surface personnel to pull up on the first rope. Divers guide the parallel plate into place and secure with bolts.

6. The first rope is then untied by divers and pulled back up the well by surface personnel.

3.6 BACKUP PRESSURE SENSOR ASSEMBLY

The backup pressure sensor consists of a Sutron 8200 data recorder, junction box, pressure sensor (typically *Druck*® or *IMO DeLaval*®), and temperature sensor. A mounting board assembly, or gas purged system, may also be involved depending upon the configuration selected (see Section 2.3.3).

Site preparation required for the backup pressure sensor assembly, other than selecting the 8200 data recorder and junction box locations, is dependent upon the configuration. Configuration one (direct measurement) may involve installing the guide brackets for the mounting board. The length of the mounting board should have been determined during the design phase. The guide brackets are short lengths of stainless steel with the ends boxed in to "capture" the mounting board. The top guide bracket is constructed differently so that it does not fully "capture" the mounting board. This facilitates the configuration, where the top bracket is at pier height, by allowing the mounting board to be lowered at an angle until the next lower guide is encountered. A bolt on either side of the top guide is then tightened to secure the mounting board. The guide brackets may be installed in many ways, depending upon conditions. The guides may be attached to a backing board which is then attached to a support structure. They may be fastened directly to a support structure (typically a vertical bulkhead). They may be attached to slotted track bars hung off of a standard belly band/threaded rod type installation. The mounting board shall be installed as near to plumb, within 1 cm/m (1/8 inch/ft), as is possible.

Configuration two (indirect measurement) involves the installation of a gas purged system consisting of a nitrogen tank, regulator, pressure manifold, tubing, and brass orifice. The gas purging system should be installed in accordance with the *Users Guide for the Gas-Purged Pressure Recording (Bubbler) Tide Gage, February 1977.* The sensor is teed to the undamped side of the pressure tubing.

3.7 ANTENNA

The antenna has a mounting bracket provided that clamps to the end of a 5 cm (2 inch) diameter galvanized steel pipe. The pipe may be as short as 0.6 m (2.0 ft) in length or a maximum of 3.0 m (10.0 ft) if unsupported. Longer lengths require support by guy wires or some other method. One end of the pipe shall be threaded so that it can be screwed into a baseplate. The baseplate can be bolted either to the instrument shelter roof or pier deck. Any openings cut or drilled into the roof should be waterproofed with an appropriate sealant. If the roof cannot support the antenna, the pipe may be bolted to the deck and run up alongside the shelter until it is at least 0.6 m (2.0 ft) above the roof. Stainless steel U-bolts shall be used to secure the pipe to the shelter.

Mounting the antenna inside the instrument shelter is an option if it is a fiberglass shelter. Bolting a 5 cm (2 inch) PVC flange to the wall and cementing in a 5 cm (2 inch) sweep elbow is the recommended mounting method. The antenna will transmit through the fiberglass wall/roof. The interior power cable will not interfere with the signal.

3.8 CONDUIT

All cables exterior to the shelter, with the exception of the antenna cable, shall be protected by rigid conduit. All cables, which may be exposed to potential harm, shall be protected by conduit, regardless of location. The conduit can be PVC, galvanized steel pipe, or any other corrosion resistant material. Some locations may require explosion proof conduit. Conduit to the protective well shall junction through a service elbow located just below the flange and upper well vent cover. The service elbow can be bolted, screwed, or glued to the well. Conduit diameter size is dependent upon the number and type of cables to be run through it, but a minimum diameter of 3 cm (1.25 inch) is recommended for the three sensor cables that will be running between the well and the 9000 RTU.

Sweep type (large radius) bends shall be used where ever possible to facilitate pulling cable through angles in the conduit. All PVC connections shall be primed and joined with PVC cement. Junction boxes shall be used when the conduit run is long and intricate. A pull through line shall always be left in the conduit to facilitate the addition of future sensor cables. The conduit shall be securely fastened to the support structure. Galvanized omega clamps are recommended for securing the conduit to wood and concrete surfaces.

3.9 SENSOR REFERENCE MARK

The Sensor Reference Mark (SRM) is defined as a mark, established within one or two leveling setups of the primary water level sensor, that meets the criteria listed below. Its purpose is to facilitate leveling requirements associated with maintaining the NGWLMS sensors, by providing a stable point from which to track NGWLMS sensor elevations, through the establishment of a leveling history. The intent is that the SRM will be used to determine differences in elevation resulting from maintenance performed on the primary sensor, and from any destabilizing movement occurring on the support structure itself.

3.9.1 PERMANENT SRM ESTABLISHMENT CRITERIA

The SRM may be one of two types. The first type shall be installed when the SRM can be established in accordance with monumentation requirements specified in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* (User's Guide). A pre-existing network bench mark is the first choice for the SRM. A notation should be added to the bench marks description recording its designation as SRM. If a new mark is set as a SRM, it shall be a NOS bench mark disk stamped appropriately for the station and incorporated into the station bench mark network. A mark set in a concrete pier is considered acceptable.

3.9.2 TEMPORARY SRM ESTABLISHMENT CRITERIA

The second type shall be installed when the SRM cannot be established in accordance with the User's Guide, such as on a wooden pier. In this case a tide staff, ETG, or temporary bench mark (TBM) can be used. The SRM TBM may be a disk or some other type of fixed object (preferably more permanent than a nail or some other typical "very temporary" TBMs) providing a recoverable high point. If a disk is installed, the stamping shall be designated with TBM, the last four digits of the station number, a number, and the present year. For example, the SRM at Fort Point, CA, would be stamped TBM 4290 1 1991. If some other high point is used, it shall be painted or distinctively marked some other way, and the designation shall follow the same format. The TBM shall be fully described and illustrated on the bench mark sketch similar to a network bench mark, however, it's elevation will not be published.

4 FIELD UNIT ASSEMBLY INSTALLATION AND INITIALIZATION

This chapter addresses the installation and initialization of the NGWLMS field unit assembly. It is assumed that all site preparations have been completed in accordance with Chapter 3, including power and telephone (if feasible). Support documentation (*9000 RTU Operations And Maintenance Manual, NGWLMS User And Operators Manual, Model 8200-0 Data Recorder Operations And Maintenance Manual*) should be consulted if more detail on system operation is desired.

4.1 FIELD UNIT ASSEMBLY INSTALLATION

This section covers mounting and interconnecting the field unit assembly components. The field unit assembly is defined as the following components:

- 9000 Remote Terminal Unit (RTU).
- Primary water level sensor (acoustic + 2 air temperature sensors).
- Aquatrak® (acoustic sensor) installation kit.
- 8200 Data Recorder.
- Backup water level sensor (pressure + temperature sensors).
- Backup sensor mounting assembly.
- GOES antenna and optional solar panel(s).
- Associated cables, connecters, etc.

A field unit installation is comprised (but not necessarily in the order) of the following:

- Construction, testing, and installation of the primary water level sensor sounding tube assembly.
- Construction, testing, and installation of the backup water level sensor assembly.
- Leveling connection of acoustic sensor to bench mark network.
- Mounting and testing the GOES flat plate antenna.
- Mounting the solar panels (optional).
- Mounting the 8200 Data Recorder.
- Mounting the 9000 RTU.
- Documentation.

The following general procedures shall be observed in all cases:

All wire and resistor connections shall be double checked for correct placement and tightness by a second person before the system is powered up.

All cable ends, sensor openings, instrument panels, etc., shall be protected from the elements (dirt, moisture, etc.) during the installation process.

All parameters (time, date, coefficients, passwords, etc.) entered into the field unit, via the laptop computer, shall be verified by a second person.

All documentation items, such as measurements, serial numbers, etc. shall be verified by a second person.

Any non-standard components, configurations, or any other special circumstances, shall be carefully documented.

All excess cable shall be neatly coiled and hung in a service loop inside the instrument shelter. This will facilitate repairs or replacement later on. Avoid coiling the antenna cable too tightly as this may contribute to unacceptably high signal loss.

4.1.1 ACOUSTIC SENSOR SOUNDING TUBE ASSEMBLY

Construction and installation of the acoustic sensor sounding tube assembly involves:

- Determining the sounding tube assembly length.
- Constructing the sounding tube assembly.
- Testing the acoustic sensor/sounding tube assembly.
- Testing the two temperature sensors.
- Attaching the two temperature sensors and bails.
- Mounting the assembly in the protective well.
- Running the sensor cables to the 9000 RTU.
- Documentation.

4.1.1-A Computing the sounding tube assembly length.

The sounding tube assembly is composed of three sections:

1. The calibration (cal) tube (known length).
2. The brass antifouling tube (known length).
3. The cpvc sounding tube (variable length).

The cal tube consists of a length of 1 cm (1/2 inch) diameter cpvc tube with the top end outside diameter machined down to accommodate the acoustic sensor head, a cpvc coupler (with inside ridge machined out to fit over the tube) glued near the top end to provide a surface for the sensor head to abut, a small hole about 0.2 m (0.5 ft) from the tube bottom, a partially split cpvc coupler cemented onto the bottom, and a stainless steel hose clamp used to attach the cal tube to the sounding tube. Each cal tube is numbered and calibrated with an acoustic sensor head to create a matched set.

The cal tube total length is typically 1.3 m (4.4 ft) long [NOTE: Earlier versions of the cal tube were 0.2 m (0.5 ft) shorter]. However, a length of 1.2 m (3.9 ft) is used in the following computations as the remainder of cal tube extends above the top well flange, and therefore is not used in computing the sounding tube length.

There is also a 0.5 m (1.6 ft) cal tube that may be used where there are limitations on the height of the protective well (see Section 2.3.2-B). If this is the case, use 0.6 m (1.9 ft) instead of 1.2 m (3.9 ft) in the computations below.

The brass antifouling tube is typically 0.9 m (3.0 ft) in length, but may be less in those shallow depth cases where it must be shortened to keep the brass\cpvc junction below lowest expected water level.

Therefore, only the cpvc sounding tube is usually a variable that must be computed. However, the orifice offset is one other factor that must be taken into account. It is a requirement that the sounding tube terminate 0.2 m (0.5 ft) above the orifice. Since the orifice cone is recessed down about 0.1 m (0.2 ft) into the flange, the offset ends up 0.1 m (0.3 ft) above the well bottom. Therefore the total sounding tube assembly length is 0.1 m (0.3 ft) shorter than the protective well length.

The protective well length is defined as the distance from the top surface of the top well flange (not the top hat assembly flange) to the bottom surface of the bottom well flange (not the orifice assembly flange). Confirm the protective well length onsite.

The cpvc sounding tube length is computed as follows;

Protective well length	(.) (.)	(flange to flange)
Orifice offset	- 0.1 m (0.3 ft)	
	= (.) (.)	Sounding tube assembly total length
Cal tube (standard size)	- 1.2 m (3.9 ft)	
Antifouling tube	- 0.9 m (3.0 ft)*	* (may be shorter)
	= (.) (.)	Sounding tube section length

As an example, assume a 6.1 m (20.0 ft) protective well with a standard length antifouling tube.

Protective well length	6.1 m (20.0 ft)	
Orifice offset	- 0.1 m (0.3 ft)	
	= 6.0 m (19.7 ft)	Sounding tube assembly total length
Cal tube (standard size)	- 1.2 m (3.9 ft)	
Antifouling tube	- 0.9 m (3.0 ft)	
	= 3.9 m (12.8 ft)	Sounding tube section length

Therefore use two 1.5 m (5.0 ft) sections with couplers, and cut the one 1.5 m (5.0 ft) trim section (no coupler) to 0.9 m (2.8 ft), to provide the required 3.9 m (12.8 ft) (see next section for description of sounding tube kit).

4.1.1-B Constructing the sounding tube assembly.

The Aquatrak® installation kit was specifically fabricated for use with the NOS NGWLMS Aquatrak® sensor of the 3000 series labeled NOS-NG. The kit is used to standardize installations. The kit contains enough cpvc tubing to construct a 9.7 m (31.9 ft) long sounding tube assembly. If a longer assembly is required, use sounding tube sections from other kits. Table 5 lists the parts provided with the Aquatrak® installation kit (*BARTEX* S/N S-3000-28).

DESCRIPTION	PART NO.	QTY.
Sound Tube, cpvc, 1.5 m (5.0 ft)	NPN	4
Sound Tube, Trim cpvc, 1.5 m (5.0 ft)	NPN	1
Sound Tube, Red Brass, 0.9 m (3.0 ft)	NPN	1
Center bail, S.S., 15 cm (6 inch)	6-18002-1	5
Tube cutting guide, Alum.	B-18006-2	1
Sleeve Coupling, cpvc	NPN	1
Cable Ties	Panduit #PLT 1.51-M	12

Table 5
Aquatrak® Installation Kit Parts List

In addition the following tools and materials will be needed:

A. cpvc primer (typically purple) and cement (typically orange)
B. hacksaw
C. trimming knife

Inspect the lower edge of the top coupler on the cal tube for a bead of cpvc cement. Sand down any bead that is found. A bead will prevent the coupler from seating flush on the acoustic sensor mounting plate.

Construct the sounding tube assembly, using the Aquatrak® Installation Kit as follows:

- Cut the trim tube to the required length using the cutting guide. Carefully deburr the inside and outside of the cut end.
- Prime the uncut end of the trim tube and the coupler end of a 1.5 m (5.0 ft) length.
- Apply cement sparingly to the tube only in an even band approximately 1 cm (1/2 inch) from the primed end. Do not allow any cement to go into the tube end.
- Immediately insert the tube end into the primed coupler with a twisting motion until the tube bottoms out.
- Repeat the previous three steps to join the other end (cut end) of the trim tube to the antifouling tube. Ensure that the hose clamp is tight and is securely fastening the antifouling tube and coupler together.
- Repeat the cementing steps to join the remaining sounding tube sections to the section just constructed.

- Connect the cal tube to the sounding tube using the stainless steel hose clamp. Ensure that the sounding tube butts firmly against the inside ridge of the cal tube coupler and that the hose clamp securely fastens the two.
- Wait at least 30 minutes after the last joint is cemented before handling.
- Place a hand on either side of each joint and give a firm twist to test the integrity of the connection before deployment.

4.1.1-C Testing the acoustic sensor/sounding tube assembly.

Test the acoustic sensor/sounding tube assembly as follows before proceeding further:

- Attach the acoustic sensor head to the sounding tube assembly.
- Wire the cable into the 9000 RTU (see Figure 4-9 for wiring diagram).
- Power up the 9000 RTU (it does not have to be mounted).
- Toggle the "READ AQT A" switch on the acoustic sensor module.

Record the value displayed on the LED panel. Check that the displayed value is equal, within +/- 0.1 m (0.2 ft), to the length of the sounding tube (from cal hole to end). If the value is different, measure that value down from the cal hole and mark where it falls. If it falls at a joint, the joint is probably bad. If it falls between joints, then there may be something stuck to the inside of the tube that is sending back a reflection. The tube may need to be flushed out or that section may need replacing. If it appears that the acoustic sensor is bad, replace it or consult headquarters before deploying. Record the test results on the *Sensor Test Worksheet* (see Chapter 6).

4.1.1-D Testing the two temperature sensors.

Test the two temperature sensors before attaching them to the sounding tube. It is recommended that the backup water level assembly temperature sensor be tested in conjunction with the two air temperature sensors. The backup temperature sensor can be tested by either; hooking it up to the 8200 data recorder and letting the 9000 RTU log the readings, or by connecting the backup temperature sensor as an ancillary sensor and enabling it as a **GROUP 1** sensor (see Section 5.3). Readings in degrees C are only available from the 9000 RTU, as the 8200 data recorder displays the voltage reading.

- Designate one sensor as the upper (t_1) and the other as the lower (t_2). Mark the upper (t_1) sensor and mating cable plugs with tape or some other method to differentiate it from the lower (t_2). The backup water level assembly temperature sensor shall be designated t_b.
- Connect the two air temperature sensor cables to the mating cables and wire into the 9000 RTU (see Figure 4-9 for wiring diagram). Power up the 9000 RTU and log into the program using a laptop computer. Follow instructions specified in Section 4.2.2 to log temperature data.
- View the logged data and complete the *Sensor Test Worksheet*. The sensors may not track each other exactly as the thickness of the rubber coating may vary. They should eventually acclimate, however, and the difference between the two should be within +/- 0.3^{O} C. If the differential exceeds +/- 1.0^{O} C, replace or consult with headquarters before deploying.

4.1.1-E Attaching the two temperature sensors and bails.

Mount the temperature sensors and bails as follows:

- Measure and mark on the sounding tube the appropriate spots for the temperature sensors: 0.6 m (2.0 ft) above the cal hole for the upper sensor and as determined in Section 2.3.2-C for the lower sensor.
- Attach the lower temperature sensor to the marked spot and use tie wraps to secure the cable up along the sounding tube to where the upper sensor is to be attached.
- Attach the upper sensor and use tie wraps to secure both cables the rest of the way up to the elbow junction box level.
- Secure the excess cable length by either running it up and down the sounding tube between sensors, or by attaching it as a coiled loop.
- Ensure that the cable is not covering the cal hole.
- Attach a center bail so that it straddles each cpvc coupler, with each one oriented at 90 degrees from the previous bail. Place the lowest bail just above the brass tube joint. Do not place the last bail on the brass tube.
- Take measurements for documentation, particularly the elevation of the lower temperature sensor (see Chapter 6).

4.1.1-F Mounting the assembly in the protective well.

The assembly shall be mounted in the well as follows:

- Attach the stationary section of the mounting plate assembly to the top well flange using two 1 cm (1/2 inch) bolts. Hand tighten only.
- Insert the sounding tube assembly into the protective well so that the bottom edge of the top collar of the cal tube ends up flush with the top of the mounting plate clamp. Secure the clamp around the tube.
- Pull the temperature sensor plugs out through the junction box, or up through the plate, depending on the well configuration. Feed the acoustic sensor mating cable in through the junction box and up through the plate.
- Attach the removable section of the acoustic sensor mounting plate assembly using two 1 cm (1/2 inch) bolts and hand tighten.
- Set the top hat on the mounting plate and adjust the positioning so that all four 1 cm (1/2 inch) bolt heads fit flush into the top hat's flange holes. Secure the top hat in position using four 2 cm (3/4 inch) bolts and then tighten the mounting plate 1 cm (1/2 inch) bolts by using a flathead screwdriver and a wrench. Wedge the screwdriver head in between the 1 cm (1/2 inch) bolt heads and the flange hole sides to hold the bolt and use the wrench to tighten. Note: Do not fully tighten down top hat until the field unit installation has been completed and levels run.

NOTE: Stainless steel hardware used with the acoustic mounting plate must use nylon washers and have a heat shrink material applied to that part of the shaft that will be in contact with the plate. This is to prevent galvanic corrosion between dissimilar metals.

4.1.1-G Running the sensor cables to the 9000 RTU.

The cables must be protected by conduit when exterior to the shelter. It is typically easiest to feed the cables through the conduit starting at the well end since this avoids having to feed through the plugs. A pull through line should have been left through the conduit when it was installed.

Run the cables inside the shelter along the wall to the 9000 RTU mounting area. Bundle and tie wrap the wires together whenever they are exposed. Secure them to the wall as appropriate. Leave any excess for each cable neatly coiled and hung. Instructions for connecting the cables to the 9000 RTU are in Section 4.1.7.

4.1.1-H Documentation.

Construction and installation of the primary water level sensor assembly is to be documented using the NGWLMS Site Report and the NGWLMS Well/Sounding Tube Worksheet. Sensor test results should be reported on the Sensor Test Worksheet.

4.1.2 BACKUP WATER LEVEL SENSOR ASSEMBLY

Installing the backup water level sensor assembly involves:

- Testing the backup water level pressure and temperature sensors.
- Installing the sensors (direct or indirect configuration).
- Installing the junction box.
- Running and connecting the alpha (combined water level pressure and temperature sensor) cable to the 8200 data recorder.

Two different manufacturer's pressure sensors are being used as backup sensors, the Druck® and the IMO®. The sensors are similar in physical appearance and operation. Installation differences consist of a minor wiring change, a different slope value in the 8200 data recorder setup, and different mounting components.

4.1.2-A Testing the backup pressure and temperature sensors.

The sensors shall be tested before installation. This requires that the 8200 data recorder be temporarily connected and initialized (see section 4.2.1).

- Connect the sensors to the 8200 data recorder.
- Lay the backup sensor on the pier deck and record at least an hour's worth of values. The recorded values should approximate zero.
- The temperature sensor should be tested in conjunction with the primary sensor air temperature sensors for comparative purposes (Section 4.1.1-D).
- Record the test data on the Sensor Test Sheet.

4.1.2-B Direct (in water) installation.

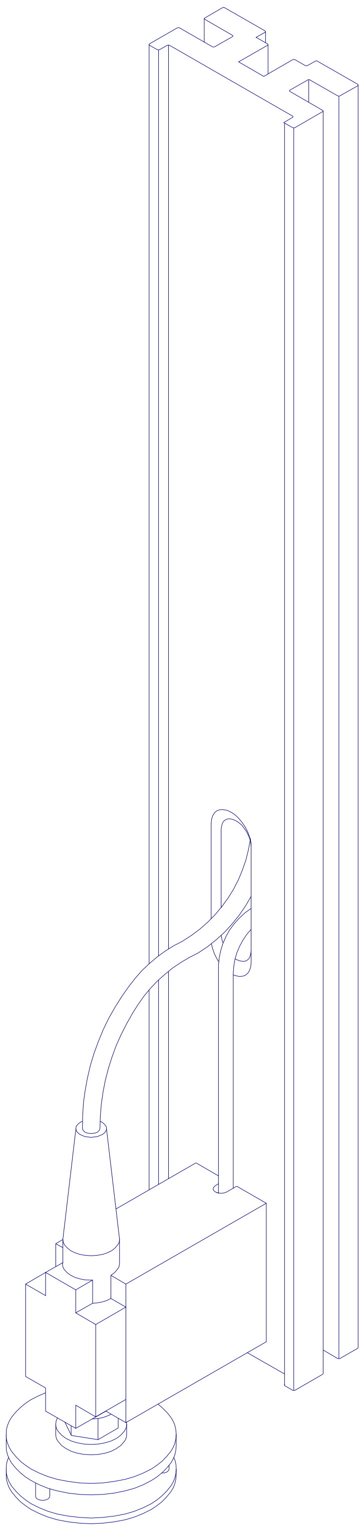


Figure 4-1
Backup Sensor
Mounting Board

Installation of the sensors is dependent upon the configuration selected. If the sensors are to be installed directly in the water, it may be desirable to utilize the mounting board assembly (Figure 4-1). If so, use the following procedure to assemble the mounting board and deploy the sensors.

- Drill the cable slot and holes for the mounting block. Fasten the mounting block, lifting eye, and conduit connector to the mounting board.
- Remove the back cableway panel and feed the backup and temperature sensor cables up through the cable slot, up the cableway, and out through the conduit connector.
- Place the sensors in the mounting block and tighten the screws.
- Install the backup sensor parallel plate being careful not to cross thread the nylon insert.
- Replace the back cableway panel and secure using small stainless steel sheet metal screws.
- Secure line to lifting eye.
- Insert the mounting board assembly into the guide brackets installed during site preparation and ensure that it is fully seated. Tighten the bolts on the top bracket to lock the mounting board into place.

4.1.2-C Indirect (out of water) installation.

If the sensors are to be installed out of the water, tee the pressure sensor off of a convenient section of gas tubing on the undampened side of the bubbler manifold. Tie wrap the temperature sensor to the pressure sensor.

4.1.2-D Junction box installation.

Location of the junction box is dependent upon the type of configuration selected for the site.

- If the sensors are installed directly, mount the junction box plug side down in a spot that is sheltered from the elements and the public. Mount the junction box so that the two sensor cables form a sufficiently long service loop to allow removal of the mounting board.
- If the sensors are installed indirectly, mount the junction box in a convenient, protected, location inside the shelter.

	DRUCK® SENSOR CABLE						**TEMPERATURE SENSOR CABLE**		
Wire	RED	WHITE	YELLOW	BLUE	ORANGE	BLACK	SHIELD* **SHIELD**	**WHITE**	**BLACK**
JUNCTION BOX TERMINAL BLOCK	A1	A2	A3	A4	A5	A6	A7	A8	A9
ALPHA CABLE	RED	WHITE	YELLOW	BLUE	ORANGE	BLACK	SHIELD*	GREEN	BROWN

* The shields from both the Druck® and the temperature sensor cable should be connected to A7. The shields may be covered by colored plastic. They will be thicker than other wires.

ALPHA CABLE

	IMO® SENSOR CABLE						**TEMPERATURE SENSOR CABLE**		
Wire	RED	WHITE	YELLOW	BLUE			GREEN* SHIELD **SHIELD**	**WHITE**	**BLACK**
JUNCTION BOX TERMINAL BLOCK	A1	A2	A3	A4	A5	A6	A7	A8	A9
ALPHA CABLE	RED & ORANGE	WHITE	YELLOW	BLUE		BLACK	SHIELD*	GREEN	BROWN

* The green wire from the IMO® and the shields from the IMO® and temperature cable should be connected to A7. The shield may be covered by colored plastic. It will be thicker than other wires.

ALPHA CABLE

Figures 4-2 and 4-3
Junction Box Terminal Block Connections for Druck® and IMO® Sensors

- Ensure that the small junction box vent hole (in the back) is not blocked.
- Remove the junction box face and feed the backup and water temperature sensor cables into the junction box through two of the strain relief plugs. Use the wiring diagrams in Figures 4-2 and 4-3 to connect the cables to the terminal strip. Feed the alpha cable (combined backup/water temperature cable) through the remaining strain relief plug. Connect the wire leads to the terminal block as shown in Figures 4-2 and 4-3.
- Insert a small bag of desiccant before sealing the junction box.

4.1.2-E Running the alpha cable to the 8200 data recorder.

Run the alpha cable through conduit and/or along the inside shelter wall to the 8200 data recorder. Refer to Section 4.1.4 on how to connect the cable to the 8200 data recorder terminal block. Have the connection verified.

4.1.3 LEVELING TO THE SENSORS

The primary sensor must be connected to the bench mark network in order to reference the data to the bench marks (particularly the SRM) and monitor the stability of the sensors and support structure. This section describes the special fixtures and procedures used to accomplish this.

Connect the acoustic sensor leveling point to the bench mark net, SRM, and staff (if existent) in accordance with the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations (October 1987)* and the following procedures.

4.1.3-A Leveling to the acoustic sensor

The leveling point for the acoustic sensor is defined as the top shoulder of the upper coupler on the cal tube. It is exposed by loosening the lower one or two Allen screws of the metal coupler on the acoustic sensor transducer head. The upper Allen screw on the coupler is not to be disturbed. The upper screw head has been coated with paint, and covered with shrink wrap, to detect any disturbance. <u>Any time the upper Allen screw is accidentally loosened, or found loose, the head shall be replaced and the disturbance documented</u>.

Two leveling fixtures have been fabricated to facilitate leveling to the acoustic sensor leveling point. The first fixture is made to slip snugly onto the short section of cpvc tube extending above the leveling point coupling. The fixture has a rounded high point on which to hold the rod and has the fixture length, measured in both metric and english units to the thousandth place, engraved on its side. Figures 4-4 and 4-5 illustrate the use of the leveling fixture. The length of the leveling fixture shall be compensated for in the leveling record (NOAA Form 75-29). Figure 4-6A is a sample level sheet with the leveling fixture corrected for by subtracting the length of the fixture from the backsight. The abstract (NOAA Form 76-183) shall show the elevation of the leveling point only as shown in Figure 4-6C.

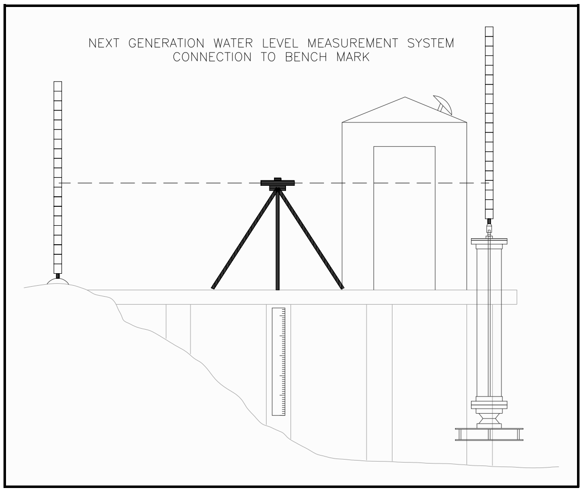


Figure 4-3
Leveling Fixture In Use

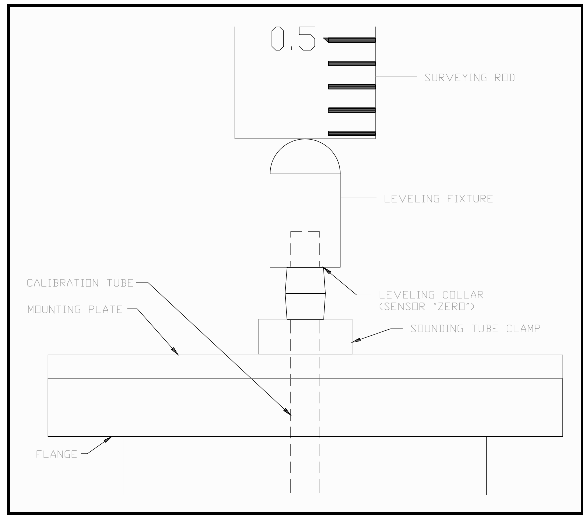


Figure 4-4
Leveling Fixture Close Up

The second fixture is called a downshot fixture because it is used in cases where the leveling point is too high for a rod shot. The downshot fixture is comprised of a square aluminum tube, circular level bubble, adjustable legs, and a precise steel tape (metric/english units in hundredths). The level is placed so that a hole in the square tube is fit snugly onto the short cpvc tube section, the steel tape is hanging vertically down the side of the well, and the legs adjusted so that the level bubble indicates level. It may help to place the leveling fixture on top of the tube to prevent the downshot fixture from lifting up. The zero end of the tape is then aligned with the leveling point and a shot to the tape can be made. Figure 4-6B is an sample level record sheet showing the use of the downshot fixture.

Other fixtures or techniques shall be preapproved by N/OMA12.

4.1.3-B Leveling procedures

Levels to the primary sensor shall be spur runs, either from the tide staff rod stop or the ETG reading mark, or from the SRM. The spur line requirement is dropped when the tide staff and ETG are no longer used for daily observations (after the ADR versus NGWLMS comparisons are completed and the ADR is removed). Frequency of levels is in accordance with the *Users Guide* and *Project Instructions*. Removal and installation levels are required any time the acoustic sensor/cal tube pair or the stationary half of the mounting plate are to be disturbed or replaced.

After the levels have been abstracted and double checked, compute the difference in elevation between the acoustic sensor leveling point and the primary bench mark. This will be needed, along with the elevation of the PBM above the site datum, for one of the primary water level sensor coefficients used to initialize the 9000 RTU (see section 4.2.2).

Leveling procedures for the SRM are as follows;

- The SRM shall be connected every time levels are run to the sensor.
- In cases where several sets of levels may be required during sensor maintenance, (i.e., the removal and reinstallation of a sounding tube, acoustic sensor mounting plate [stationary half]), the first set of levels will connect to a minimum of three bench marks, including the PBM and SRM. The second set of levels may connect the sensor to the SRM only.
- Removal levels must be checked against SRM level history before any sensor assembly may be physically removed. If a difference exceeding 0.006 m (0.020 ft) between successive runs is found, the removal levels shall be rerun again, this time including additional marks, to verify the movement.
- If the historical difference between the SRM and sensor(s) does not exceed 0.006 m (0.020 ft), while the historical difference between the PBM and sensor(s) does exceed 0.006 m (0.020 ft), verification levels for the PBM/sensor difference are still required. The support structure and sensor(s) may be moving at the same rate.
- If annual inspection levels have been, or will be, run within +/- two weeks of the maintenance action, levels to the SRM (or PBM if no SRM) only are acceptable, <u>if</u> the SRM has a demonstrated history of stability.

(07/89)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

PRECISE LEVELING
THREE-WIRE

FORWARD RUN

TIDE STATION	FROM B.M.	WEATHER	NUMBER	SHEET	OF	TO B.M.	TIME	DATE
Anywhere, USA	Staff stop @ 9.000 '	Sunny and warm	123-0000	1	2	Aquatrak leveling point	09:15 am	6/20/89

2 ORDER, CLASS 1

BACKSIGHTS						FORESIGHTS				
NO. OF STATION	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP.	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	REMARKS
										⊼ P. Hawkeye
1	3656					1015				Ф E. Hemingway
	3499	34987	157			0855	08550	160		Φ R. Rodney
	3341		158			0695		160		Zeiss Ni2 #98995
	10496			315		2565			320	1/2 cm K&E #9647
	2565	34987							315	
	7931/3	08550							635/2	= 318 x 0.333 = 106 m = 0.11 km
	26437/2	26437/2								
	13218	13218								
		13218								
		0615	Leveling fixture correction applied							NOTE: Foresight on leveling fixture,
		12603								0.0615 m inscribed on fixture

FORWARD RUN.... + 1.2603 m
BACKWARD RUN... − 1.2602 m
DIFFERENCE........ − 0.0001 m
ALLOWABLE......... 0.0010 m (one setup limit)
DISTANCE............ 0.11 km

FIGURE 4-6A

(07/89)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

PRECISE LEVELING
THREE-WIRE

FORWARD RUN

TIDE STATION: *Anywhere, USA*

FROM B.M.: *ETG (0 - 50 ')*

WEATHER: *Sunny and warm*

NUMBER: *123-0000* SHEET *1* OF *1*

TO B.M.: *Aquatrak leveling point*

TIME: *09:45 am* DATE: *6/20/89*

2 ORDER, CLASS *1*

NO. OF STATION	BACKSIGHTS THREAD READING	BACKSIGHTS MEAN	BACKSIGHTS THREAD INTERVAL	BACKSIGHTS SUM OF INTERVALS	ROD TEMP.	FORESIGHTS THREAD READING	FORESIGHTS MEAN	FORESIGHTS THREAD INTERVAL	FORESIGHTS SUM OF INTERVALS	REMARKS
1	0212					0120				
	0196	01960	16			0105	01050	15		
	0180		16			0090		15		
	0588			32		0315			30	
	0315	01960							32	
	0903/3	01050	Downshot foresight added to backsight						62/2	= 31 x 0.333 = 10 m = 0.01 km
	03010/2	03010/2								
	01505	01505								
										NOTE: Foresight on down shot leveling fixture

FORWARD RUN.... + 0.1505 m
BACKWARD RUN... − 0.1506 m
DIFFERENCE........ + 0.0001 m
ALLOWABLE.......... 0.0010 m (one setup limit)
DISTANCE............ 0.01 km

FIGURE 4-6B

(07/89)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ABSTRACT OF PRECISE LEVELS

SHEET	OF
1	1

TIDE STATION	STATE	NUMBER
ANYWHERE	USA	123-0000

PARTY CHIEF	OBSERVER	LEVEL (Mfg. & type)	ROD (Mfg. & type)	ORDER	CLASS	DATE
P. HAWKEYE	P. HAWKEYE	ZEISS Ni2 #98985	1/2 cm K&E #9647	2	1	6/20/89

ROD TEMP	F OR B RUN	DIFFERENCE IN ELEVATION	MEAN DIFFERENCE	DIVERGENCE		DISTANCE		DESIGNATION OF SECTION	FIELD ELEVATIONS ABOVE STAFF ZERO		REMARKS
				Ea. Sec.	Σ	Ea. Sec.	Σ		METERS	FEET	
°C		METERS	METERS	MM (TENTHS)		KM					ELEVATION OF ROD STOP ABOVE STAFF ZERO
	F	+ 1.2603				0.11		Staff stop @ 9.000 '	2.7432	9.000	
	B	− 1.2602	+ 1.2602	− 1	− 1	0.11	0.11	Aquatrak leveling point	4.0034	13.135	SPUR
								Staff stop @ 9.000 '			
								0000 A 1989			
								0000 A 1989			PBM
								0000 B 1989			
								0000 B 1989			
								0000 C 1989			
								0000 C 1989			
								0000 D 1989			
								ETC., ETC.			

FIGURE 4-6C

4.1.4 8200 DATA RECORDER

Installing the 8200 data recorder involves:

- Mounting the 8200 data recorder.
- Connecting the 8200 cables (Alpha and Communication).
- Installing the batteries.
- Documentation.

4.1.4-A Mounting the 8200 data recorder.

Mount the 8200 data recorder at the spot selected during the site reconnaissance. Double check the 8200 data recorder location to ensure the following:

- Within 3 m (10 ft) of the 9000 RTU.
- Comfortable access to the compartment.
- Situated to facilitate cable run from sensors and to the 9000 RTU.
- Sufficient right side clearance for cable entries.
- Sufficient front clearance for opening compartment door.

4.1.4-B Connecting the 8200 cables (Alpha and Communication).

- Run the alpha cable in through one of the two side portholes (size PG9) with strain relief plugs. Connect the alpha cable to the 8200 data recorder terminal block as shown in Figure 4-7.
- Add a jumper (small length of ground wire) between the shield ground and the 8200 chassis lug located in the lower left corner of the front panel. Use a nut and washer to secure the wire.

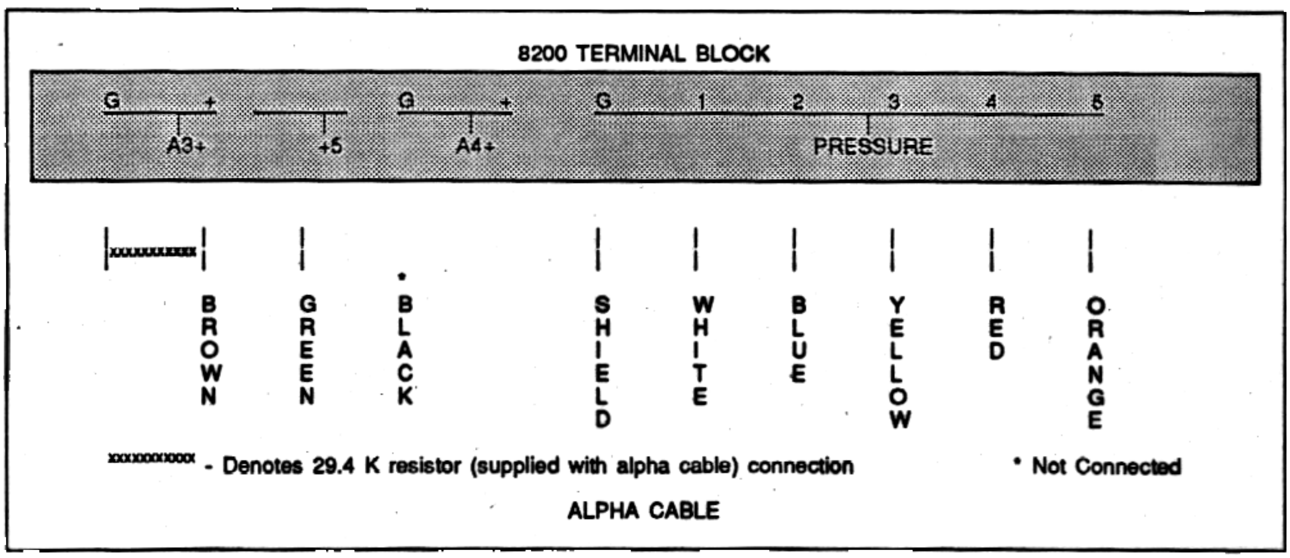


Figure 4-7
Alpha Cable To 8200 Data Recorder Terminal Block

- Do not ground or otherwise connect the 8200 Data Recorder enclosure to the 9000 RTU enclosure (other than communications cable). The two systems should be electrically isolated from each other.
- Plug the connector end of the communications cable into the jack labeled "RS-232" on the front panel of the 8200 data recorder. Secure the connector with the two screws. The other end of the cable is then fed out through the remaining porthole strain relief plug and over to the 9000 RTU for connection. Tighten both strain relief plugs.
- Have the alpha cable connection verified for location and tightness.

4.1.4-C Installing the batteries.

The battery cable connector plugs into a connector on the back side of the 8200 data recorder front panel. This must be done by feel so prior practice is advised. The plug has two round holes and a tab. The holes are aligned vertically and the tab is oriented to the right side (porthole side) of the enclosure. Using one hand, hold the plug and feel for the two "holes" on the back of the panel. Push the plug in until a solid connection is felt. The tab must be pressed in to remove the plug.

- Place the batteries (four six-volt or a 12 volt rechargeable) in a harness with cable in the compartment below the front panel. Plug it in.
- Once the battery pack is connected, the 8200 data recorder automatically begins operation. Several status messages will flash across the LED panel and it will then go dark. The ON/OFF "button" on the front panel just turns the LED display panel on and off, not the data recorder. See Section 4.2.2 for instructions on interacting with the 8200 data recorder.

4.1.4-D Documentation.

- Complete documentation as detailed in Chapter 6, particularly serial numbers or other information from inside the enclosure.

4.1.5 GOES FLAT PLATE ANTENNA

Installing the GOES flat plate antenna involves:

- Mounting the antenna.
- Running the cable to the 9000 RTU.
- Testing the antenna cable.
- Documentation.

4.1.5-A Mounting the antenna.

Verify that the nuts on the back of the flat plate antenna are secure. Place the antenna mounting bracket on the antenna mast. Orient the antenna so that the arrow **(UP ^)** on the back is pointing up. Adjust the antenna to the specified azimuth (provided in degrees true) by pointing to a known landmark, or by using a compass. If a compass is used, correct the specified azimuth to degrees magnetic with the local deviation. Tilt the antenna to the specified elevation using an inclinometer.

Have the angle and elevation verified. Use "Never Seize" or equal on the two allen screws used to tighten down the mounting bracket.

4.1.5-B Running the cable to the 9000 RTU.

- If the antenna is further from the 9000 RTU than the standard length of 10 m (30 ft), low loss cable (hard line coaxial cable) shall be used to minimize line loss. This should have been determined during the design phase and a low loss cable custom made for the site. The cable should be one continuous length without any connectors. Connectors will cause additional line loss.
- Attach one end of the cable to the jack on the antenna. Be especially careful not to cross thread the connectors when attaching. Waterproof the connection using coaxial cable putty or vulcanized rubber tape layered over by electrical tape (see next Section 4.1.5-C before doing this).
- Run the cable back to the 9000 RTU being careful to avoid sharp bends. The maximum bend radius for the standard cable is 3 cm (1 inch).
- Conduit is not required unless the antenna cable is exposed to possible physical harm from the public. Use fasteners at least every two feet to secure the cable. Attach the other end of the cable to the jack on the 9000 RTU. Black tie wraps are recommended over white ones as they are less likely to become degraded by ultraviolet rays.

4.1.5-C Testing the antenna cable.

The antenna cable shall be tested for excessive line loss. Test procedures are detailed in Section 4.2.2 as the 9000 RTU must be initialized to test the antenna. An antenna cable that is coiled too tightly may contribute to excessive line loss.

4.1.5-D Documentation

- Document the antenna s/n, cable type (standard or low loss), non-standard cable lengths, azimuth and elevation angles, etc..

4.1.6 SOLAR PANELS (OPTIONAL)

A solar panel may be used in lieu of, or in addition to, AC power at appropriate locations to recharge the 9000 RTU battery. If a solar panel is used in addition to AC, a decision must be made whether or not to leave the AC cable plugged in. In general, it is preferred to have the AC power connected as the constant charge is better for the battery than the cyclical "exercising" from the solar panel. It may not be desirable to have the AC power connected in areas of high lightning risk as power surges from nearby lightning hits can enter the 9000 RTU through the AC line and cause extensive damage.

A solar panel may be used to recharge the 8200 data recorder if the NEMA enclosure is modified (has a third port added) and the factory issued dry cell batteries are replaced with gel cell rechargeable batteries. A separate solar panel (not the 9000 RTU panel) shall be used for the unit.

4.1.6-A Assembling the panel(s).

Some assembly or prewiring may be necessary. Refer to the manufacturer's instruction sheet enclosed with the panel(s). Some manufacturer's panels have an opening which allows the installation of a strain relief plug. A spare 9000 RTU plug may be used for this purpose. The wiring box and connections on the panel shall be adequately protected against the environment.

4.1.6-B Mounting the panels(s).

The panel(s) may be mounted on the same mast as the GOES flat plate antenna, if there is sufficient room, or to a separate mast. The panel may be mounted flat on the roof if vandalism is a problem, but the panel will be less efficient this way. Also, if the solar panel is some distance from the instrument, there may be a substantial voltage drop. Refer to the manufacturer's instructions for specifics on mounting brackets and hardware included with the solar panel(s). Panel orientation should be towards the equator with the back edge tilted up from the horizon as specified in Table 6.

LATITUDE (Degrees)	TILT ANGLE (Degrees)
0^0 to 15^0	15^0
15^0 to 25^0	Latitude
25^0 to 30^0	Latitude + 5^0
30^0 to 35^0	Latitude + 10^0
35^0 to 40^0	Latitude + 15^0
> 40^0	Latitude + 20^0

Table 6
Solar Panel Tilt Angles

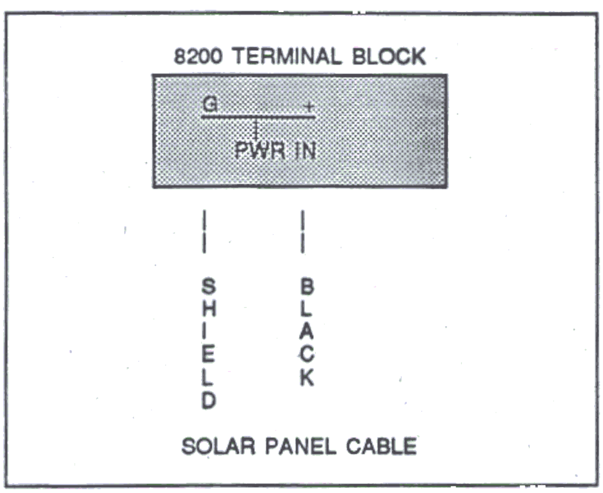


Figure 4-8
Solar Panel Cable To
8200 Data Recorder

4.1.6-C Connecting the cable(s).

If a solar panel is to be used to charge the 8200 data recorder batteries, the 8200 data recorder enclosure should have already been modified as per Section 4.1.6 to include a third porthole and strain relief plug before being issued to the field. The factory issued batteries should also have been replaced with rechargeable batteries. Run the solar panel cable into the 8200 data recorder and connect the two wires into the terminal board as shown in Figure 4-8. The cable wire colors may differ from those shown in the diagram depending upon the cable type used.

Check the solar panel with a voltmeter to confirm the proper polarity and voltage output. The 8200 data recorder internally regulates the solar panel so no external regulator is required. If a solar panel is to be used to charge the 9000 RTU battery, connect the cable as detailed in Section 4.1.7(D).

4.1.7 9000 RTU

Installing the 9000 RTU involves the following:

- Mounting the 9000 RTU.
- Connecting sensor cables.
- Connecting communication cables.
- Connecting optional solar panel cable.
- Connecting the ground.
- Installing the battery.
- Documentation.

The following guidelines will apply to all 9000 RTU wiring connections:

- Snap the gray plastic panels off the cableways in between the strips of the termination board in the lower compartment.
- Run all cables inside the cableways and out through the slots to the appropriate connectors.
- Loosen the designated terminal block screw.
- Strip the wire end about 3 mm (1/8 inch) and insert into the small rectangular opening immediately beneath the screw. Retighten the screw.
- Lightly tug the wire to test for proper seating. Be sure to snap cableway panels back on.

The situation may occasionally be encountered where tightening the screw down does not secure the wire. A possibility is that the wire has been placed behind the metal clamping plate and should be pulled out and reinserted. If this does not work, what may have happened is that the small metal plate attached to the backside of the terminal strip has not been broken loose from the conformal coating. The plate can be broken loose by applying more torque to the screwdriver until the plate snaps loose and tightens down on the wire.

4.1.7-A Mounting the 9000 RTU.

Mount the 9000 RTU at the spot selected during the site reconnaissance. Double check the 9000 RTU location to ensure the following:

- Comfortable access to both compartments.
- Situated to facilitate cable runs from sensors, antenna, 8200 data recorder, power supply, and telephone.
- Sufficient right side clearance for cable entries.
- Sufficient front clearance for opening compartment doors.

4.1.7-B Connecting sensor cables.

Connect the acoustic/air temperature sensor cables to the 9000 RTU termination board in the lower compartment.

- Feed the two air temperature sensor mating cables through a porthole and connect the wire leads to the top termination board (TB1) strip as per the wiring diagram in Figure 4-9. The acoustic sensor mating cable shall be fed in through a PG9 porthole.
- Connect the wire leads to the middle termination board (TB2) strip as per Figure 4-9.
- Tighten the porthole strain relief plugs.

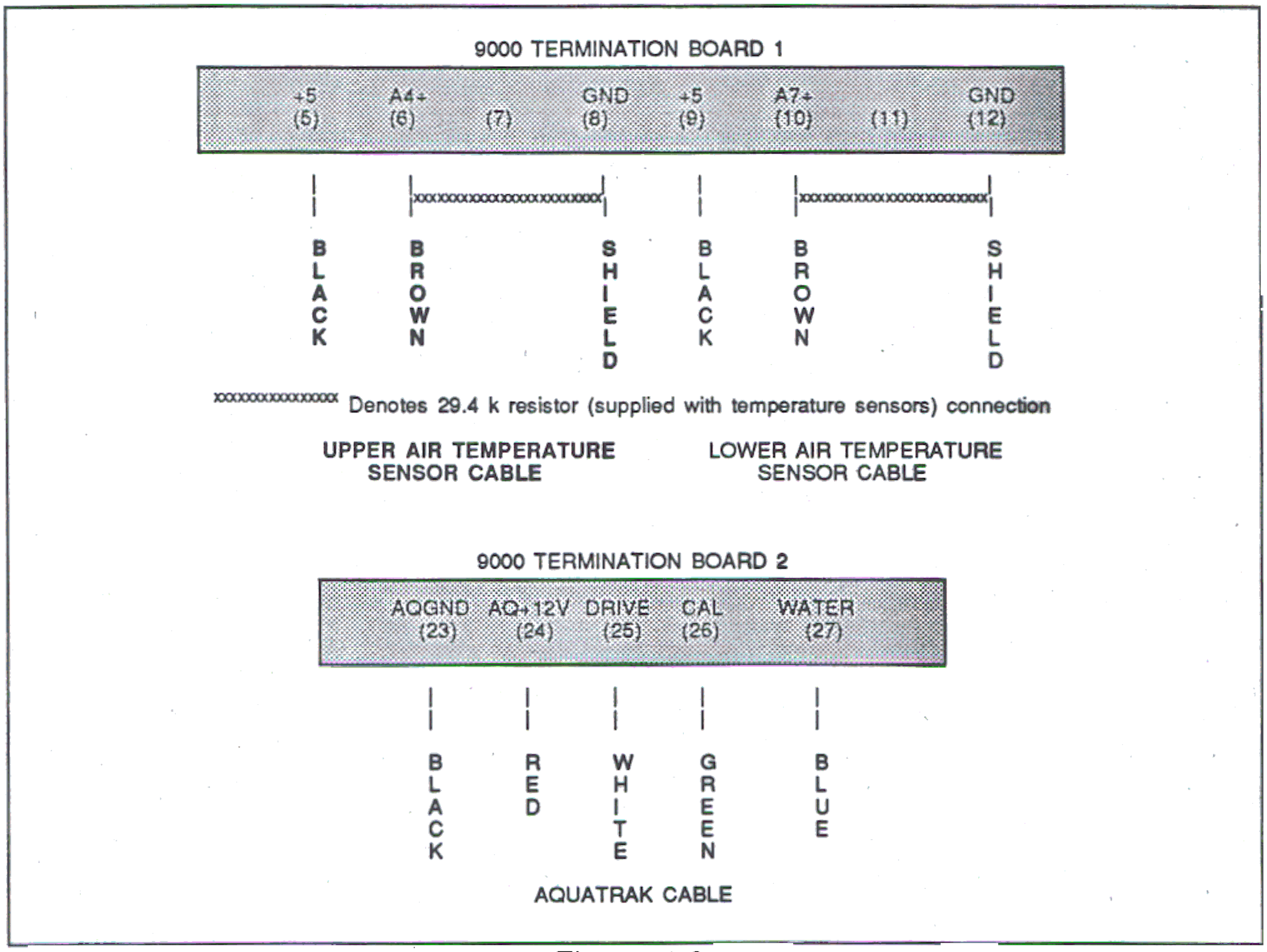


Figure 4-9
Aquatrak®/Air Temperature Sensor Cables To 9000 Termination Board

4.1.7-C Connecting communication cables.

Two types of communications cables are connected to the 9000 RTU. The 8200 data recorder communications cable is a fiber optic cable that allows the 8200 data recorder and 9000 RTU to communicate with each other, but keeps them electrically isolated from each other. This is to prevent a power surge that damages the 9000 RTU from also damaging the 8200 data recorder and causing a data break at the site.

- Run the 8200 data recorder communications cable to the bottom termination board (TB3) strip through a PG9 porthole.
- Run the cable through the cableway and connect the wire leads as per the wiring diagram in Figure 4-10.
- Run the telephone wire (if available) in through a PG9 porthole plug and connect to the top termination board (TB1) strip as per Figure 4-11. It may be necessary to wrap the telephone wire with tape where it enters the plug to ensure a good seal.
- Tighten the strain relief plugs.

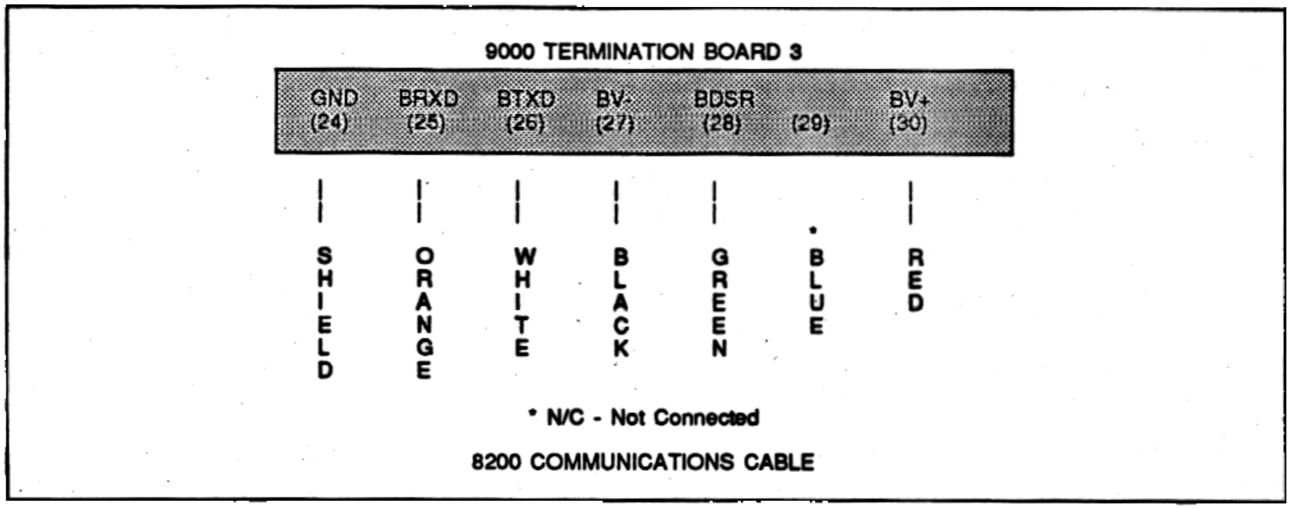


Figure 4-10
8200 Data Recorder Communications Cable To 9000 Termination Board

4.1.7-D Connecting optional solar panel cable.

If a solar panel is to be used, mount the solar panel and run the cable into the 9000 RTU through one of the PG11 portholes with strain relief plug. The 9000 RTU internally regulates the solar panel so no external regulator is required. Check the solar panel output with a voltmeter to verify polarity and voltage. If panel output is low check the panel wiring. Factory units have occasionally been found miswired. Connect the wires to the small terminal block on the power step down board in the lower compartment as per the wiring diagram in Figure 4-12. Wire colors may vary depending upon the cable type used. Be sure to snap cableway panels back on.

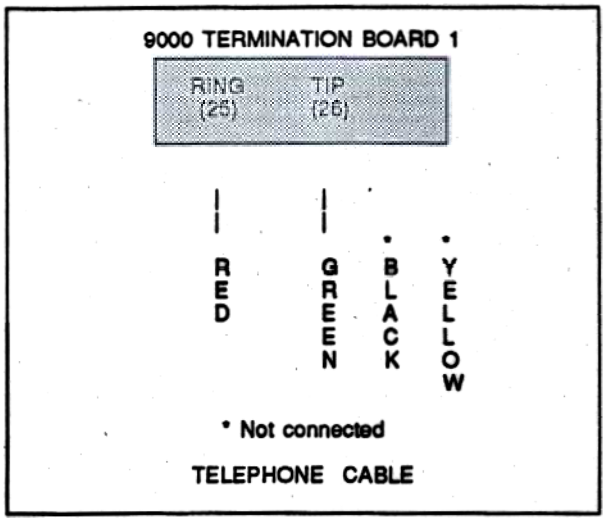


Figure 4-11
Telephone Cable To
9000 Termination Board

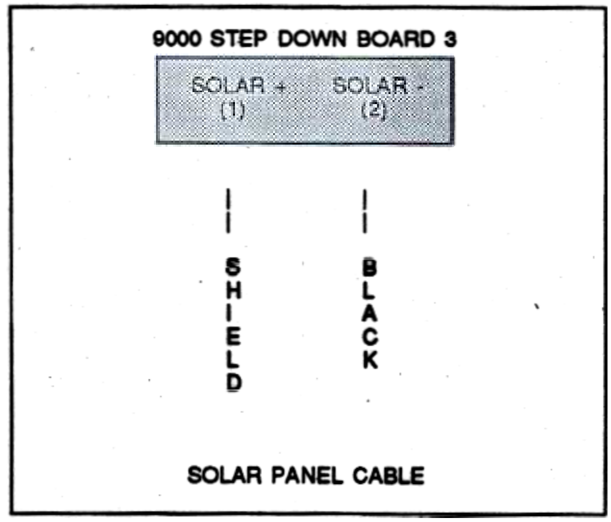


Figure 4-12
Solar Panel Cable
To 9000 RTU
Step Down Board

4.1.7-E Connecting the ground.

All stations are to be grounded, however, the extent to which grounding is required is dependent upon the station's location. At stations where the probability of a lightning strike (direct or nearby) is low or none, the 9000 RTU can be connected to an existing ground, such as the ground provided in the station's AC power supply. Where the probability is higher, a separate grounding system shall have been installed as part of the site preparation, and the 9000 RTU shall be connected to that. Heavy copper wire (#8 or greater) shall be used in either case. Connect the 9000 RTU to the appropriate ground using the lug provided in the lower back right hand corner. <u>Note: Do not ground the 8200 data recorder.</u>

4.1.7-F Installing the battery.

Mark the installation date on the battery. Clip the battery leads in the bottom compartment onto the appropriate tabs (red = +, black = -) on the 12 volt battery and position the battery so it is clear of all wires and other components. Check to be sure the leads fit snugly on the battery tabs. If they are loose, insert a long nose pliers into the end of the leads and crimp slightly to provide more tension when connected to the tabs. **DO NOT** turn the 9000 RTU on until you have read Section 4.2.2.

4.1.7-G Documentation.

See Chapter 6 for complete documentation requirements, however, each 9000 RTU has a spiral notepad in a plastic bag in the lower compartment that provides an onsite unit maintenance log. Update the notepad to include the site, date, personnel, installation information, coefficients, ancillary sensors, etc. and other pertinent information.

4.2 SYSTEM INITIALIZATION

This section provides instructions on initializing the 8200 data recorder and 9000 RTU. Initialization is the process of:

- Powering up the units.
- Entering/verifying system configuration.
- Testing sensor/component operation.
- Enter/verify associated sensor coefficients.
- Sealing systems with desiccant.

The *Sutron NGWLMS User And Operators Manual* and *Model 8200-0 Data Recorder Operations And Maintenance Manual* should be consulted on guidance for more extensive use of the software.

4.2.1 8200 DATA RECORDER INITIALIZATION

The 8200 data recorder should have been fully preprogrammed before being issued. It automatically powers on when the batteries are connected. The time and date will be set automatically by the 9000 RTU one half hour after the 9000 RTU is initialized. No further interaction with the 8200 data recorder would be required if the installer could be certain that the 8200 data recorder was properly configured before issue, that the backup sensors were operating correctly, and that the 9000 RTU was communicating with the 8200 data recorder. Therefore, it shall be standard practice to set the time and date, verify the system configuration, and confirm proper sensor operation before sealing the 8200 data recorder.

The 8200 data recorder has an internal software program which performs status checks, sets time/date, enables sensors, sets parameters, views data, downloads data, and many other functions. The instructions below address only those portions of the program associated with initializing the 8200 data recorder. The program can be accessed through one of two ways. One way is to use a PC with the TS8200 program. This will allow interaction on a menu driven basis. This is accomplished by plugging the personal computer into the RS232 jack on the front panel of the 8200 data recorder and executing the TS8200 program. A menu will appear.

The second way of accessing the internal software program is through the keypad on the front panel of the 8200 data recorder. Interfacing with the program through the keypad is not as user friendly, however, as through a personal computer with TS8200 due to the limitations of the small LED display. Therefore, the following instructions are provided as if interaction is occurring through the keypad/LED display. The keypad instructions can be easily followed if the TS8200 menu is being used instead.

4.2.1-A Setting time and date.

There is a six button keypad on the 8200 data recorder front panel. The **[ON/OFF]** button toggles the display on and off. The four arrow [up, down, left, right] buttons are used to move through different levels and options of the program. The **[SET]** button is used to change settings.

There is one main (primary) menu and five sub-menus (secondary) in the program. There are nine main menu options, five of which are entry points into the sub-menus. Some of the sub-menus have additional sub-menus (tertiary) and data item selections. The up and down arrow buttons are used to move up and down through the menu. The right arrow button is used to select options within a menu level. The left arrow quickly exits a sub-menu by going up one menu level each time it is pressed.

To interact with the software program:

Press the **[ON/OFF]** button to display:

[SUTRON 8200 VX.X] (**VX.X** is the ROM version installed)

This is a primary menu level. Press the down arrow button. This will step you down through the menu to the next primary level to display:

[UNITID: XXXXX]

Confirm that the 8200 data recorder serial number on the enclosure matches the **UNITID**. If it does not, change it by first pressing the **[SET]** button. This will start the first digit blinking. Now press either the up arrow or down arrow button to increase or decrease the number. Then go to the next digit by pressing the right arrow button and correct it. Continue this process until the entire number is correct and then press **[SET]** again. This will complete the process and allow you to continue. Press the down arrow button to display:

[DATE: 01/01/2000]

Set the date to the present GMT date by following the same process described for **UNITID**. The one difference is that the **[SET]** button must be pushed to "jump" across the slash (**/**) between month/day/year. Press the down arrow button when done to dispaly:

[TIME: XX:XX:XX]

The time starts off at midnight (00:00:00) and automatically starts incrementing. Using military time, set the time to GMT through the same process (pressing **[SET]** to jump the colons between hour:minute:second). Your watch should be synchronized with WWV (call 303-499-7111 or 202-653-1800). Press the down arrow button when done.

4.2.1-B Verifying system configuration.

The screen should now display:

[RECORDING ON]

This level will be returned to; but, first hit the down arrow 5 more times to reach the **INSPECT SYSTEM** primary level. Hit the down arrow three times until **CLEAR STATUS** is reached. Hit the **[SET]** button. This will clear out any error messages which may be generated from powering up the system. Hit the left arrow button until **INSPECT SYSTEM** appears and then the up arrow button until the **RECORDING** level is reached.

This primary level turns the recording function on or off. It should read **ON**. If it reads **OFF**, toggle it to **ON** by pressing the **[SET]** button, and be sure to use the **SAVE SETUP** command later on. The next primary level is:

[VIEW DATA]

This primary level is an entry point into a secondary sub-menu level that allows you to view data that is being collected. Press the right arrow button twice.

[LIVE READINGS]
[ANALOGX +X.XX]

LIVE READINGS is a secondary sub-menu level of **VIEW DATA**. If you had pressed the down arrow button the second time, instead of the right arrow button, another secondary level called **NEWEST READINGS** would have appeared. **ANALOGX** is a tertiary sub-menu level under **LIVE READINGS**. It displays the voltage being measured from the backup sensor. Up to three **ANALOGX** (where **X** = 1,2, or 3) channels can be viewed by continuing to press the right button. However, only those sensors that have been enabled (turned on) under a later secondary level will appear on this tertiary level. If no sensors have been enabled, then nothing will appear past **LIVE READINGS**. If the down arrow button is pressed while **ANALOGX** is being displayed, several other tertiary levels appear. They are:

[WATERLEVEL +XX.XX]
[OUTLIERS + XXX]
[DEVIATION +XX.XX]
[BATTERY +XX.XX]

Check these values for validity. To exit the tertiary level, press the left arrow button twice. Pressing the left arrow button takes you back up a level. You will see;

[LIVE READINGS]
[VIEW DATA]

If you pressed the left arrow button one more time you would go back to the top of the menu **(SUTRON 8200 VX.X)**. With **VIEW DATA** showing, press the down arrow button to display:

[SYSTEM SETUP]

This primary level has several secondary, tertiary, and lower levels that allow you to configure measurement parameters and enable sensors. Press the right arrow button once to display:

[MEASMNT SCHEDULE]

MEASMNT SCHEDULE is a secondary level of **SYSTEM SETUP.** Under it is a tertiary level with several options to configure sampling times and intervals. These are accessed by pressing the right arrow button once to display:

[MEASINT 00:06:00]

Scroll through the others by pressing the down arrow button and verify the following settings:

[SAMPINT 00:00:01]
[MEASTIME 00:07:40]
[SAMPTIME 00:04:30]
[PWRTIME 00:04:30]
[#SAMPLES/SET 181]
[#MEASMNT/LOG 001]
[PWRMODE OFF]

Then press the left arrow button to go back to **MEASMNT SCHEDULE**. If the down arrow button is pressed while **MEASMNT SCHEDULE** is displayed, the next secondary level is displayed as follows:

[ENABLE SENSORS]

ENABLE SENSORS is a secondary level of **SYSTEM SETUP**. Under it is a tertiary level with about 75 channels that can be turned on or off. Scroll through the options by pressing the down arrow button and verify, that for a standard NGWLMS installation, the following options are on:

[ANALOG3 ON]
[WATERLEVEL ON]
[OUTLIERS ON]
[DEVIATION ON]
[BATTERY ON]

The display should indicate the following:

ANALAOG3 Me Lg __
WATERLEVEL _ Lg Av
OUTLIERS __ Lg __
DEVIATION __ Lg __
BATTERY Me Lg __

Use the left arrow button to go back to **ENABLE SENSORS** and hit the down arrow to display the secondary level **CONFIG SENSORS**. Hit the right arrow to access the enabled sensors and check that they are configured as follows. Note that there is a difference in the **WATERLEVEL SLOPE** value between the Druck® and IMO® sensors. Values for English units are enclosed in parantheses.

ANALOG3	
MEASURE	ON
LOG	ON
AVERAGE	OFF
VALUE	current value
SLOPE	+0001.000
OFFSET	+0000.000
RIGHT DIGITS	3

WATERLEVEL (DRUCK®)	
MEASURE	OFF
LOG	ON
AVERAGE	ON
VALUE	current value
SLOPE	+0152.0 (+0500.0)
OFFSET	+0000.000
RIGHT DIGITS	3 (2)

OUTLIERS	
MEASURE	OFF
LOG	ON
AVERAGE	OFF
VALUE	current value
SLOPE	+0001.000
OFFSET	+0000.000
RIGHT DIGITS	0

WATERLEVEL (IMO®)	
MEASURE	OFF
LOG	ON
AVERAGE	ON
VALUE	current value
SLOPE	+0347.5 (+1140.0)
OFFSET	+0000.000
RIGHT DIGITS	3 (2)

BATTERY	
MEASURE	ON
LOG	ON
AVERAGE	OFF
VALUE	current value
SLOPE	+0001.000
OFFSET	+0000.000
RIGHT DIGITS	2

DEVIATION	
MEASURE	OFF
LOG	ON
AVERAGE	OFF
VALUE	current value
SLOPE	+0001.000
OFFSET	+0000.000
RIGHT DIGITS	3 (2)

You must save any changes made to the **CONFIG SENSORS.** If the primary level, **RECORDING**, showed **ON** when the system was powered up, and you have not made any changes under the primary level **SYSTEM SETUP**, you can leave the **SYSTEM SETUP** level by hitting the left arrow button several times. If the **RECORDING** level was toggled **OFF**, or you made changes, hit the right arrow button until the secondary level **SETUP** appears. Hit the down arrow twice until **SAVE SETUP** appears, and hit the **[SET]** button. This will save the changes.

Hit the left arrow until the primary level is reached. Hit the down arrow until the primary level **EEROM SETUP** is displayed. Hit the right arrow button to enter the level. The display will show:

[SERIAL XXXXXXXX]

Hit the down arrow button to scroll through the **EEROM SETUP** and verify the following configuration:

```
[ SERIAL PROTOCOL      ]
[ USER    RATE   2400  ]
[ DUMP RATE      9600  ]*      * dump and log rate can be set
[ LOG    RATE    9600  ]*        at any of the options
[ TIME LIMIT       60  ]
[ POWER DELAY       1  ]
[ PRESS  DELAY      5  ]
[ ANALG    DELAY  5    ]
[ AMPGAIN    xxx.xxx   ]
```

The **AMPGAIN** is a number unique to each unit and should be on a sticker inside the enclosure door. Enter the **AMPGAIN** if it is not already in the 8200 data recorder. Any changes made while in the **EEROM SETUP** level will automatically be saved.

Return to the **RECORDING** primary level and verify that it is **ON**. Push the **OFF** button to turn off the display.

4.2.1-C Verifying sensors operation.

Compare the real time backup pressure sensor water level reading to the primary water level reading. The displayed data is actually a voltage which must be converted to meters or feet. The voltage can be converted to meters by multiplying by 0.29 (0.96 for feet). The temperature data displayed by the 8200 data recorder is a voltage. Stored data from both sensors can be viewed using the program steps described in Section 4.2.1-B. Either or both data sets can be used to verify proper sensor operation or to help identify specific problems. The data should be compared against any known existing reference points, such as an ADR or bubbler gauges, if any.

4.2.1-D Sealing the unit.

The final step is to open the sealed plastic package provided with the unit and place the three bags of desiccant into the enclosure. However, do not perform this step until the whole system has been checked out and will not be opened again before departure. Place the bags so as not to press against any important connections. Close the enclosure door and seal it tightly.

4.2.2 9000 RTU INITIALIZATION

The 9000 RTU has a more sophisticated internal software program than the 8200 data recorder. Again, interaction with the 9000 RTU will be limited to only those functions involved with initialization. If the 9000 RTU has a telephone line connection, much of the interaction can be accomplished from the Field Operations Groups or Headquarters. The basic tasks which must be accomplished to initialize the 9000 RTU are:

- Power up the unit.
- Interrogate the 9000 RTU with a laptop PC.
- Set time and date.
- Enter/verify system configuration.
- Enable appropriate sensors.
- Enter/verify associated sensor coefficients.
- Test sensor operation.
- Test transmission power.
- Enable GOES transmission.
- Final check/logout.
- Documentation.
- Seal unit with desiccant enclosed.

4.2.2-A Power up the unit.

When all field unit cables are connected (sensors, antenna, 8200 Data Recorder, telephone, solar panel) plug the power cord onto an AC socket.

DO NOT turn the power switch on if the laptop PC is hooked up to the 9000 RTU. This will stop the program from running. If this happens, turn the 9000 RTU off, disconnect the laptop PC, and start over. If some checks had been performed previously, reperform them, as some parameters may have gone to default values. Turn the power switch on the power supply module to **ON** and observe the LED status light (shaped like a figure 8) panel on the central processor module. The light will flash through several patterns as the system initializes and goes through some self tests. It will eventually stabilize (about 30 seconds) so that a horizontal bar will stay lit in the center and a dot will flash in the upper left hand corner of the light panel. A laptop PC can now be connected to the 9000 RTU.

4.2.2-B Interrogate the 9000 RTU with a laptop PC.

Connect a laptop PC to the 9000 RTU using the terminal cable provided with the field unit. The plug end of the cable connects to the jack on the same side of the 9000 RTU enclosure where the cables enter. Turn the laptop on and run TS9000. When the **MAIN MENU** appears select option **C-CONNECT TO RTU** to communicate with the 9000 RTU. Hit the carriage return until the following prompt appears:

[Login User:]

Enter the user name and hit return. Entry into the program must be made at the operator or manager level in order to modify any parameters.

[Password:]

Enter the password and hit return.

[Account Number:]

Enter the account number (if any) and hit return.

A performance test will then be executed by the program and the results displayed with a disclaimer. An **ERROR** message will be displayed instead of an **OK** if any errors are detected. Hit any key and the **NGWLMS OPERATORS MENU** will display.

4.2.2-C Set time and date.

Select the **[T - System Time]** option. Be sure that your watch has been synchronized to WWV (303-499-7111 or 202-653-1800) before attempting this step. Follow the instructions to set the time and date in GMT. Note that when setting the time, the time does not actually start incrementing until you enter **Y** to a prompt that asks you to confirm that what you entered is correct. Therefore, it is helpful to enter a time setting about 30 seconds in advance, so that you will be able to start the clock exactly when real time reaches the entered time. Whenever the time and date is reset in the 9000 RTU it automatically resets the time and date in the 8200 data recorder.

4.2.2-D Enter/verify system configuration.

Return to the **OPERATORS MENU** and select the **[S- System Parameter Setup]** option. A listing, partially shown below, will provide system configuration parameters. Verify that the following parameters have been configured correctly:

[Transmission ID XXXXXXXX]
[Transmission Time XX:XX:XX]
[Transmission Interval 03 hours]
[Transmission Channel XXX]
[Station Number XXXXXXXX]
[Station Name XXXXXXXX]

Options 5 through 9 can be used to correct these, if necessary. With the exception of the **Transmission Interval** (always 3 hours), all the parameters are site specific. Both transmission time and interval are accessed under option 6. Although transmission time is only provided in an hour and minute format, it should be set to start five seconds past the minute given. This is to provide a small buffer between the start of the site's transmission and the receipt of another site's transmission at NESDIS, in case the operators watch is off a few seconds, or the unit's clock drifts. For example, if the transmission time provided is 0134, the screen should show;

[Transmission Time 01:34:05]

4.2.2-E Enable appropriate sensors.

Using the **[Enable Anc. Sensor]** option (1) of the **SYSTEM PARAMETER SETUP** menu, check to see that the proper sensors are enabled. Standard installations will use only the primary and backup water level sensors functions. Simply select the sensor number and the program will ask if it is to be enabled. Respond **[Y]** or **[N]** as may apply. The acoustic sensor is sensor 01 and the backup is sensor 02. The temperature sensors associated with the water level sensors are automatically enabled as part of those sensors.

4.2.2-F Enter/verify associated sensor coefficients.

Use the **[Sensor Variables**] option (2) to check the coefficients for the enabled sensors. Coefficient 1 for the primary water level sensor is the sensor offset noted on the acoustic sensor head and represents the distance from the leveling point on the sounding tube to the calibration reference point. Enter Coefficient 1 to the thousandth place for metric field units and to the hundreth place for English field units.

Coefficient 2 for the primary water level sensor is the site datum offset and references the primary water level data to the site datum of tabulation. The site datum offset is determined from two sources. The first source is the primary bench mark (PBM) elevation above site datum list which is provided in Appendix D. This is the elevation of the PBM relative to the original staff zero of the site, <u>not</u> the present staff zero (unless it is the original staff). The second source is the elevation of the acoustic sensor leveling point relative to the PBM, determined by running differential levels. Combine the two numbers as follows to determine the site datum offset. Perform rounding <u>after</u> the two numbers have been added together.

PBM elevation above site datum
<u>+ (Leveling point elevation - PBM elevation)</u>
= Leveling point elevation above site datum = Coefficient 2

Example: A NGWLMS has been installed at a site and levels have been run, abstracted, and double checked. It is known from Appendix D that the elevation of the PBM above site datum is 3.755 m (12.32 ft). From the levels, the elevation of the acoustic sensor leveling point above staff zero is 5.2615 m (17.262 ft) and the PBM elevation above staff zero is 4.1810 m (13.717 ft). Compute Coefficient 2 as follows:

3.755 m	(12.32 ft)		3.755 m	(12.32 ft)
<u>+ (5.2615 - 4.1810 m)</u>	<u>(17.262 - 13.717 ft)</u>	OR	<u>+ 1.0805 m</u>	<u>(3.545 ft)</u>
			= 4.8355 m	(15.865 ft)

Round 4.8355 m (15.865 ft) to 4.836 m (15.86 ft) and enter as Coefficient 2.

Note that if the acoustic sensor leveling point had been lower than the PBM, the value in the parentheses would be negative and that the value is, in effect, subtracted from the PBM above site datum value. Also note that in the metric case, if the 1.0805 m was rounded to 1.080 m before adding it to the 3.755 m, Coefficient 2 would end up being 4.835 m, which is 1 mm off from the correct value of 4.836 m. The procedure is to round <u>after</u> all mathematical functions have been performed (in this case the addition of the two values).

The two coefficients are applied to the raw water level measured by the acoustic sensor to reference it to the site datum. The raw water level is the distance measured from the calibration reference point (located just below the calibration hole) to the waters surface. For more information on calibrating the acoustic sensor, consult *NGWLMS Field Unit Acoustic Water Level Sensor Calibration Procedure.*

The two coefficients are used (Figure 4-13) to reference the raw water level data to the site datum (labeled as water level data in the log), as follows:

Coefficient 2 - (Raw water level + Coefficient 1) = Water level above site datum.

Coefficients 3 and 4 of the primary water level sensor are for the upper and lower temperature sensors. The value entered for each coefficient should be 29400. The program will display the coefficient in scientific notation [2.940000+04].

Coefficient 5 designates which type of cal tube is installed at the site. Enter a 4 for a standard cal tube, or a 2, if the 0.5 m (1.6 ft) cal tube is being used.

There are three coefficients displayed for the backup water level sensor but only coefficient 1 is used. Coefficient 1 is for the backup temperature sensor and is 29400. Coefficients 2 and 3 are not used and should be zero.

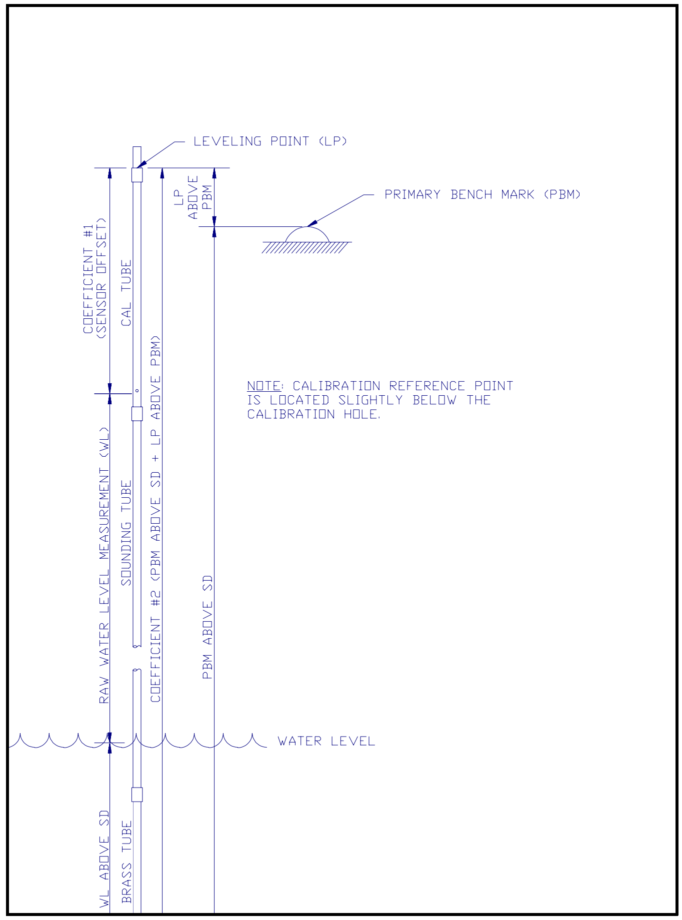


Figure 4-13
Conceptual Relationship of
Acoustic Sensor Water Level Measurement,
Coefficients, and Site Datum

4.2.2-G Test sensor operation.

There are a number of methods for checking the primary water level sensors operation. The data being collected can be viewed in real time, using the acoustic sensor module LED display or laptop computer, and the stored values in the log can be viewed via the laptop. The data can be used to verify proper sensor operation or to help identify specific problems. The data should be compared against any known existing reference points, such as the ADR gauge, bubbler gage, staff readings, etc.. Raw water level data can also be checked against actual onsite measurements.

The backup water level sensors should have been checked using the 8200 data recorder program, however, also look at the data using the 9000 RTU to ensure that the two units are communicating properly.

Return to the **OPERATORS MENU** and hit **Esc.** Then select the **[R - Real Time Sensor Display]** option. Use the sub-menu to view the data coming from all the sensors. Return to the operators menu and select the **[L - View Log]** option. Select the appropriate sensor and specify the time period desired. Remember that the data displayed in the log are averaged values while real time data are individual samples.

4.2.2-H Test transmission power.

Transmission power should be tested to ensure that it is set properly and that sufficient power is making it through the cable to the antenna. The standard setting is 9 - 10 watts at the 9000 RTU. The **[T - Transmit Test Format]** option under the **GOES SETUP MENU** is used to send a transmission. The screen will display the forward power and other related measurements after the transmission has been completed.
DO NOT transmit unless the antenna has been disconnected and a dummy load is hooked up. Transmitting a test message may cause the loss of some other organization's GOES data by transmitting simultaneously with it. Transmitting with no antenna or no dummy load will harm the unit.

Test the transmission power two ways and record the results on the Sensor Test Worksheet. First;

- Disconnect the antenna cable from the 9000 RTU.
- Connect a wattmeter to the 9000 RTU using a short length of cable.
- Connect a dummy load to the wattmeter.
- Initiate a test transmission.
- Record the maximum wattmeter reading during transmission.
- Record the results displayed on the screen.
- Reconnect the antenna cable to the 9000 RTU.
- Disconnect the antenna cable from the antenna.
- Connect the wattmeter to the end of the antenna cable.
- Connect the dummy load to the wattmeter.
- Initiate a test transmission.
- Record the maximum wattmeter reading during transmission.
- Record the results displayed on the screen.

If the power being transmitted from the 9000 RTU is lower than 7 watts at the antenna end of the cable, or if substantial line loss is detected, contact headquarters for direction. Substantial line loss is defined as being greater than 3 watts loss per 7 watts of power/per 10 m (30 ft) of cable. Dependent upon the signal strength being received at NESDIS corrective action may or may not be required.

4.2.2-I Enable GOES transmission.

Return to the operators menu and select the **[G - GOES Transmission Options]** option. Then select the **[E - Enable or Disable Transmitter]** option to turn the transmitter on. Use the **[F - View or Reset Software Fail Safe]** option to check that the software failsafe is ok. Use the **[V - Verify]** option to check all the parameters.

4.2.2-J Final check/logout.

Two final steps should be done before logging out. Go to the **OPERATORS MENU** and select **[P - PERFORMANCE CHECK]**. This option will initiate a system performance monitoring sequence and reports on the status of each. No status lines should read **ERROR**, unless the GOES transmitter is intentionally disabled. Next, use the **[I - SYSTEM INFORMATION]** option on the operators menu. This option displays a summary of the system setup parameters, including GOES transmission information, and enabled sensors with coefficients.

To log out, go to the **OPERATORS MENU**, and hit the **F1** function key. This will display the **MAIN MENU**. Enter **[X - EXIT]** to logout.

4.2.2-K Documentation.

See Chapter 6 for complete documentation requirements, however, items of special note from this section are the system parameters, coefficients, sensor test results, and transmission test results.

4.2.2-L Seal unit with desiccant enclosed.

When the system has checked out, and confirmation has been received from headquarters, place the bags of desiccant into the upper 9000 RTU compartment. Then seal both compartments. This step should be delayed until just prior to the field personnels departure to avoid exposing the desiccant to multiple openings of the enclosure.

4.2.3 FIELD UNIT OPERATIONAL CHECK

Proper operation of the field unit satellite communications shall be verified by field personnel before leaving the area. This can be accomplished by contacting headquarters personnel, who will check to see if transmissions are being received and are acceptable, or by calling NESDIS directly and accessing up to the last 72 hours of transmissions. Contacting headquarters is preferred, however, time differences and personnel availability may necessitate the direct link with the NESDIS database. A PC with modem, an inhouse software program, and the GOES platform ID are required. The NESDIS database can be accessed by using the inhouse software package to link with the database, "capture" the data in a file, and then decode it. The inhouse software package is labeled **MDAPSXXX.EXE** (**PDAPSXXX.EXE** for sites with English units), where the **XXX** is either **AOG**, **POG**, **OSD**, or **SLL**. Each version of the program has its own NESDIS password as database access may be limited to a finite number of contacts during the course of a day. When executed, the program calls the NESDIS database in Wallops Island, VA, and collects the data for a specific GOES platform ID. The program then automatically decodes the data and sorts it into several different files by data type so that it may be easily reviewed and validated.

```
DIAL NESDIS FROM FIELD PROGRAM         ####################################
                                       # C O N F I G U R A T I O N        #
                                       #                                  #
   D. Dial NESDIS                      #   Telephone No: XXXXXXXXXXXXX    #
   C. Change Configuration             #         User ID: NOSXXX          #
   Q. Quit                             #        Com Port: X               #
                                       #     Platform ID: XXXXXXXX        #
                                       # File Messages: YES               #
                                       #       Baud Rate: XXXX            #
Enter Selection (DCQ)                  ####################################
```

Figure 4-14
NESDIS Data Retrieval Program Menu

The program is started by typing **MDAPSXXX** (or **PDAPSXXX**) and enter. Figure 4-14 shows the menu that will appear on the screen. If the configuration needs to be changed hit **C** and enter. To change any values simply type over the information (partial changes cannot be done) in the highlighted boxes and hit enter. The **Telephone No:** area will be the first parameter highlighted. Enter the NESDIS telephone number in the format appropriate for the area and situation. This will typically be T-1-804-824-0105. The **T** tells the modem to use a tone type dial. If omitted, or replaced by a **P**, the modem will use a rotary dial. Some stations will not have tone line service. Commas can be used to enter a slight pause. The **User ID:** is specific to each version of the program and usually does not need to be changed. The **Com Port:** is either 1 or 2 depending on how the PC is configured. If a device timeout error message is displayed when attempting to make a call, then the wrong communications port has been specified. The GOES **Platform ID:** for the station being examined must be entered. The **File Messages:** configuration cannot be changed. The **Baud Rate:** must be set for the modem in use (typically 1200 or 2400). Any changes to the parameters will be written and saved in a file called station.dat. If the configuration is correct, hit **D** and enter. The program will automatically dial

NESDIS. If a busy signal is received, or contact is not made for some other reason, hit the **F10** function key to redial. If a redial is not desired, hit the **F1** function key to terminate the program.

When the NESDIS database is contacted, the user will see the login process scroll down the screen. There may be some long pauses, but no interaction is required on the part of the user. Next, blocks of data (mostly in binary code) will scroll across the screen. Each block represents a separate transmission. Then, individual lines of characters will appear and be written over multiple times. This is the decoding of the data blocks. Finally, the program will return to the cursor prompt.

The program has created several files which hold the captured and decoded data. Each file can be examined to check that the transmissions are being received within specified parameters and that the data is valid. Note that these files are written over each time the program is executed.

The first file created is **GOES.MES**. This file holds the blocks of undecoded data, with each block being a discreet transmission. Figure 4-15 shows a typical data block. Although most of the block is in binary code, there are a few parameters which may be examined. The **PPPPPPPP** at the beginning of the block is the GOES Platform ID. The **YYDDDHHMMSS** is the year (**YY**), the julian day (**DDD**), the hour (**HH**), the minute (**MM**), and the second (**SS**). This represents the time that the transmission is received by NESDIS. The seconds place should be between 9-11 seconds after the minute. If not, adjust either the 9000 RTU time or the transmission time accordingly.

```
PPPPPPPPYYDDDHHMMSSQ##-QQQCCCCQQBBBBBMNNNNNNNN@]#$%^&**&$((*N9)!
#%$867IT098N04V5B^P0Q3984N5PVQ34N[50QV34B5P%08V23QBN&[P05V54O9&&BTD8
72@[57235Q4W6S@w$@QX#%$WSC^EDV&RFB$&V^%BR*T(N)@#$%^&*@@@@Q34$M
@@@$PN8434354Q3RWEST34560P89UNV34PY9B83[B8345PBV1QN345VP5*&#&*^*(T&
^C#V^(&B8!#QX@%$CW^VDBR*T(N@$#C%VE^&BR*NT(MY@X#$%CW^VE&BR&B&*^#B
*TB(N)*)(&N!Q$#@XA%WSCE^DV&R*TG(NYHQX@#%$CSW^EDV&RFB*TGN(%!C$^E&^
YHMU)JQX@#@@@7VB$WAE^DV&R%$^CVDE&RBF*TGN(YMH#E%VC$@&^RB*T&B*^6
```

Figure 4-15
NGWLMS Transmission Block

The **Q** is a NESDIS quality code. It typically is **G** for good message or **?** meaning there is a parity error. The **##** is the GOES signal strength, which should be between 42 to 48. Around 35 or less, transmissions cannot be received. If the signal strength is under 42 contact headquarters for direction. At 50 or more, NESDIS will require that it be reduced.

The **QQQ** is another NESDIS quality code, typically **0NN** or **1NN**.

The **CCCC** is the channel where the first three digits are the numeric channel and the last is the satellite designation (E or W).

The **QQ** is another NESDIS quality code, typically **FF**. The **BBBBB** is the number of bytes for the transmission. The number of bytes for a full transmission for each station will vary, depending upon how many sensors are enabled.

Systems transmitting metric units data have an **M** in the next spot. Systems transmitting English units data do not have any code identifying it as such.

The **NNNNNNNN** is the eight digit NGWLMS station number. Verify that it is correct.

The **GOES.ERR** file holds messages that were short or had parity errors. It contains the header line (bold print in Figure 4-15) from each defective transmission.

The **PWL.DAT** file holds the primary water level data and follows the format shown in Figure 4-16. Each line represents one hour of data and has the NGWLMS station number (**NNNNNNNN**) and the date and time (**YYDDDHHMM**) at the start of each string. There should be ten primary water level values (**PWL**), ten standard deviations (**SD**), ten outliers (**OL**), ten upper air temperatures **(AT1**), and ten lower air temperatures (**AT2**). Metric values are reported to the thousandth place and English units are reported to the hundreth place. Verify that the water level readings are reasonable. The standard deviation and outliers should reflect the site type, i.e., larger values would be expected for an open coast site as opposed to a protected harbor site. Differences between the two air temperatures should not exceed 5 degrees.

```
NNNNNNNNYYDDDHHMM PWL PWL PWL PWL PWL PWL PWL PWL PWL PWL SD SD SD
SD SD SD SD SD SD SD OL OL OL OL OL OL OL OL OL OL AT1 AT1 AT1 AT1 AT1 AT1 AT1
AT1 AT1 AT1 AT2 AT2 AT2 AT2 AT2 AT2 AT2 AT2 AT2 AT2
```

Figure 4-16
Primary Water Level Data

The **BWL.DAT** file holds the data from the backup water level data and is formatted similarly to the primary water level data as shown in Figure 4-17. Each line is tagged with the NGWLMS station number and date/time and has one hours worth of data. Backup water level is only stored every half-hour, however, in order to conserve space in the transmission message. Two backup water level (**BWL**) values follow the header values, then two standard deviation (**SD**) values, two outlier (**OL**) values, and then two temperature (**WAT**) values. Compare the backup water level data to the primary water level data for verification. Check the temperature data to ensure that the values are reasonable.

```
NNNNNNNNYYDDDHHMM BWL BWL SD SD OL OL WAT WAT
```

Figure 4-17
Backup Water Level Data

The **RWL.DAT** is the redundant primary water level data file. It contains only the redundant primary water level data values that are contained in each transmission and is configured as shown in Figure 4-18.

```
NNNNNNNNYYDDDHHMM RWL RWL RWL RWL RWL RWL RWL RWL RWL RWL
```

Figure 4-18
Redundant Water Level Data

The **ANC.DAT** file contains data from any ancillary sensors which may be enabled at the station. Only one value per hour is recorded for each ancillary sensor. Figure 4-19 shows the format. Disabled sensor places are held by 9's. Verify that the values are reasonable.

SSSSS = Wind Speed
DDDDD = Wind Direction
GGGGG = Wind Gust
AAAAA = Air Temperature
WWWWW = Water Temperature
BBBBB = Barometric Pressure
CCCCC = Water Conductivity
EEEEE = Current Speed
IIIII = Current Direction
PPPPP = Dewpoint
RRRRR = Rainfall
OOOOO = Solar Radiation
11111 = Analog 1
22222 = Analog 2

```
NNNNNNNNYYDDDHHMMSSSSSDDDDDGGGGGAAAAAWWWWWBBBBBCCCCCEEEEEIIIIIPP
PPPRRRRROOOOO1111122222
```

Figure 4-19
Ancillary Data

The last file is **STAT.DAT**. This file contains the critical values used to configure the 9000 RTU at the station as shown in 4-19. First is the Platform ID (**PPPPPPPP**), then a NESDIS quality code (**Q**), the date/time (**DDDHHMMSS**) when NESDIS received the transmission, the NGWLMS station number (**NNNNNNNN**), the primary water level Coefficient 2 (**2222**), the primary water level Coefficient 1 (**1111**), a NESDIS status code (**EEE**), the number of resets (**RR**), a checksum value (**KK**), the starting date/time (**YYDDDHHMM**) of the transmission, the signal strength (**##)**, a NESDIS quality code (**QQQ**), the channel (**CCCC**), and the transmission byte length (**BBB**). Check to ensure that the values are correct or fall within the guidelines.

```
PPPPPPPPQDDDHHMMSSNNNNNNNN 22221111EEERR KKYYDDDHHMM##-QQQCCCCBBB
```

Figure 4-20
Configuration Data

NESDIS status codes (**EEE**) are as follows;

Decimal Value	Error Condition
1	ROM Checksum Error
2	RAM Test Error
	EE Write Error
	RAM Checksum Error
	EE Checksum Error
	Analog Error
4	SYSTAT Bit 10: SDL Error
	SYSTAT Bit 11: TAG Missing Error
8	SYSTAT Bit 8: Term UART Error
	SYSTAT Bit 9: Radio UART Error
	SYSTAT Bit 12: Missing Board Error
	SYSTAT Bit 13: Met Error
	SYSTAT Bit 14: GOES Error
16	Battery < 12.5 volts
32	8200 Error
64	Charger voltage < 15.0 volts
128	> 5 sec off sample end - Aquatrak 181 samples
256	>15 sec off sample end - Aquatrak 181 samples
512	8200 time update not enabled

4.2.4 FIELD UNIT GRAPHICS SOFTWARE PROGRAM

Graphically displaying the primary water level data is a quick way to visually check the field unit performance. The TIDES ABC program, originally developed for on demand access to a predecessor telemetry system, has been modified to access data from the NGWLMS. Please note that at this time, TIDES ABC is only capable of operating with English unit (feet) 9000 RTU's. A metric version has not been developed. This section will briefly describe the program's support requirements, capabilities, and operation. The *TIDES ABC Users Manual, December 2, 1985*, should be consulted, however, for detailed instructions on how to use the program.

4.2.4-A Support requirements

There are specific hardware and software requirements on both the 9000 RTU and the user end which must be met if TIDES ABC is to be used to collect and display the primary sensor water level data. There are also constraints due to the fact that TIDES ABC is not tailored to NGWLMS.

The 9000 RTU must have the following:

- The 9000 RTU must have version 2.4F of the operating system and SDL program REV F or later. Earlier versions do not support TIDES ABC although the appropriate subroutines can be downloaded into RAM which will allow TIDES ABC to work.

- A special password must also be programmed into the 9000 RTU which allows the TIDES ABC access to the data.
- The 9000 RTU must have a telephone line or the user must be on site to communicate with the 9000 RTU.

The user must have a personal computer with the TIDES ABC software program and a minimum of the following:

- IBM PC/XT/AT or 100% compatible
- 448 kilobytes memory
- 1 double sided, double density, floppy diskette drive (hard disk recommended)
- Math coprocessor
- HAYES® internal 1200B modem or external modem
- Graphics cards: any IBM color graphics adapter compatible, HERCULES® monochrome or compatible, or TECMAR® Graphics Master in color or monochrome.

Optional hardware is:

- Supported printers are: EPSON® FX80 or compatible, QUADRAM® QUADJET, or OKIDATA® ML92.
- Parallel printer interface and cable.

4.2.4-B Program operation

The TIDES ABC program operates by downloading primary water level sensor data from a remote unit into the personal computer memory and then displaying it in the specified format. Only the primary water level sensor data can be downloaded. TIDES ABC was not originally programmed to download the backup water level or any of the other ancilllary sensor data.

The TIDES ABC program has the following features:

- It is a menu driven program using the function keys.
- It interrogates a site through the selection of a station from a station directory.
- It can compute predicted tides, if harmonic constituents are available.
- It can store up to two months of tidal data and predictions on disk for each station.
- It corrects the GMT data to local standard time.
- It provides two types graphic displays for one to six days of data: observed versus predicted data, and anomalies versus predicted data, where anomalies are the difference between observed and predicted data.
- Tabular presentations of observed and predicted data.

Main Menu:		
F1	-	Interrogate stations
F2	-	Graphic and tabular displays
F3	-	Configuration and editing
F10	-	Terminate program

Figure 4-21
TIDES ABC Main Menu

After the TIDES ABC program is installed (see manual for details) type **TIDESABC** to execute the program. Figure 4-21 shows the main menu.

There must be a station subdirectory created to hold each station's configuration and data files in order to be able to contact a station and collect data from it. TIDES ABC creates a station directory which numbers and lists existing station subdirectories. All functions request a station reference number before executing that function. Create a subdirectory named **SXXXXXXX**, where **XXXXXXX** is the station number. Put all configuration files for that station in that subdirectory. Station configuration files are created using Option F3. Option F3 is password protected so that unauthorized users cannot corrupt configuration files. There are three configuraton files to consider.

The first, the station data file, contains the information listed below. It is important to know the tidal datums for the site when configuring the station data file. The station data file contains the following station configuration parameters;

STATION NAME:	Name of site
STATION NUMBER:	7-digit site ID number
PHONE NUMBER:	Site telephone number
STATION TYPE:	NGWLMS or predecessor system (enter a 4)
HIGH LIMIT:	Highest expected water level
LOW LIMIT:	Lowest expected water level
MAX CHANGE:	Highest expected rate of change
GAUGE OFFSET:	Value required to reference raw data to datum
STATION DATUM:	MSL - MLLW (Used to scale predicted water levels)
DATUM TYPE:	Reference datum used (typically MLLW)
GMT OFFSET:	Station location time offset to GMT
NUMBER OF DAYS:	Number of days of data to be downloaded

The second file is the configuration file which contains information on the PC system hardware and the TIDES ABC default options. The third file is the constituent file which contains the harmonic constituents used to generate the predicted tides for the site. If no harmonic constituents are available the predicted tides will not be generated and graphed.

Option F1 interrogates the stations to retrieve data.

Option F2 is used to view the data in various formats (tabular vs. graphic) and combinations (observed, predicted, anomalies) after it has been retrieved.

Option F10 exits the program.

Consult the TIDES ABC manual for details on installing and operating the program.

4.3 NONSTANDARD 9000 RTU CONFIGURATIONS

Sections 4.1 and 4.2 have been dedicated to the installation and initialization of what has been defined as a standard NGWLMS field unit configuration. In addition to the standard configuration, however, there are several nonstandard options for configuring the NGWLMS. This includes substituting different components or enhancing the unit through the addition of supplemental input/output devices. This section provides instruction on the installation and operation of nonstandard 9000 RTU configurations.

4.3.1 TSUNAMI WARNING SYSTEM OUTPUT DEVICE

NOS has traditionally cooperated with the NWS in the operation of a tsunami warning system. Typically, NWS has "piggybacked" NWS equipment onto existing NOS water level gages to telemeter analog data in real-time to the appropriate tsunami warning center. NWS requires real time analog water level data averaged differently than standardly done by the NGWLMS in order to detect tsunami events. The NGWLMS can be interfaced by NWS through the addition of a computer-to-analog output module that provides a continuous analog output (4-20 ma) of water level from the primary water level (acoustic) sensor and a SDL subroutine that continuously samples and averages the water level.

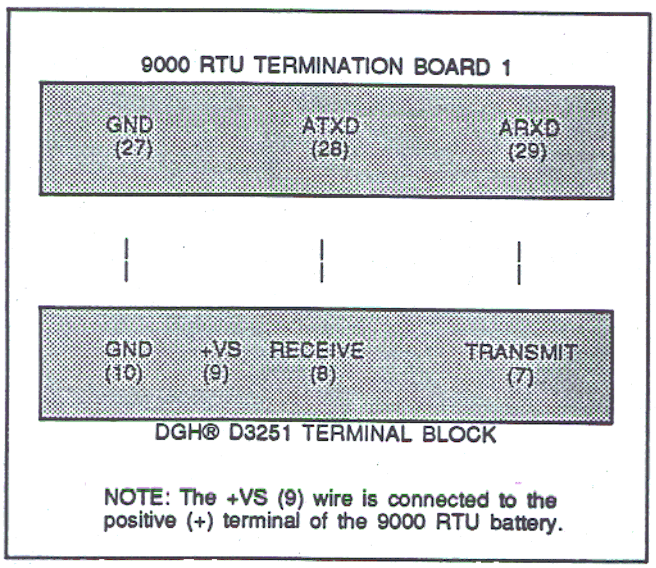


Figure 4-22
Computer-to-Analog Module
to 9000 RTU Wiring Diagram

4.3.1-A Requirements and Installation

The analog output module is a self-contained computer-to-analog output interface. The particular unit used is a model D3251 made by DGH Corporation® which has a RS232 interface and a 0-20 ma current output. The D3251 is capable of recognizing many different commands and operating in different modes. All the factory default settings are used and only the $1AO commmand is used to set the analog voltage. The format of this command is $1AO+xxxxx.xx followed by enter. The value xxxxx.xx is the desired output in milli-amps. For complete information on the module and commands refer to the *DGH D3000/4000 Series Users Manual*.

The following hardware/software is required:

- DGH® Model 3251 computer-to-analog interface module or equal.
- SDL program REV E or later.
- Upgrade existing battery to 40 amp-hours or additional 12 volt battery run in series.

The module is installed by attaching it to a convenient area inside the lower compartment of the 9000 RTU. This is usually done with a velcro patch as the interface module is very light. The module is connected to the top termination board and the positive terminal of the battery as shown in Figure 4-22.

It will be necessary to upgrade the existing 12 volt battery to 40 amp-hours or install a second one in series with the first. This is to maintain the backup life of the battery as the interface module and NWS equipment provide an additional drain on the system. The second battery will have to be installed exterior to the 9000 RTU. Run the battery wires in one of the portholes.

This completes the NOS portion of the tsunami warning system installation. NWS is responsible for the connection of their equipment to the module.

4.3.1-B Initialization

SDL program REV E (and later) contains the software subroutine required for the tsunami warning system. The software collects and averages the primary water level sensor data, transforms it to an output current (milliamps), and writes it to the module. The software also contains tests for verifying the current output to the module. The subroutine is activated by going to the NGWLMS **MAIN MENU** and selecting the **TSUNAMI** option (press **M**). This brings up the screen shown below.

```
Tsunami Mode:            Enabled
Average Interval (sec)   XX
Output Slope             X.XX
Output Offset            X.XX
Last Avg Lvl (ft)        XX.XX
Last Output (ma)         XX.XX

TSUNAMI Menu
 1 - Enable/Disable Tsunami
 2 - Change Average Interval
 3 - Change Slope
 4 - Change Offset
 5 - Short Test
 6 - Long Test
        (Esc to exit)
        Enter Choice:
```

Set the interval, slope, and offset using options 2 through 4 of the submenu. Be sure to document the values on the NGWLMS Site Report. The tsunami mode is started by selecting option 1 and enabling the subroutine.

Connect an amp meter to use options 5 and 6. Option 5 initiates a short test which stops the sampling and sends a preset output to the module. The module will first be set to 4.00 ma, then 12.00, 19.99, 12.00 and back to 4.00. There is a five second delay between values and the values are displayed on the screen as they are sent. The short test takes about 30 seconds. Option 6 is like option 5 but is much longer. The output starts at 4.00 ma and increases by 0.25 ma every 15 seconds until it reaches 20.00 ma. It then decreases in a similar fashion. It takes about 30 minutes to complete option 6.

The **Last Avg Lvl (ft)** and **Last Output (ma)** are the last averaged water level value and its computed output in milliamps. These values do not automatically update unless some key other than 1 through 6 is pressed to refresh the screen. Also be aware that it is possible to catch the values as the program has computed the average water level but not the current output.

4.3.2 EXTERNAL OUTPUT DISPLAY DEVICE

It is often advantageous at some NOS water level stations to provide a local display of the real-time water levels and/or ancillary sensors. There may be a need to provide the information to a local user or as part of a public display.

Hardware and software requirements are as follows:

- The 9000 RTU must have operating system 2.5B and SDL program VER G or later.
- A one or two line, 20 - 24 character LCD panel.
- A 5 volt, 1.5 amp power supply.

4.3.2-A Installing the LCD panel.

The panel can be packaged in whatever type of housing is appropriate for the application. The panel is connected to its own power supply to avoid any drain on the 9000 RTU. The power supply can be packaged in the same housing as the panel or installed in a separate location. Figure 4-23 shows the connection of the LCD panel wires to termination board 1.

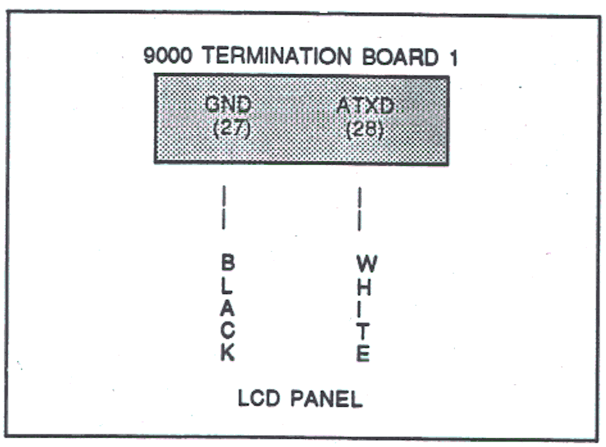


Figure 4-23
LCD Panel Cable To 9000 RTU

4.3.2-B Initializing the LCD panel.

Initializing the LCD display panel is a menu selectable item from the operators menu. Select **D - Display** and the following menu will appear. Default values for the parameters are shown.

```
DISPLAY MODE:                  DISABLED
LOCAL DATUM OFFSET (M)                0
TIME ZONE (e.g. EDT)                GMT
TIME OFFSET FROM GMT                  0
LAST AVG LVL

1 - Enable/Disable Display
2 - Change Local Datum Offset
3 - Change Time Zone Letters
4 - Change Time Offset
       (Esc to Exit)
       Enter Choice:
```

Set the local datum offset by entering 2 at the **Enter Choice:** prompt. The local datum offset is the value required to correct the water level computed by the 9000 RTU (water level above station datum) to whatever reference datum (typically MLLW) is to be displayed. This requires knowing the elevation of that datum relative to station datum which must be obtained from headquarters.

Select 3 from the menu and enter the 3 letter abbreviation for whatever time zone is to be displayed. Select 4 and enter the GMT offset. Finally, select 1 and enable the sensor. The **LAST AVG LVL** displays the last value that is stored in the log and to which the local datum offset is applied.

4.3.3 PRESSURE TRANSDUCER PRIMARY WATER LEVEL SENSOR

There are areas where the acoustic sensor, or other types of sensors requiring protective wells, cannot be used due to the impracticality of installing and maintaining a protective well. Areas where no vertical support structures exist, that are subject to heavy ice cover, or that are exposed to severe weather are a few examples. If water level data are desired at these locations, an option is the use of a pressure transducer as the primary water level sensor. A pressure transducer can be secured underwater and only a small tube or cable has to be protected through the air/water interface.

There are several drawbacks to using pressure transducers that place limitations on their use. Pressure transducers tend to be less accurate, typically expressed as some percentage of the range. Variations in water salinity/density introduce inaccuracies. They are difficult to reference to a bench mark network, as there is no well defined sensor zero that can be easily surveyed to. Transducers tend to drift over time. Finally, they are very susceptible to marine fouling (if deployed directly in water - see below for alternatives) and failure when they remain in the ocean for extended periods.

A *Paroscientific* Digiquartz® is used when a pressure transducer is the primary sensor, due to its high accuracy specification and stable drift characteristics. Special software is being written at this time which will allow the *Paroscientific* to also be selected as a **GROUP 1** (six minute data) sensor. Current software allows selection only as a **GROUP 2** (hourly data) sensor. This modification will allow the Digiquartz® to collect six minute averaged water level data similar to the acoustic sensor. Both the acoustic sensor and Digiquartz® can operate as primary sensors at the same time.

The software will be implemented through a SDL program chip change and will convert the ancillary sensor slot to a Group 1 status. The software change is not yet ready at this date, but will be the change following SDL program Version G. It is recommended that the Engineering Note accompanying the software program change be consulted for additional information not available at the time of this manual.

4.3.3-A Site preparation

The Digiquartz® can be deployed in two different configurations, similarly to the backup sensor. The first configuration (direct) is to deploy the Digiquartz® in the water. The second configuration (idirect) is to install a standard buabbler orifice, purge system, and nitrogen tank and use the Digiquartz® to measure the changes in line pressure caused by the change in hydrostatic pressure over the orifice. The purge system and Digiquartz® are typically housed in a separate NEMA enclosure about the same size as the 8200 data recorder. A temperature sensor must be installed adjacent to the Digiquartz®, similar to the backup sensor.

The Digiquartz® is available in several models. The 8000 series incorporates the pressure transducer into a self contained, stainless steel, shock resistant, sealed pressure case, submersible unit that is suitable for direct deployment in the water. The 2000 series is better suited for the indirect configuration due to the facility with which it can be interfaced with the gas pressure lines, its smaller size, and rugged design. The 8000 series model can be used for either configuration, while the 2000 series model can only be used for the indirect configuration.

NOS does not have any standard auxillary components to support the Digiquartz® if the direct configuration is selected, therefore, a custom installation must be designed. A Digiquartz® deployed as a primary water level sensor must be installed so that the sensor zero (bottom of the sensor) can be referenced to the bench mark network (unless a tide staff and observer configuration is used). This is generally accomplished by designing a mounting board that allows a measurement to be made between the sensor zero and an accessible rod stop. The sensor cable should be protected against the environment. A water temperature sensor (standard *YSI*) shall be installed adjacent to the Digiquartz®. It is recommended that a sacrificial anode be attached to the Digiquartz® (a threaded slot is provided) and that the sensor body be coated with antifouling paint to retard marine growth.

If the indirect configuration is selected, a standard fiberglassed brass bubbler orifice mounting board can be installed and the neoprene tubing run up to the instrument shelter. The brass orifice must be equipped with parallel plates. The shelter houses the nitrogen tank, regulator, and a NEMA enclosure. The NEMA enclosure contains a gas manifold with control panel, the Digiquartz®, and an air temperature sensor. The Digiquartz® is connected to an undampened section of gas line and monitors the line pressure. The NEMA enclosure configuration is called a Digibub.

It is recommended that a conductivity sensor be installed in conjunction with the Digiquartz®, so that the water level data may be corrected for temperature and density, particularly in areas subject to large variations in salinity.

4.3.3-B Installation

If the direct configuration is selected the Digiquartz® and temperature sensor cables are run through conduit and connected directly to the 9000 RTU as detailed below. If the indirect configuration is selected, the Digibub is mounted on the shelter wall, following the same mounting criteria as specified for the 9000 RTU.

Connect the Digiquartz® to the 9000 RTU as shown in Figure 4-24. Note that the red sensor wire must be connected to the positive (+) terminal of the 9000 RTU power stepdown board with an inline 5 amp fuse. The fuse shall be located in the 9000 RTU compartment, not the pressure transducer NEMA box.

Connect the temperature sensor with the Digiquartz® to the 9000 RTU as shown in Figure 4-25.

4.3.3-C Initilization

Access the 9000 RTU using a PC and initialize the Digiquartz® as follows:

- Enter the three coefficients for the Digiquartz®. The coefficients are specific to each sensor and are on a calibration sheet supplied with each sensor. They are:

Coefficient #1 = A
Coefficient #2 = B
Coefficient #3 = T_0

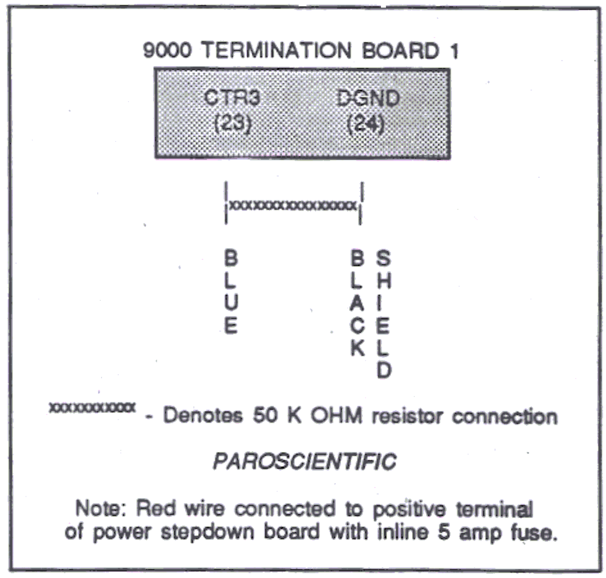


Figure 4-24
Paroscientific to 9000 RTU

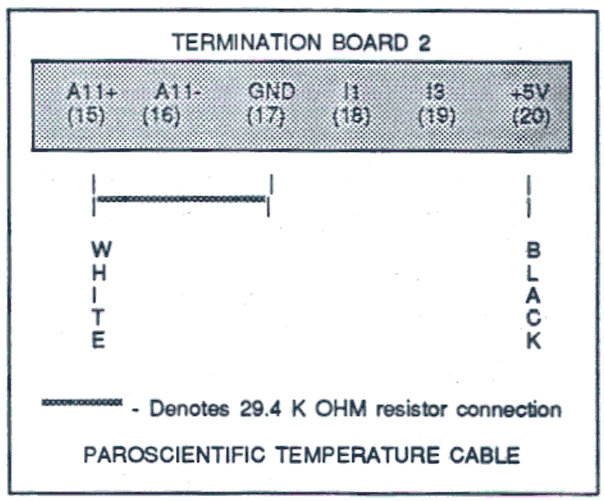


Figure 4-25
Paroscientific Temperature Cable to 9000 RTU

- Enter the temperature coefficient: Coefficient #1 = 29400 (2.94000E+004)
- Enable the Digiquartz® (Paroscientific) sensor listed under **GROUP 1** and the Analog 2 sensor listed under **GROUP 2**. The temperature sensor associated with the Digiquartz® use the Analog 2 channel.

Sensor output for the Digiquartz® is in meters, and degrees centigrade for the temperature sensor.

he Digibub is operated the same as conventional bubbler gauge pressure manifolds with one exception. Consult the Bubbler Gage Users Guide listed in the reference section for further information on normal bubbler gage operation and maintenance. The exception is an extra valve labeled "VENT FOR CALIBRATION" on the control panel. It is used only for periodic calibration of the Digibub and should be kept closed during normal operation.

The Digibub can be calibrated by recording the zero pressure offset of the pressure transducer. Zero pressure checks help monitor the long term stability of the Digiquartz® and provide a means of data correction. The checks should be performed upon installation and during maintenances. Perform the checks as follows:

- During normal operation, close the inlet valve.
- Close the outlet valve.
- Open the "VENT FOR CALIBRATION" valve.
- Record a minimum of five 6-minute readings to ensure the Digiquartz® is fully vented to the atmosphere.
- Return to normal operation by reversing the previous steps.

CAUTION: The green *NUPRO* bellow valves will be fully open after one to one and a half turns. Turning beyond this point may cause the cap to come off.

Record the results under the additional sensor tests section on the Sensor Test Worksheet.

4.3.4 CELLULAR TELEPHONE

In areas where the site is not near a telephone line, but is covered by a cellular telephone network, it may be more economical to install a cellular telephone than to bring in telephone lines. Installation is similar to a regular telephone line in that the wire connections are the same. Connect the wires to ring and tip on termination board 1 as shown in Figure 4-11 in Section 4.1.7-C.

The cellular telephone should have its own power supply, and not draw from the 9000 RTU, to avoid shortening the 9000 RTU's stand alone battery life in the event of an AC and/or solar panel power failure.

Note that the telephone is cellular on the *NGWLMS Site Report*.

4.3.5 RADIO COMMUNICATION

Another option for receiving data and communicating with the 9000 RTU is through line of sight radio. This option may be selected if there is a need for real time water level data from a site. It is also another way to communicate with a remote site that cannot be connected to telephone service. The 9000 RTU operating system can be accessed over the radio and all functions executed, such as changing coefficients, setting time, downloading software, etc.. The radio communications option can operate in conjunction with the GOES satellite transmissions, or become the primary data collection path.

A radio communications board, software, antenna, transmitter and receiver are required. As of this edition, however, the radio communications option is not in standard use by NOS. Therefore, menu selections to configure and enable the radio are not in the present software. Contact headquarters for further information if the radio option may be required for a remote site or special application.

5 ANCILLARY SENSORS

In addition to the standard primary (acoustic plus two air temperature) and backup (pressure plus temperature) water level sensors, the NGWLMS 9000 RTU can accommodate other meteorologic and oceanographic ancillary sensors. This chapter provides guidelines for ancillary sensor site preparation, installation procedures, and documentation requirements.

Table 7 lists the 14 ancillary sensor types which may be operated with the 9000 RTU. Note that only 11 of the 14 can operate simultaneously as some of the sensors use the same input channels. Some of the sensors (highlighted in Table 7) are capable of measuring more than one parameter, i.e., the wind sensor measures wind speed, direction, and gusts. NOS has selected specific manufacturers' instruments for some of the sensor options, and the siting/installation information in this document is directed towards them. To date, specific instrumentation has not been selected for the remainder of the sensor options, so little information has been provided for these. Future revisions of the manual will address these sensors as instrumentation is specified.

WIND	BAROMETRIC PRESSURE
AIR TEMPERATURE	SOLAR RADIATION
DEW POINT	RAINFALL
WATER CURRENT +	WATER CONDUCTIVITY*
WATER TEMPERATURE	PAROSCIENTIFIC*
ANALOG 1	FREQUENCY 1*
ANALOG 2	FREQUENCY 2 +

+, * - Cannot operate simultaneously with each other

Table 7
Ancillary Sensors

Proper siting of the ancillary sensors, particularly for the meteorological sensors, may be difficult to achieve in some cases. The main objective of siting a sensor is to ensure that the data being collected will satisfy program requirements. This usually requires that the data be representative of the conditions typical for the area. Criteria will be provided for siting each sensor, however, an ideal location that meets all the criteria may not be possible. In these cases compromises will be necessary. The installer must consider the purposes of the data collection program and select a site that will best meet the objectives.

In general, siting criteria for the meteorological sensors have been taken from the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements* (see References).

5.1 WIND SENSOR

The wind sensor used with the 9000 RTU is the Wind Monitor Model 05103 manufactured by the *R. M. Young Company*. See Appendix E.1 for manufacturer information. It measures wind speed and direction. It has a helicoid shaped four blade propeller molded of polypropylene plastic for wind speed and a vane assembly whose position is transmitted through a coupling located in the main housing for wind direction.

5.1.1 SITING CRITERIA

Because atmospheric properties can vary considerably with height, and be affected by surrounding obstructions, a set of somewhat arbitrary conventions have been established so that measurements conducted at different locations can be compared on a common basis.

- The standard mounting elevation is 10 m (30 ft) above the ground in open, level, terrain.
- A horizontal distance of ten times the height of an obstruction should be maintained, between the wind sensor and the obstruction, for the surrounding area to be considered open terrain. An obstruction can be manmade (building) or natural (tree).
- If the sensor is to be mounted on the roof of a building, it should be mounted at a height 1.5 times the height of the building. This is to remove the sensor from the area in which the air flow is affected by the building. For tall buildings where this guideline cannot be met, a 3 to 5 m (10 to 15 ft) mast should be mounted on the side of the building with the prevailing wind.
- If the sensor is to be mounted on a tower, the sensor should be above the tower or on a boom. The boom should be twice as long as the maximum diameter or diagonal of the tower, and should be directed into the prevailing wind.

The above criteria are primarily meant for inland based measurements and may be difficult to fully meet at the typical NGWLMS site. Completely satisfying them may not be critical, however, as coastal locations typically generate sea/land breezes which can dominate the wind patterns. It is this cyclical pattern that should govern the wind sensor placement at most sites. The above criteria can be still be used as guidance for the sensor placement, but must be adapted to coastal sites. For example, the seaward end of a pier might represent the best wind sensor site for a pier station.

In general, a meteorological tower will probably provide the best platform from which to conduct wind measurements, as well as other meteorological parameters. The tower should be of the open grid type of construction that will not twist, rotate, or sway. Enclosed towers, stacks, storage tanks, grain elevators, cooling towers, etc., should not be used. See Section 5.12 for further details on meteorological towers.

5.1.2 INSTALLATION

The Model 05013 wind sensor clamps onto a standard 2.5 cm (1 inch) diameter iron pipe which can be mounted onto a mast, tower, tower boom, or whatever support structure has been selected at the site. The sensor should initially be loosely clamped onto the pipe as it will need to be aligned with regard to direction, however, this must be done after connection to the 9000 RTU.

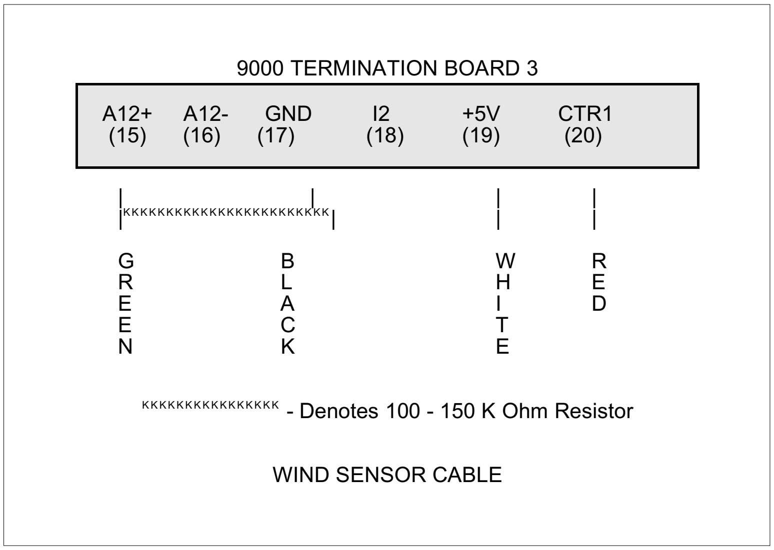


Figure 5-1
Wind Sensor Cable to 9000 RTU

Figure 5-1 is the wiring diagram for connecting the wind sensor into the 9000 RTU. The green wire is the direction, the white is for direction excitation, and the red is for speed. A 100 - 150 K ohm resistor is required due to the potentiometer in use for the direction output having an open section (dead spot) of 5 degrees. The pull down resistor will avoid erratic readings when the direction is at this open section.

Enable the sensor and enter the two wind sensor coefficients. Coefficient 1 is 0.09778 (9.77800E-002) and coefficient 2 is 355 (3.55000E+002). The sensor output is in m/sec and degrees. To convert wind speed from m/sec to miles/hour, multiply the indicated speed by 2.24.

The wind sensor must be aligned with regard to direction.

- Align the vane by pointing it toward a distant reference point of known azimuth, or use a compass (correct for magnetic deviation), and sight along the centerline of the sensor.
- While the vane is held in position, the mounting post assembly is slowly turned on the mounting pipe until the 9000 RTU indicates the proper heading. It is usually easiest to sight from the propeller end toward the fin, with the output reading 180^{O} from the reference point.
- Once the sensor is properly oriented, the SS band clamp on the mounting post is tightened.
- The orientation ring is raised and its indexing pin engaged in the notch on the bottom of the sensor mounting post. While holding the orientation ring in position, the remaining band clamp is tightened. The index notch on the mounting post was aligned at due south by the manufacturer.

5.1.3 DOCUMENTATION

Documentation for the wind sensor installation should, at a minimum, provide the following information:

- Installation date
- Sensor serial number
- Cable length
- Full description of physical installation, including: support structure (mast, tower, building, etc.), sensor elevation above grade, orientation of tower boom, surrounding obstructions, etc.

5.2 BAROMETRIC PRESSURE SENSOR

The barometric pressure sensor used with the 9000 RTU is a *SETRA Systems, Inc.* Model 270 pressure transducer. See Appendix E.2 for manufacturer information. Early models were modified by NOS with a 24 VDC to 12 VDC converter (a small circuit board attached to the sensor) while later models use 12 VDC directly. A minor software change was required to accommodate the later model. This software change is present in those 9000 RTUs operating with SDL program version REV F or later. The early model can be used with version REV F or later software but the wiring connections are different and a wire jumper is required.

5.2.1 SITING CRITERIA

Site selection is not required for the sensor as it is mounted inside the 9000 RTU and vented to the outside.

5.2.2 INSTALLATION

The sensor is mounted inside the lower portion of the 9000 RTU using a modified bracket assembly. The bracket supplied with the barometric sensor from *SETRA* is turned around (see Figure 5-2) and has two 3/8 diameter inch holes drilled 1-1/4 inch apart to match the 9000 porthole configuration. Two 5/16 x 2 inch threaded bolts with nut and washers (lock and flat) along with three porthole plugs complete the assembly. The assembly uses the top row of 9000 RTU portholes to attach the bracket and a lower porthole to vent the sensor. Install the sensor as follows:

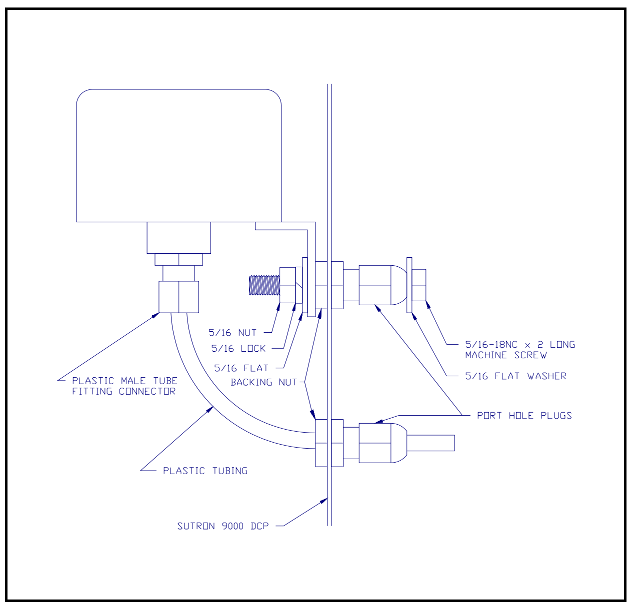


Figure 5-2
Barometric Sensor Installation

- Remove the top two front porthole plugs. Also remove the third from the top, front row, porthole plug. Save the black backing nuts from all three.

- Mount the three porthole plugs (from assembly) into the three portholes cleared in the first step. Use the backing nuts to attach the porthole plugs to the bulkhead.
- Insert the two bolts into the top two porthole plugs from the outside and hand tighten the plug glands.
- Mount the sensor bracket onto the bolts and thread a flat washer, lock washer, and nut onto each bolt, and tighten.
- Feed the tygon tube down and out the lower porthole. Do not allow the tube to sag inside the 9000 RTU so that moisture cannot collect in a low point. Hand tighten the plug gland cut the tube flush with the plug end.
- It is critical that the sensor, including the bracket, is not touching the bulkhead so that it is electrically isolated from the 9000 RTU. The backing nut part of the porthole plug will accomplish this if the above assembly procedure is correctly followed.
- Connect the sensor wires as shown in Figure 5-3. Use the top half of the diagram for the later model and the bottom half for the earlier. NOTE: Figure 5-3 assumes a SDL program version REV F or later.

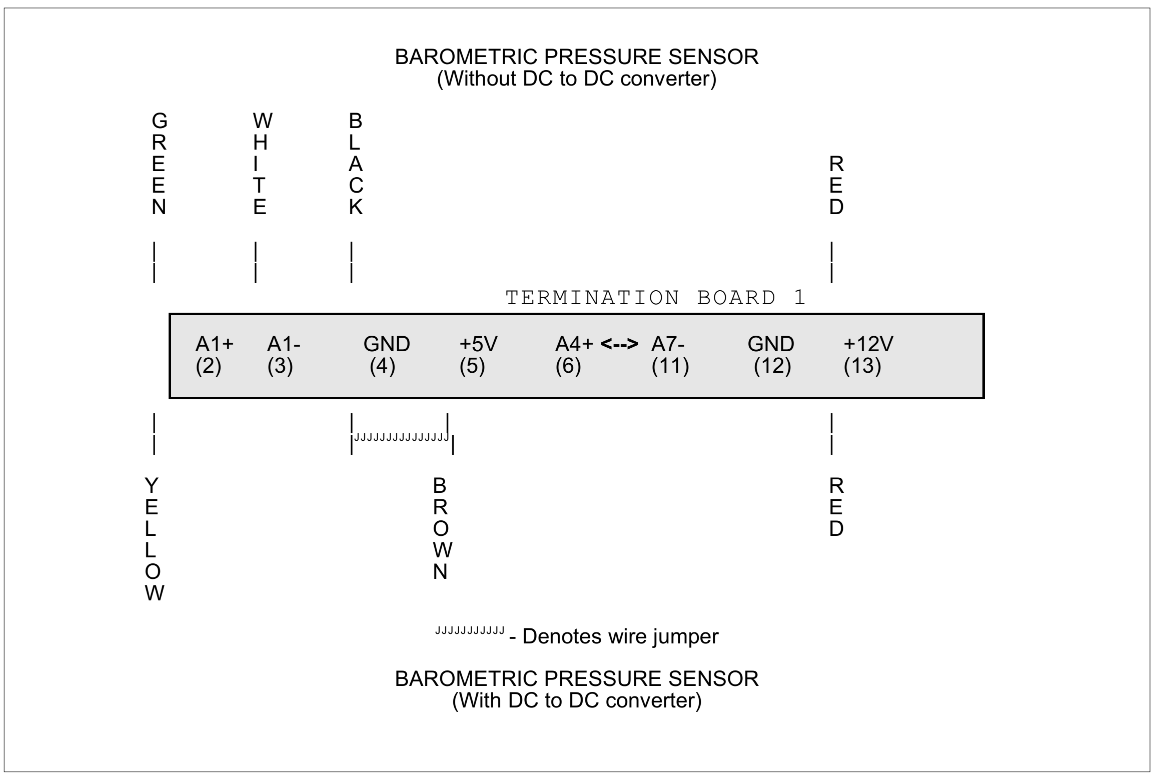


Figure 5-3
Barometric Sensor Cable to 9000 RTU

- Enable the sensor and enter the coefficients: Coefficient 1 = 60 (6.00000E+001) and Coefficient 2 = 800 (8.00000E+002).

The sensor output is in millibars. To convert to inches of mercury, multiply the indicated pressure by 0.02992.

5.2.3 CALIBRATION

The barometric pressure sensor readings should be calibrated by one of two methods. If a NWS weather office is nearby, call and conduct some simultaneous readings. Alternately, compare the readings to a previously calibrated hand held portable barometer. The readings can be adjusted by changing Coefficient 2. For example, if the readings are 1.2 mbar higher than the reference, change Coeffcient 2 to 798.8.

5.2.4 DOCUMENTATION

Installation and calibration information shall be documented on the NGWLMS Site Report and the Sensor Test Worksheet and, at a minimum, provide the following:

- Sensor serial number and model type (early vs present)
- Calibration method and results.
- Coefficient 2 if different than 800.

5.3 AIR TEMPERATURE SENSOR

The air temperature sensor used with the 9000 RTU is a *YSI* Model 44032 (-40^{O} to +50^{O} C) installed in conjunction with the *R. M. Young Company* Gill Multi-plate Model 41002 radiation shield. See Appendix E.3 for manufacturer information.

5.3.1 SITING CRITERIA

Air temperature is another meteorologic property that can change considerably with height and can be affected by surroundings. The following criteria are also meant for inland sites, but can be used as general guidelines.

- Standard mounting elevation is 1.2 to 2.0 m (4.0 to 6.5 ft) above grade.
- The sensor should be mounted over a plot of open level ground at least 9 m (30 ft) in diameter. The ground beneath the sensor should be short grass or natural earth, not asphalt, concrete, areas of standing water, etc..
- The distance between the sensor and any obstruction should be at least 4 times the height of the obstruction. It should be at least 30 m (100 ft) from large paved areas and not close to steep slopes.
- If mounted on a tower, the sensor should be on a tower boom at least as long as the tower diameter.
- Temperature sensors should have downward facing aspirated shields.

Clearly, a pier based site cannot meet some of the above criteria. In those cases, the sensor should be sited out over the water (on a tower boom) or as close to the edge of the pier as possible.

5.3.2 CALIBRATION

First, test the air temperature sensor in conjunction with the other thermistors as described in Section 4.1.1-D. Enable it as a **GROUP 1** sensor so that it will log a value every six minutes. Figure 5-4 shows the wiring connection.

5.3.3 INSTALLATION

The air temperature sensor is housed in an aspirated radiation shield. The purpose is to keep direct sunlight off the sensor yet still allow adequate ventilation. The radiation shield has a hex plug in the bottom machined to a 1.4 cm diameter to grip the *YSI* thermistor. The radiation shield bracket attaches with a u-clamp to a vertical standard 1 inch diameter iron pipe. Earlier versions could be threaded onto the end of a standard 1 inch diameter pipe with threaded end.

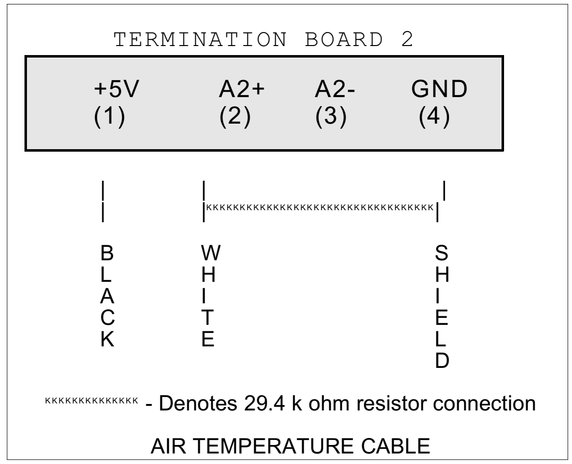


Figure 5-4
Air Temperature Cable to 9000 RTU

Install the sensor as follows:

- Install the sensor/radiation shield and protective conduit.
- Pull the sensor cable through the conduit to the 9000 RTU.
- Connect the temperature cable as shown in Figure 5-4.
- Enable the air temperature sensor as a **GROUP 2** sensor.
- Enter Coefficient 1 = 29400 (2.94000E+004).

Sensor output is in centigrade. Convert to fahrenheit by $(9/5 \times C) + 32^{O} = F$.

5.3.4 DOCUMENTATION

Installation and testing information shall be documented on the NGWLMS Site Report and the Sensor Test Worksheet and, at a minimum, provide the following:

- Record sensor test results.
- Document cable length, and mounting method.
- Describe the physical installation with regard to compliance with the criteria listed above. Provide the elevation above grade.

5.4 SOLAR RADIATION SENSOR

No sensor has been specified at this time

5.4.1 SITING CRITERIA

Measurements should be taken in a location free from any obstructions that could cast a shadow onto the sensor and not be near any light colored walls or any other surfaces likely to reflect sunlight. Artificial sources of radiation should also be avoided.

5.4.2 INSTALLATION

To be determined.

5.4.3 DOCUMENTATION

To be determined.

5.5 DEWPOINT SENSOR

No sensor has been specified at this time

5.5.1 SITING CRITERIA

Siting criteria considerations for the dewpoint sensor are identical to the air temperature sensor. An aspirated radiation shield is also required for this sensor.

5.5.2 INSTALLATION

To be determined.

5.5.3 DOCUMENTATION

To be determined.

5.6 RAINFALL SENSOR

No sensor has been specified at this time.

5.6.1 SITING CRITERIA

The rainfall sensor should be located so that it is shielded from the wind, but not placed in an area where excessive turbulence may develop. Other general criteria are as follows:

- It should be mounted on level ground.
- Obstructions to the rainfall sensor should not be closer than two to four times the height of the obstruction.
- The ground surface around the sensor should be natural. Paved surfaces may allow water to splash into the sensor.
- The sensor should be mounted a minimum of 0.3 m (1.0 ft) above grade and high enough so that it will not be covered by snow.
- A wind shield should be used in open areas.

5.6.2 INSTALLATION

To be determined.

5.6.3 DOCUMENTATION

To be determined.

5.7 WATER CURRENT SENSOR

No sensor has been specified at this time. The water current sensor input is designed to accept a speed and direction signal. Note that the water current sensor cannot be operated if the Frequency 2 sensor option is also to be utilized.

5.7.1 SITING CRITERIA

Siting criteria for the water current sensor are dependent upon the objectives of the data collection program under which the sensor is being deployed. In general, water current varies with depth and can be significantly altered by obstructions, therefore, these factors must be considered in siting the sensor.

- The sensor shall be mounted below the lowest expected water level plus a wave allowance so that there is no chance that it will ever be exposed or subjected to "surf" conditions.
- The sensor should be offset as much as possible from any obstructions which could alter the flow in the area of interest.

5.7.2 INSTALLATION

To be determined.

5.7.3 DOCUMENTATION

To be determined.

5.8 WATER CONDUCTIVITY SENSOR

The water conductivity sensor used by the 9000 RTU is the *Sea-Bird Electronics, Inc.,* Model SBE 4-01 conductivity meter. See Appendix E.8 for manufacturer information. The sensor has a flow through cell (sensing element) where resistance is measured. Note that the water conductivity sensor cannot be operated if a *Paroscientific* water pressure sensor, or a sensor using the Frequency 1 sensor option, is to be operated due to conflicts with input channels.

5.8.1 SITING CRITERIA

Conductivity is measured primarily to determine salinity, therefore the sensor should be located in an area representative of the larger area as a whole.

- The sensor should be mounted below the lowest expected water level (plus wave allowance), discussed in Section 2.3.2, so that it is never exposed to air or "surf" conditions.
- The sensor should not be sited near any freshwater outflows or any other types of discharges that could change the conductive property of the water over a limited area.
- Proximity to metal or other materials will not affect the measurements, unless galvanic corrosion is occurring in the immediate vicinity.

5.8.2 INSTALLATION

The conductivity sensor is a cylinder, approximately 20 cm (8 inches) long and 5 cm (2 inches) in diameter. There is a guard bracket which jackets the cylinder for mounting and protects the conductivity cell. The sensor has a zinc anode attached to it to protect the anodized aluminum housing. An anti-foulant (tributylin) is used to keep marine growth from fouling the conductivity cell.

- Attach the guard bracket to whatever backing board has been fabricated.
- Place the anti-foulant into the tygon tube as per manufacturers directions.
- Fasten the meter to the cell guard bracket.
- Install the backing board/meter assembly
- Connect the sensor cable to the 9000 RTU as shown in Figure 5-5.
- Enable the sensor and enter the coefficients. The coefficients are provided by the manufacturer and are found on the calibration certificate that should accompany the sensor. The five coefficients (a, b, c, d, m) that are specific to each sensor correspond respectively to the 9000 RTU coefficients 1-5.

Conductivity output displayed in the 9000 RTU is in Siemans/meter.

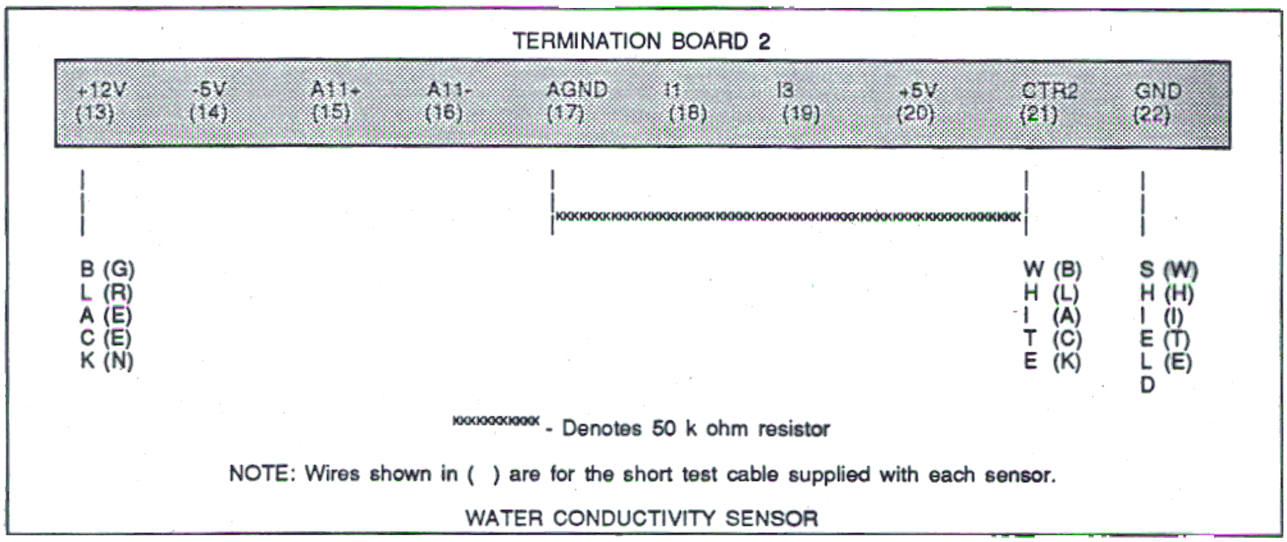


Figure 5-5
Water Conductivity Sensor Cable to 9000 RTU

5.8.3 DOCUMENTATION

At a minimum, provide the following:

- Serial number.
- Mounting configuration description
- The five coefficients.
- Potential discharge "contamination" problems, including natural causes (rivers, creeks, etc.).
- Cable length.
- Sensor depth.

5.9 WATER TEMPERATURE SENSOR

The water temperature sensor used as an ancillary sensor with the 9000 RTU is a *YSI* Model 44032 (-5^{O} to +40^{O} C). See Appendix E.9 for manufacturer information. Although it is similar to the temperature sensor supplied with the backup sensor, the cable lengths and connectors are different. The water temperature sensor is intended to be redundant to the backup sensor temperature sensor (if deployed underwater) and is configured to be installed in the protective well.

5.9.1 SITING CRITERIA

The water temperature sensor is to be sited inside the protective well, as specified in the following section, unless there are instructions to install it in some other manner. This may occur where it is not possible to install a protective well and the *Paroscientific* Digiquartz® sensor is used instead. If the configuration is used where the Digiquartz® is not deployed underwater, then the water temperature sensor should be mounted as close to the bubbler orifice as possible. Be sure not to install it near an outflow, discharge, or any other situation which might affect the water temperature over a limited area, resulting in nonrepresentative data.

5.9.2 CALIBRATION

First, test the water temperature sensor as described in Section 4.1.1-D. Note that if the sensor is hooked up and enabled as the water temperature sensor, it will only log a value once every hour. If there is no air temperature sensor at the station, hook the water temperature sensor up as the air and enable it as a **GROUP 1** sensor so that six minute values will be logged. If this is not possible, wire the sensor as shown in Figure 5-6, and the values will have to be monitored in real time.

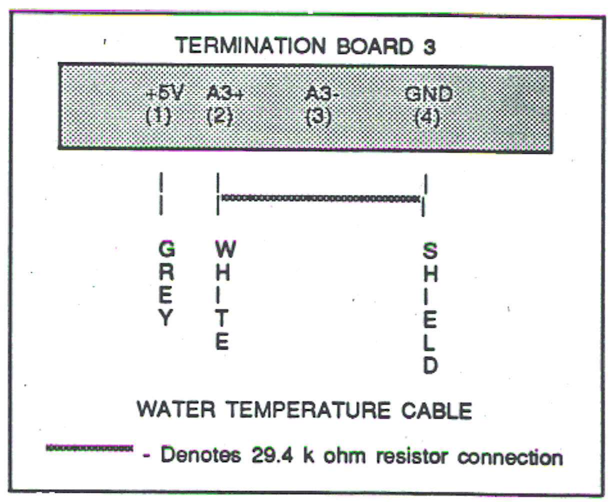


Figure 5-6
Water Temperature Cable to 9000 RTU

5.9.3 INSTALLATION

The water temperature sensor cable is 10 m (30 ft) in length with a water proof connector. The water temperature sensor shall be attached 0.2 m (0.5 ft) above the end of the brass antifouling tube. Be sure to use a non-metallic method, such as plastic tie wraps, to attach the sensor to the tube to avoid galvanic corrosion.

The cable mating connectors should be positioned in the protective well similar to the air temperature and acoustic sensor mating cable connectors. The water temperature sensor mating cable is 15 m (50 ft) in length and shall run in conduit between the protective well and the 9000 RTU.

- Connect the water temperature sensor cable to the 9000 RTU as shown in Figure 5-6. Note that the water temperature sensor does not require a resistor, as opposed to the water temperature sensor associated with the backup water level sensor.
- Enable the water temperature sensor as a **GROUP 2** sensor.
- Enter Coefficient 1 = 29400 (2.94000E+004).

The sensor output is in degrees centigrade. Convert to degrees fahrenheit by $(9/5 \times C) + 32^{O} = F$.

5.9.4 DOCUMENTATION

Installation and testing information shall be documented on the NGWLMS Site Report and the Sensor Test Worksheet. At a minimum, provide the following:

- Sensor elevation.
- Sensor test results.
- Mounting configuration description if other than sounding tube attachment.

5.10 WATER PRESSURE (*PAROSCIENTIFIC*) SENSOR

The water pressure sensor selected for use as an ancillary sensor with the 9000 RTU is the *Paroscientific, Inc*., Digiquartz® depth sensor. See Appendix E.10 for manufacturer information. It is the same sensor that can be used as an alternative primary water level sensor (see Section 4.3.3), however, in this capacity it is only collecting one sample per hour.

5.10.1 SITING CRITERIA

Siting criteria for the water pressure sensor will depend upon the program objectives under and the configuration selected (direct versus indirect measurement). In general, the water pressure sensor should be sited using the same criteria as the backup water level pressure sensor. The primary consideration should be that the sensor/orifice is mounted below the lowest expected water level (plus a wave allowance), described in Section 2.3.2, so that there is no chance that it will ever be exposed or subjected to "surf" conditions.

5.10.2 INSTALLATION

The water pressure sensor/orifice shall be securely mounted on a backing board fabricated for the location. If a leveling reference is required, the standard bubbler or backup sensor mounting board assembly can be used with some modification to the sensor mounting block.

- If sited underwater, the Digiquartz® shall have a sacrificial zinc anode attached to it. It has an unified fine thread opening (1/4 inch, 28 thread/inch) for this purpose.
- Connect the water pressure sensor cable as shown in Figure 5-7 (NOTE: Awaiting final wiring configuration from OSD - see section 4.3.3).

5.10.3 DOCUMENTATION

At a minimum, provide the following:

- Serial number.
- Mounting configuration description.
- Cable length.
- Sensor depth.

5.11 ANALOG 1, 2 AND FREQUENCY 1, 2 SENSORS

Any type of sensor that uses an analog or frequency type counter can be connected to the 9000 RTU as an ancillary sensor. Siting and installation requirements for selected instruments will be provided as program needs arise.

5.11.1 SITING CRITERIA

To be determined.

5.11.2 INSTALLATION

To be determined.

5.11.3 DOCUMENTATION

To be determined.

5.12 METEOROLOGICAL TOWERS

Two types of towers have been procured to be used as support structures for the appropriate ancillary sensors. One type is the *ROHN*® 25G equilateral triangular design tower which is composed of connectable 3 m (10 ft) lengths of hot dip galvanized steel. The other type is the *Shakespeare Company*® 6 m (20 ft) round tapered fiberglass masts. The triangular towers are to be installed hinged at the bottom so that the towers can be tilted and lowered to the ground for easy maintenance access to the sensors. The fiberglass masts are light enough to unbolt at the base and lower to the ground. An advantage of the fiberglass mast is that it is more easily accepted in areas where appearance is a concern.

Siting the towers may be very difficult as essentially two sets of criteria must be considered: first, the tower must be installed in accordance with the criteria listed below, and second, the site must also satisfy the criteria for the ancillary sensor(s) that the tower shall support. Criteria for siting the towers shall take priority, however, as the tower siting criteria are safety related.

5.12.1 STEEL TOWER SITING CRITERIA

It is important to site the steel towers very carefully as they are great conductors of electricity. Always consider what will the tower hit if it should fail and collapse.

- The tower location shall be sufficiently clear and out of falling distance of utility lines. Safe distance from utility lines is defined as at least twice the height of the highest point of the tower.
- A location that will allow the use of a "house bracket is preferred as this will allow the tower to be erected without guy wires, up to 10 m (30 ft) above the house bracket height. The house bracket should be mounted at least 4 m (12 ft) above grade to be effective. If only a standard instrument shelter is available, mount the bracket as high as possible.
- A location that will allow a clear line of ground space so that the tower can be fully lowered for maintenance access to the sensor(s).

5.12.2 FIBERGLASS TOWER SITING CRITERIA

Fiberglass masts are not the conductors that the steel towers are but the major concern is to avoid having a failed tower create a safety hazard.

- The mast location shall be sufficiently clear and out of falling distance of utility lines. Safe distance from utility lines is defined as at least twice the height of the highest point of the tower.
- A location that will allow the mast to be firmly bolted at the base, e.g., through bolted to a pier support member, never the decking. If only decking is available, a steel plate equal or larger than the mast baseplate shall be placed on the underside of the decking and the base bolts run through it to distribute the stresses.
- A location that will allow a clear line of ground space so that the mast can be fully lowered for maintenance access to the sensor(s).

6. SITE DOCUMENTATION

Documentation of a NGWLMS installation shall be accomplished through the use of standard forms and thorough annotation of all deviations in site selection, testing, installation, maintenance activities, and repairs conducted. The traceability and trackability of the data are of the utmost importance and shall not be compromised.

Standard forms and tools developed for documentation are as follows:

- NGWLMS Site Report.
- NGWLMS Well/Sounding Tube Worksheet.
- Sensor Test Worksheet.
- 9000 RTU Log Book (onsite).
- Software.

6.1 NGWLMS SITE REPORT

The NGWLMS Site Report (see Figures 6-1A,B) is a form developed to fully document NGWLMS site installations, operation, and maintenance. The form addresses most significant aspects of the site, including location, local contact, shelter, utilities, components, equipment, sensors, leveling, etc. The report is to be completely filled out at installation and annual inspections. If module serial numbers are not on the front panels, use the serial numbers recorded in the log book, rather than removing the modules. Record ancillary sensor documentation and any deviations, non-standard parts or procedures utilized, or field modifications performed.

6.2 NGWLMS WELL/SOUNDING TUBE WORKSHEET

The NGWLMS Well/Sounding Tube Worksheet (see Figure 6-2) shall be submitted with the installation station report. The worksheet which was used to design the installation could be modified, if necessary, to show the "as-built" installation, or a separate drawing may be submitted. The worksheet/drawing shall provide the elevations, on the existing staff/ETG, of:

- Harbor bottom.
- Pier deck(s), platform floors, etc.
- Protective well features (top, bottom, couplers, vent holes, brackets, parallel plates).
- Sounding tube features (top, bottom, temperature sensors, cal tube hole, brass/cpvc junction).
- Backup sensor assembly features (staff stop, sensor, backing board top/bottom).
- Datums (highest & lowest observed/expected tides, MHHW, MLLW).
- Any other information deemed relevant.

N/OMA121 FORM 91-01 NOAA/NATIONAL OCEAN SERVICE	SITE NAME	SITE ID NUMBER

NEXT GENERATION WATER LEVEL MEASUREMENT SYSTEM (NGWLMS) SITE REPORT

INSTRUCTIONS: This form is to be fully completed (all information shall be verified correct and measurements retaken) and submitted on site installation and inspection. At other site visits (repair/modifications) and on removal, only changes need be recorded. This form shall be accompanied by the NGWLMS Well/Sounding Tube Worksheet or equivalent sketch.

LATITUDE (N/S)	LONGITUDE (E/W)	TIME MER. (E/W)

FACILITY

☐ ESTABLISHED ☐ INSPECTED ☐ REPAIRED ☐ REMOVED

BY:	DATE
APPROVED BY:	DATE
RECEIVED (NOS HQ) BY:	DATE

OWNER'S NAME (And Local Representative)

ADDRESS/TELEPHONE #

LOCAL CONTACT

NAME	HOME TELEPHONE #	BUSINESS TELEPHONE #		
HOME ADDRESS	DATE HIRED	NEW? ☐ YES ☐ NO	PAY/MONTH	

SHELTER & PLATFORM

DESCRIPTION, REMARKS (Size, construction, access, utilities, etc)

☐ Continued on reverse

9000 RTU

RTU S/N	DATE RTU INSTALLED	RTU TELEPHONE #		RTU POWER SOURCE ☐ AC ☐ SOLAR	OPERATING SYS VER	SDL PROGRAM VER
RTU BOARDS CHANGED? ☐ YES ☐ NO	PWR SUPPLY BD S/N	SAT/RADIO BD S/N	COMM CNTL BD S/N	GENERAL I/O BD S/N	MEMORY EXP BD S/N	CPU BD S/N
RTU DESICCANT CHANGED? ☐ YES ☐ NO	MODEM BD S/N	AQUATRAK BD S/N	BACKPLANE BD S/N	TRANSITION BD S/N	TERMINATION BD S/N	AC PWR STDN BD S/N

DESCRIPTION, REMARKS (Location, mounting, etc)

☐ Continued on reverse

PRIMARY WATER LEVEL SENSOR

AQUATRAK S/N	MATCHED TUBE S/N	SENSOR OFFSET	AQ. CHANGED? ☐ YES ☐ NO	DATE AQ. INSTALLED	TEMPERATURE SENSORS SEPARATION

DESCRIPTION, REMARKS	CPVC SOUNDING TUBE LENGTH (Level point to brass tube end)	BRASS TUBE LENGTH	# BAILS

☐ Continued on reverse

PROTECTIVE WELL

MATERIAL (diameter, schedule, color, etc)	PIPE LENGTH (flange to flange)	DATE WELL INSTALLED	INTAKE: DOUBLE CONE ☐ SHROUD ☐ SIDE ☐	INTAKE/WELL (Cleaned by divers) ☐ YES ☐ NO
BRACKETS (number, type, material, etc)		TOP HAT? ☐ YES ☐ NO	COPPER INSERT? ☐ YES ☐ NO	PARALLEL PLATES? ☐ YES ☐ NO

DESCRIPTION, REMARKS (Well location, vent holes number/size/elevation, mounting, brackets, components, etc)

MARINE FOULING POTENTIAL: LIGHT ☐ MEDIUM ☐ HEAVY ☐ SEASONAL ☐

☐ Continued on reverse

GOES TRANSMISSION & SOLAR PANEL

ANTENNA S/N	DATE ANTENNA INSTALLED	CABLE LENGTH	LOW LOSS CABLE USED? ☐ YES ☐ NO	GMT OFFSET	AZIMUTH	LOCAL DEV.	ELEVATION
PLATFORM ID NUMBER	CHANNEL	TRANSMIT TIME	SOLAR PANEL MANUFACTURER & S/N			RATING	ANGLE

DESCRIPTION, REMARKS (Antenna mounting, etc)

☐ Continued on reverse

FIGURE 6-1A

8200 DATA RECORDER

8200 S/N	DATE 8200 INSTALLED	PROGRAM VERSION	POWER SOURCE	DESICCANT CHANGED?	CPU S/N	INTERCONNECT S/N
			☐ DC ☐ SOLAR	☐ YES ☐ NO		
DESCRIPTION, REMARKS (Mounting, location, etc)					AMP GAIN	SENSOR SLOPE

☐ Continued below

BACKUP WATER LEVEL SENSOR

SENSOR MANUFACTURER	SENSOR S/N	DATE SENSOR INSTALLED	SENSOR CONFIGURATION	PARALLEL PLATES?
☐ DRUCK ☐ IMO ☐ PAROSCIENTIFIC ☐ OTHER ______			☐ WATER ☐ BUBBLER	☐ YES ☐ NO

DESCRIPTION, REMARKS (Sensor location, installation details, etc)

☐ Continued below

OTHER SENSORS

AIR TEMPERATURE	DATE INSTALLED	BAROMETER S/N	DATE INSTALLED	CONDUCTIVITY S/N	DATE INSTALLED
☐ YES ☐ NO					
WATER TEMPERATURE	DATE INSTALLED	WIND SENSOR S/N	DATE INSTALLED	MET TOWER TYPE:	DATE INSTALLED
☐ YES ☐ NO				STEEL ☐ FIBERGLASS ☐	

DESCRIPTION, REMARKS (Sensor/tower location, installation details, etc)

☐ Continued below

LATEST LEVELS

DATE OF LEVELS	NUMBER OF BENCH MARKS CONNECTED	NUMBER OF BENCH MARKS ESTABLISHED	NUMBER OF BENCH MARKS RECOVERED	PBM CONNECTED?	DOWNSHOT LEVELING FIXTURE REQUIRED?
				☐ YES ☐ NO, EXPLAIN	☐ YES ☐ NO

REMARKS

☐ Continued below

AQUATRAK COEFFICIENT 2A (PBM above site datum: from HQ)	
AQUATRAK COEFFICIENT 2B (Leveling point above PBM: from levels)	+
AQUATRAK COEFFICIENT 2 (2A + 2B = 2)	=

REMARKS (Continuations, recommendations, etc)

FIGURE 6-1B

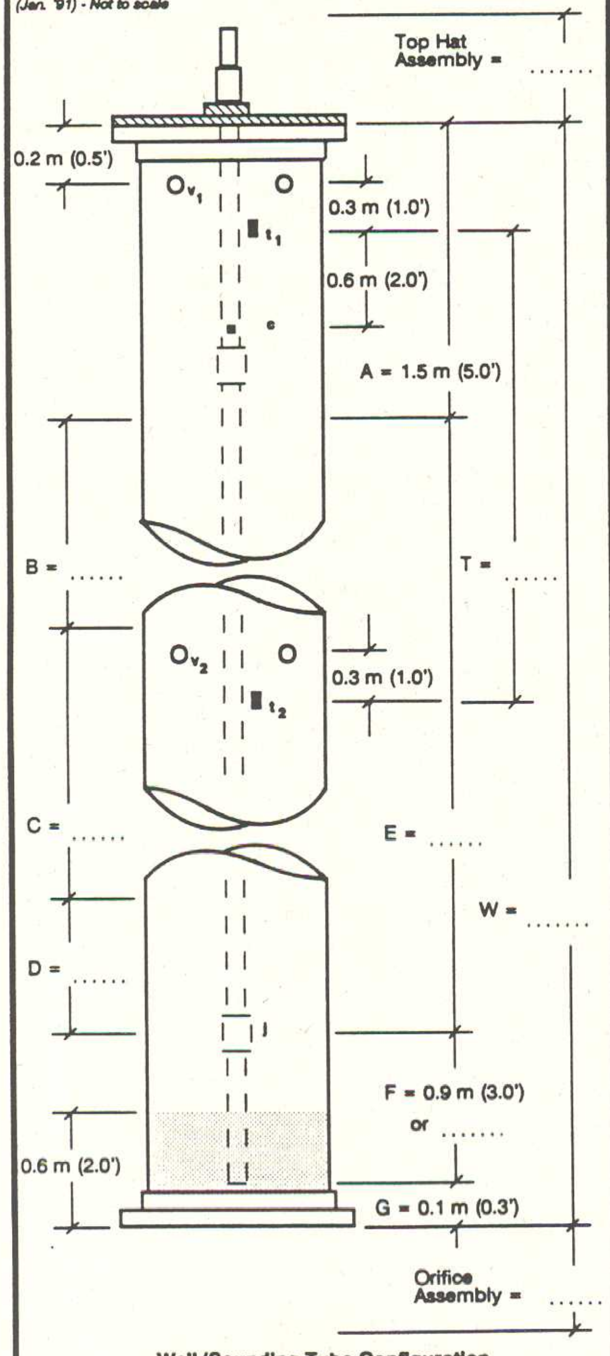
FIGURE 6-2

NGWLMS WELL/SOUNDING TUBE WORKSHEET

Station Name ______________________ ID# __________

Drawn by: ______________________ Date: __/__/__

(Jan. '91) - Not to scale



Well/Sounding Tube Configuration

A = Minimum cal tube/blanking zone clearance = 1.5 m (5.0')
B = Additional length (if any) required by deck elevation
C = (High obs/est - Low obs/est) + 2 x (Wave allowance)
{(   ) - (   )} + 2 x (   ) = __________
D = Additional safety factor length (if any)
E = B + C + D
F = Brass tube length = 0.9 m (3.0') or less
G = Sounding tube/orifice offset = 0.1 m (0.3')
W = Total well (flange to flange) length = A + E + F + G
T = Distance between upper and lower thermistors. See Section 4.1.1-E for t2 elevation computation.

Elevations on staff/ETG of ______________

Well/Sounding Tube Elevations

Draw well/sounding tube showing elevations of pier deck, harbor bottom, vent holes (v1 and v2), temperature sensors (t1 and t2), cal hole (c), brass/cpvc junction (j), highest and lowest observed/expected tides, and other datums or components as deemed necessary to fully document the the installation. Use the hash marks on both sides to scale out the drawing.

NGWLMS WELL/SOUNDING TUBE WORKSHEET INSTRUCTIONS

The worksheet is intended for use in designing and documenting the protective well/sounding tube lengths and elevations. One copy should be used to design the well/sounding tube installation at each site, and a second "as-built" copy submitted to document the installation. The worksheet is divided into two parts, a configuration side and an elevation side. The configuration side provides a conceptual sketch of the well/sounding tube with the predetermined measurements noted. It addresses the overall length of the well. The elevation side addresses the relationship of the well/sounding tube to the support structure and to the relevant water level datums.

Two types of information are required to design the well/sounding tube. First, the relevant water level datums such as lowest and highest expected/observed water levels, with a wave allowance applied, should be known. The great diurnal tide range (Gt) is required to compute the elevation of the lower temperature sensor in the protective well. Ensure that the datums are on the 1960-78 epoch. Second, existing elevations of various support structure components, such as the pier deck, instrument shelter floor, harbor bottom, etc., should be known. These elevations can be scaled off, on the right hand side of the worksheet, with zero typically equal to Mean Lower Low Water (or Low Water in the Great Lakes). The elevations can be used to evaluate how the well/sounding tube can best be installed in compliance with the requirements.

The configuration side provides a step-by-step process to determine the length of the well. Length A is the 1.5 m (5.0 ft) minimum clearance required for the cal tube/blanking zone above the highest expected/observed water level elevation. Length B is the additional height required for the top hat assembly to reach the pier deck, instrument shelter floor, etc., above and beyond the highest expected/observed water level elevation. Length C is the difference between the highest and lowest expected/observed water levels with wave allowances applied. Length D is the safety length added on at the well bottom, over the minimum depth requirement for the orifice, if sufficient water depth is available. Length E is the sum of B + C + D. Length F is the length of the brass antifouling tube, usually 0.9 m (3.0 ft), but possibly shorter if water depth limitations apply. Length G is the 0.1 m (0.3 ft) sounding tube end/well orifice offset. W is the total well length, defined as the top of the top well flange to the bottom of the bottom well flange, and computed by adding A + E + F + G. This can be rewritten as E + 2.5 m (8.3') if a standard brass tube is used.

Length T is the distance between the two thermistors. The upper sensor (t_1) is always placed at 0.6 m (2.0 ft) above the cal <u>hole</u> on the standard cal tube, or 0.3 m (1.0 ft) for the 0.5 m (1.6 ft) cal tube. The elevation of the lower sensor (t_2) is determined as specified in Section 4.1.1-E, and length T computed accordingly.

Vent holes (v_1 and v_2) distances are also shown. If any of these set distances or lengths must be modified, simply cross out the printed value and write in the actual. The abbreviations (v_1, v_2, t_1, t_2, j, c) can be used on the as-built sounding tube elevation sketch. Spaces to note top hat and orifice assembly lengths are also provided on the configuration.

WORKSHEET EXAMPLE

Figure 6-3 is an example on how to compute a protective well length and the elevation of the lower thermistor. All elevations used are on the existing staff. Consider a station with the following parameters. The station has an existing staff with a highest observed water level of 4.0 m (13.1 ft) and a lowest observed tide of 1.0 m (3.3 ft). The nearest wave station, referenced from Table 2, has an average wave height of 0.8 m (3.0 ft). Because the station location is somewhat sheltered from direct wave action, a decision is made to reduce it to 0.6 m (2.0 ft). The pier deck is 7.6 m (25.0 ft) and the harbor bottom is -3.0 m (-10.0 ft). The problem is to determine the length and elevation requirements for the NGWLMS protective well and sounding tube.

First, scale off the elevation side of the worksheet and draw lines marking the pier deck, extreme observed tides plus wave allowances, and harbor bottom. The highest observed water level plus wave allowance is 4.0 + 0.6 m (13.1 + 2.0 ft) = 4.6 m (15.1 ft). The lowest observed water level plus wave allowance is 1.0 - 0.6 m (3.3 - 2.0 ft) = 0.4 m (1.3 ft). Next, on the configuration side of the worksheet, compute the value of C (high obs/est - low obs/est + [2 x wave allowance]): 4.0 - 1.0 m + [2 x 0.6 m] (13.1 - 3.3 ft + [2 x 2.0 ft]) = 4.2 m (13.8 ft). Enter this in the appropriate space on the diagram.

Next, look at the top end of the well. The minimum elevation of the top of the well is length A above the high observed plus wave allowance, or 1.5 + 4.6 m (5.0 + 15.1 ft) = 6.1 m (20.0 ft). However, since the pier deck is higher than this elevation, 1.5 m (5.0 ft) is added to bring the well top up flush with the deck. This provides an additional safety margin against extreme high water level values, allows easy access to the top hat for maintenance, and avoids a potential temperature problem by keeping the entire well length below the pier. This additional distance is called length B and is shown on the configuration diagram.

Now consider the bottom end of the well. The low observed datum plus wave allowance is at 0.4 m (1.3 ft). At least 1.0 m (3.3 ft) more depth is needed to accommodate the brass tube and the sounding tube above orifice requirement. Adding on lengths F and G, 1.0 m (3.3 ft), on places the well bottom at -0.6 m (-2.0 ft). The harbor bottom is at -3.0 m (-10.0 ft) so plenty of water depth is available. There is no need to consider shortening the brass antifouling tube. Therefore, since at this point the well is 8.2 m (26.9 ft) in length, an additional 0.6 m (2.0 ft) is added on as a safety factor against extreme low water levels. This puts the well bottom at -1.2 m (-3.9 ft) which leaves plenty of clearance for the orifice assembly. The orifice assembly is approximately 0.2 m (0.8 ft) in depth. The additional value is called D and is shown on the configuration diagram.

Length E is the sum of B + C + D = 1.5 + 4.2 + 0.6 m (5.0 + 13.8 + 2.0 ft) = 6.3 m (20.8 ft).

Total well length, W, is now computed by adding: A + E + F + G, or E + 2.5 m (8.3 ft), since the standard brass tube was used. W = 6.3 + 2.5 m (20.8 + 8.3 ft) = 8.8 m (28.9 ft).

The final step is to determine the elevation of the lower thermistor so that T can be computed. The great diurnal range (Gt) at this site is 1.5 m (5.0 ft), and mean higher high water (MHHW) is at 3.4 m (11.0 ft). Following the criteria detailed in Section 4.1.1-E, select the formula MHHW + [0.3 x Gt] = 3.4 m + [0.3 x 1.5 m] (11.0 ft + [0.3 x 5.0 ft]) = 3.8 m (12.5 ft). This is less than the high observed value of 4.0 m (13.1 ft), therefore position the lower thermistor at this elevation. The elevation of the upper thermistor is 0.5 m (1.5 ft) below the top of the well which is 7.1 m (23.3 ft). T, or the distance between the two, = 7.1 - 3.8 m (23.3 - 12.5 ft) = 3.3 m (10.8 ft).

Now, using the scale set up earlier, draw the well on the elevation side of the worksheet. Mark off on the well where the vent holes (v_1 and v_2), the thermistors (t_1 and t_2), the calibration hole (c), and the cpvc/brass joint (j) are, and note their elevations. The above steps are performed to design the well. If any changes become necessary during actual installation, the worksheet can also be used to document the as-built.

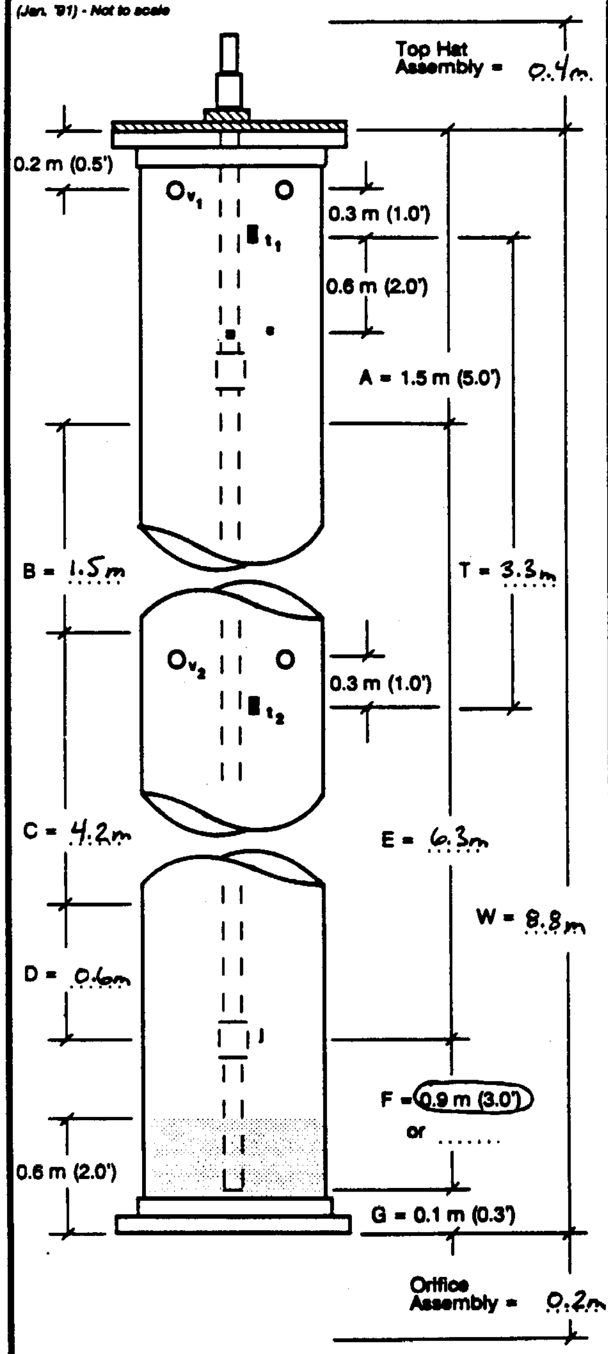
FIGURE 6-3

NGWLMS WELL/SOUNDING TUBE WORKSHEET

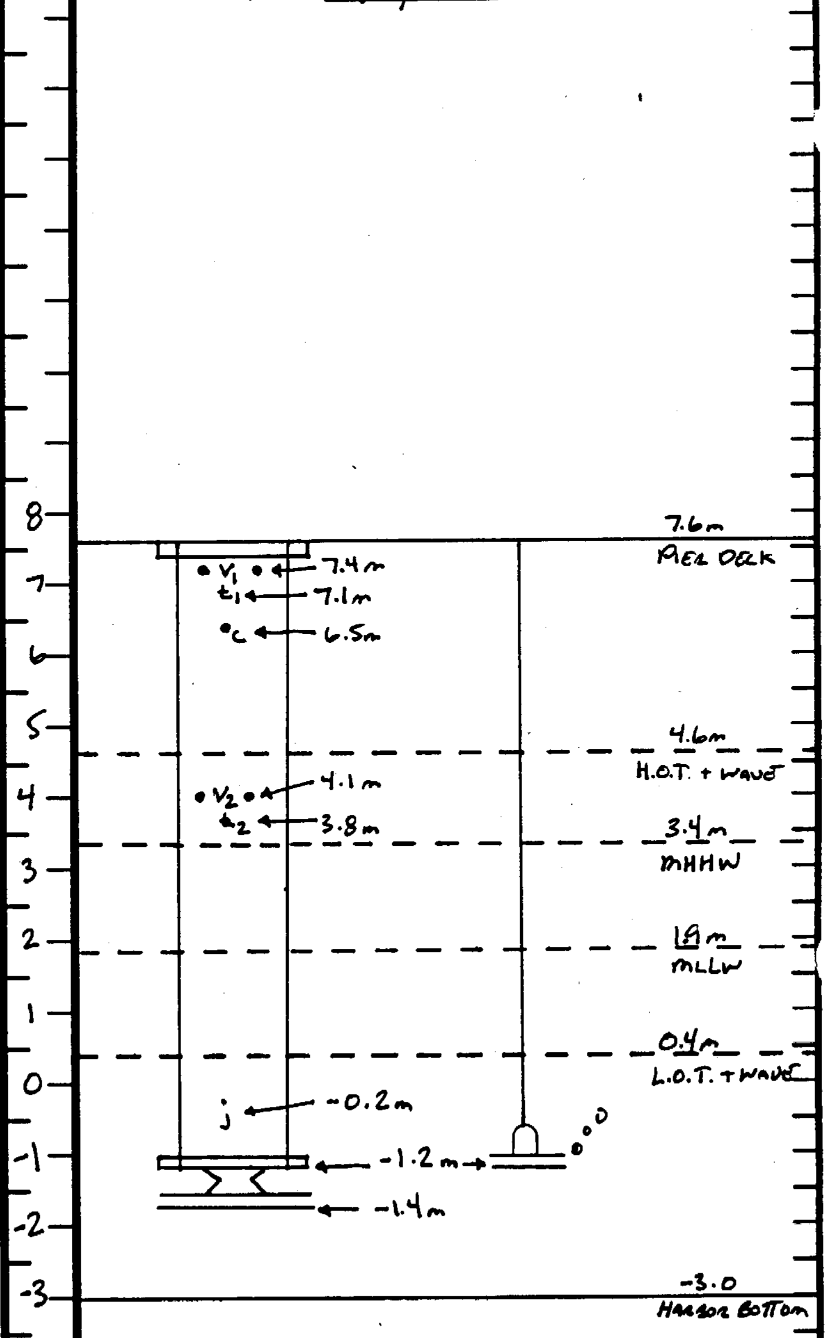
Station Name ANYSITE, USA ID# 123-4567

Drawn by: JOE FIELDS Date: 6/6/90

(Jan. '91) - Not to scale



Elevations on staff/ETG of 2/29/90



t_2 = 3.4m + (0.3 x 1.5m) = 3.8m < 4.0m H.O.T.

Well/Sounding Tube Configuration

A = Minimum cal tube/blanking zone clearance = 1.5 m (5.0')

B = Additional length (if any) required by deck elevation

C = (High obs/est - Low obs/est) + 2 x (Wave allowance)

{(4.0m) - (1.0m)} + 2 x (0.6m) = 4.2m

D = Additional safety factor length (if any)

E = B + C + D

F = Brass tube length = 0.9 m (3.0') or less

G = Sounding tube/orifice offset = 0.1 m (0.3')

W = Total well (flange to flange) length = A + E + F + G

T = Distance between upper and lower thermistors. See Section 4.1.1-E for t2 elevation computation.

Well/Sounding Tube Elevations

Draw well/sounding tube showing elevations of pier deck, harbor bottom, vent holes (v1 and v2), temperature sensors (t1 and t2), cal hole (c), brass/cpvc junction (j), highest and lowest observed/expected tides, and other datums or components as deemed necessary to fully document the the installation. Use the hash marks on both sides to scale out the drawing.

6.3 SENSOR TEST WORKSHEET

The Sensor Test Worksheet (see Figure 6-4) is a form that provides space to document the data recorded while testing each of the standard suite of sensors. It shall be used whenever sensors are installed or replaced at a NGWLMS site. Each section refers to a particular section which specifies the test data that shall be recorded. Submit the worksheet with the NGWLMS Site Report.

6.4 9000 RTU LOG BOOK

Each 9000 RTU has a spiral notebook, sealed in a plastic bag, inside the bottom compartment, that is used to log all activities performed on that unit. This provides field personnel working on the unit with the maintenance history of the unit onsite. The notebook, at installation, should contain the following:

- Date, location, and names of the installation crew.
- All serial numbers associated with the installation.
- All sensor coefficients.
- Sensor test results.
- Site GOES transmission information.

The logbook is to be kept in the lower compartment of the 9000 RTU.

6.5 SOFTWARE

Software is planned to automate all site documentation as well as track parts inventory and maintenance activities for operational statistics on system reliability, maintainability, and availability. The software will be issued with training and instructions when available.

(Jan. '91 Edition)

SENSOR TEST WORKSHEET

STATION NAME: ______________________ STATION NUMBER: ______________

PERSONNEL: ______________________ DATE: ____________

This form shall be used to document sensor test data. It shall be submitted with a NGWLMS Site Report form whenever sensors are installed, inspected, or replaced.

AQUATRAK/SOUNDING TUBE ASSEMBLY TEST (See Section 4.1.1C):

"READ AQT A" (9000 display) value = ________ + coefficient 1 = ________

Sounding tube length (leveling point to antifouling tube end) = ________

Differential = ________ (+/- 0.06 m {0.2 ft} allowable)

Aquatrak S/N: ____________

Cal tube S/N: ____________

Sensor Offset: ____________

TEMPERATURE SENSORS TEST (See Section 4.1.1D):

t_1 = upper thermistor, t_2 = lower, t_a = air, t_b = backup, t_w = water

	WATER TEST TEMPERATURE READINGS				
TIME	t_1	t_2	t_a	t_b	t_w

If the differential exceeds +/- 1.0 degree C, consult HQ. The average difference between sensors should be within +/- 0.3 degree C.

BACKUP PRESSURE SENSOR TEST (See Section 4.1.2A):

Backup Sensor S/N: ____________

TIME	*SENSOR*	*TIME*	*SENSOR*	*TIME*	*SENSOR*

BAROMETER CALIBRATION (See Section 5.2.2)

Barometer S/N: ____________ Portable S/N: ____________

TIME	*BAROMETER*	*PORTABLE*	*DELTA*

Enter the time, the first set of readings, and their difference (delta) in the first line. If delta exceeds +/- 1.0 mbar, adjust coefficient 2 as directed in Section 5.2.2. Take a second set of readings after the adjustment to verify the calibration. Record the new coefficient 2 below.

New coefficient 2 (if adjusted): ____________

GOES TRANSMISSION TEST (See Section 4.2.2H):

Antenna S/N: ____________

Cable type: ____________

Cable length: ____________

	RTU END	*ANTENNA END*
WATTMETER		
*FWD PWR**		
*REF PWR**		
*1ST LOOP**		
*2ND LOOP**		

*From Sutron 9000 program

If power at antenna end is less than 7 watts, or if substantial line loss is detected, contact headquarters for further direction. Substantial line loss is defined as being greater than 3 watts loss per 7 watts of power/10 meters (30 ft) of cable.

ADDITIONAL SENSOR TESTS: Ancillary sensor tests, data comparisons, supplementary test data, remarks, etc..

FIGURE 6-4

REFERENCES

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2). Lightning Protection Institute. Lightning Protection Institute Standard of Practice, Third Edition, 1987. Lightning Protection Institute. Harvard, IL 60033

3). Lockhart, Thomas J. *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meterological Measurements, August 1989.* US Environmental Protection Agency, Office of Research and Development, Atmospheric Research and Exposure Assessment Laboratory. Research Triangle Park, NC 27711

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7). Shih, Hsing H. *Water Level Measurement Errors Caused by Tide Gage Stilling Wells: Part III, Development of Design Modifications to Reduce Errors Induced by Current, Wave, and Marine Fouling Appendices, March 1, 1983.* Office of Oceanography and Marine Services, Rockville, MD 20852

8). SUTRON Corporation. *NGWLMS User's and Operator's Manual, June 1988.* The SUTRON Corporation, Herndon, VA 22071

9). SUTRON Corporation. *SUTRON 9000 RTU Operations and Maintenance Manual, December 1988.* The SUTRON Corporation, Herndon, VA 22071

10). SUTRON Corporation. *SUTRON Model 8200-0 Data Recorder Operations and Maintenance Manual, December 1988.* The SUTRON Corporation, Herndon, VA 22071

11). Young, Stephen A. *Users' Guide For the Gas-Purged Pressure Recording (Bubbler) Tide Gage, February 1977.* Oceanographic Division, Rockville, MD 20852

APPENDIX A NGWLMS COMPONENTS LIST

A.1 MANUFACTURER PROVIDED COMPONENTS

A.1.1 9000 REMOTE TERMINAL UNIT (RTU) - The 9000 RTU consists of a Data Instrumentation Sub-unit and an Interconnection Sub-unit housed in a NEMA enclosure with two doors. 9000 RTU components are:

<u>NEMA enclosure: 38.0 x 75.0 x 22.0 cm (15.0 x 29.5 x 8.75 inch)</u>

- 7 kg (15 lbs) empty.
- Double compartment construction with one door for each compartment; top compartment: 37.5 x 40.0 x 20.3 cm (14.75 x 15.75 x 8.0 inch), bottom compartment: 37.5 x 28.6 x 20.3 cm (14.75 x 11.25 x 8.0 inch).
- Doors hinged with a .06 Ga. continuous bridge and sealed with neoprene gasket using draw latches.
- .09 thick aluminum alloy 5052-H32 iridited per MIl-C-5541 Class 3.
- Outside surfaces and edges painted.
- Mounting tabs and feet on bottom; top mounting tabs have 1 cm (7/16 inch) diameter holes, spaced 24.3 cm (9.6 inch) apart, bottom mounting tabs are have 1 cm (7/16 inch) slots.
- One handle on top and one on side.
- I/O transition board mounted on wall separating compartments. Gasket and pcb conformal coating provide environmental seal between compartments.
- Humidity indicator valve on door.
- AC power cord 3 m (10 foot).

<u>Data Instrumentation Sub-unit: 30.5 x 34.4 x 15.2 cm (12.0 x 13.5 x 6.0 inch)</u>

- 7 kg (15 lbs).
- Mounted in top compartment.
- .06 thick aluminum alloy 5052-H32 iridited per MIL-C-5541 Class 3.
- Outside surfaces and edges painted.
- Modular construction with 10 module capacity:

1. Power supply
2. UHF Satellite Radio
3. Communications controller
4. General Purpose I/O
5. Memory expansion
6. Central Processor
7. Telephone modem
8. Aquatrak®
9. Spare (empty)
10. Spare (empty)

- Backplane mother board.
- Flat cables from 9000 modules mate with connectors on the upperside of I/O transition board mounted on bottom of compartment.

Interconnection Sub-unit

- 3.4 kg (7.5 lbs) excluding battery
- Mounted in lower compartment.
- AC power step-down board.
- Termination board with two flat cables to transition board.
- *YUASA* NP24-12 12 volt, 24 amp-hour battery: 14.0 x 21.6 x 14.0 cm (5.5 x 8.4 x 5.5 inch), 10 kg (22 lbs).
- Cable grips for external sensors routed through wall.

A.1.2 WATER LEVEL SENSORS AND AUXILARY COMPONENTS - Two water level sensors are included with each field unit. The primary sensor is an acoustic transducer and the backup sensor is a pressure transducer with its own data logger.

Primary sensor components

- Aquatrak® acoustic transducer head.
- 15 m (50 ft) mating cable.
- Two *YSI* 44032 thermistors with 3 m (10 ft) cable.
- Two 15 m (50 ft) mating cables.

Backup sensor components

- *Druck* 10/D or *IMO* pressure transducer: 0-10 m (0-30 ft) range.
- One *YSI* 44032 thermistor.
- Junction box for atmospheric venting/cable merging.
- *Sutron* 8200 Data Recorder mounted in 30.5 x 30.5 x 30.5 cm (12 x 12 x 12 inch) NEMA enclosure with 3 m (10 ft) cable (to RTU).
- Two 15 m (50 ft) cables between sensor/junction box, one 15 m (50 foot) unified cable between junction box/data recorder.
- Four 6-volt dry cell batteries.

A.1.3 SATELLITE ANTENNA

Sutron flat plate PVC GOES antenna: 28.0 x 28.0 x 20.3 cm (11.0 x 11.0 x 8.0 inch).

- 10 m (30 ft) cable.
- Mounting hardware.

A.2 AUXILARY COMPONENTS

A.2.1 FIELD UNIT

Support structure.
Instrument shelter.
Utilities (electric/solar panel and telephone).
Grounding system.

A.2.2 PROTECTIVE WELL

White, Schedule 80, 15 cm (6 inch) diameter, PVC pipe.
Schedule 80, 15 cm (6 inch) diameter, PVC couplers, flanges, caps.
Acoustic Sensor Mounting Plate Assembly.
NO HUB coupler used for vent hole covers.
Brass double cone orifice with parallel plates.
Copper sheet insert.
Support brackets and associated hardware.

A.2.3 SOUNDING TUBE

Aquatrak® sounding tube installation kit (*BARTEX* PN: S3000-28G).

- 5 - Center bails (*BARTEX* PN: 6-18002-1).
- 1 - Cal tube (to be matched with acoustic sensor)
- 1 - 1.5 m (5.0 ft) cpvc trim tube (no coupler)
- 4 - 1.5 m (5.0 ft) cpvc tubes (with couplers)
- 1 - 0.9 m (3.0 ft) brass antifouling tube with coupler
- 1 - cutting jig
- 1 - package tie wraps

Leveling fixture(s).

A.2.4 BACKUP PRESSURE SENSOR ASSEMBLY

Mounting/backing board assembly and mounting hardware.

A.2.5 ANTENNA MOUNT

5 cm (2 inch) diameter, galvanized steel pipe with couplers and baseplate.

A.2.6 CONDUIT

PVC or galvanized steel pipe, sized as required.
Couplers, elbows, and outlet bodies.

APPENDIX B SITE PREPARATION TOOL AND EQUIPMENT CHECKLIST

This checklist attempts to list most items specifically required at NGWLMS sites as a planning aid. Common tools, such as screwdrivers, wrenches, hammers, etc., are not listed but will be needed. Hardware items are separated into general categories for ease of use. A laptop, notebook, or portable 8086/8088 (or higher) IBM (or compatible) PC with a floppy drive is also required to interact with the field unit.

STATION ____

TOOLS/SPECIAL EQUIPMENT	QUANTITY NEEDED (IF APPLICABLE)
Air tools w/Chicago Drill	______________________
Air tools w/o Chicago Drill	______________________
Chop saw	______________________
Electric drill motor	______________________
Coring equipment	______________________
Extension cord	______________________
1-1/2" Wrenches for 1" SS nuts	______________________
1-1/8" Wrenches for 3/4" SS nuts	______________________
Pipe wrenches	______________________
Pipe strap wrench	______________________
Pipe cutter	______________________
Crosscut saw	______________________
Hack saw	______________________
Hole saw kit	______________________
Piling scraper	______________________
Plumb bob	______________________
Carpenters level	______________________
Inclinometer	______________________
Compass	______________________
Telephone	______________________
Steel ruler (metric)	______________________
Steel/cloth tapes	______________________
Leveling fixtures	______________________
Rope	______________________
Boatswain chair w/rope	______________________
Jacobs ladder	______________________
Silicon sealant	______________________
Camera w/film	______________________
Flashlight	______________________
Work gloves	______________________

HARDWARE	QUANTITY
Conduit	
1-1/4 inch PVC conduit	________________________(m/ft)
1-1/4 inch sweep L 90 elbow	__________________________(#)
1-1/4 inch LB junction box	__________________________(#)
1-1/4 inch couplers	__________________________(#)
1-1/4 inch 45/90 elbow couplers	__________________________(#)
Half omega clamps for conduit	__________________________(#)
3/8 x 2-1/2 inch SS bolts	__________________________(#)
3/8 inch double expansion shields	__________________________(#)
3/8 & 1/2 inch bolts w/washers	__________________________(#)
Protective Well	
6 inch, schedule 80, PVC pipe	________________________(m/ft)
6 inch PVC slip/slip coupler	__________________________(#)
1/4 x 1 inch SS bolts (coupler)	__________________________(#)
6 inch PVC slip flanges (3)	__________________________
6 inch PVC threaded flange (1)	__________________________
3/4 inch SS bolts/nuts/washers	__________________________(#)
3/4 inch SS lock bolt	__________________________
Lock	__________________________
6 inch PVC end cap (1)	__________________________
PVC primer/glue	__________________________
6 inch NO HUB SS coupler (3)	__________________________
Copper sheet insert	__________________________
Double inverted cone	__________________________
Parallel plates	__________________________
Protective Well Brackets For Pile Connection	
6 inch pipe brackets	__________________________(#)
Pile brackets (_______ inch)	__________________________(#)
1 inch SS all thread	__________________________(#)
1 inch SS washers	__________________________(#)
1 inch SS nuts	__________________________(#)

HARDWARE	QUANTITY
Protective Well Brackets For Pier Face Connection	
6 inch pipe brackets	__________________________(#)
1 inch SS all thread	__________________________(#)
1 inch SS washers	__________________________(#)
1 inch SS nuts	__________________________(#)
4 inch L brackets	__________________________(#)
Ship channel wall brackets	__________________________(#)
1/2 x 3 inch SS bolts w/washers	__________________________(#)
1/2 x 7/8 inch expansion washers	__________________________(#)
Lag screws - 3/8 x ______ inch	__________________________(#)
Lag screws - 1/2 x ______ inch	__________________________(#)
Lag screws - 5/8 x ______ inch	__________________________(#)
Lag screw washers	__________________________(#)
Sounding Tube	
Aquatrak® sounding tube kit	__________________________
Additional CPVC/coupler sections	__________________________(#)
CPVC primer/glue	__________________________
Center bails	__________________________(#)
Tie wraps, short	__________________________(#)
Backup Sensor Assembly	
Fiberglass mounting board	________________________(m/ft)
Sensor mounting block	__________________________
Mini parallel plates	__________________________
Glide brackets	__________________________(#)
Lifting eye	__________________________
Lifting line or chain	________________________(m/ft)
or	
Brass orifice	__________________________
Neoprene tubing	________________________(m/ft)
Connectors	__________________________(#)
Manifold	__________________________
Nitrogen tank	__________________________
Regulator	__________________________

Antenna

Low loss cable	________________________	(m/ft)
2 inch galvanized pipe	________________________	(m/ft)
2 inch pipe baseplate	__________________________	
SS U-bolts (3-1/2 inch) w/nuts & washers	__________________________	(#)
SS U-bolts (5 inch) w/nuts & washers	__________________________	(#)
Guy wire	________________________	(m/ft)
SS wire cutter	__________________________	
Turnbuckles	__________________________	(#)
Thimble	__________________________	
Eye bolts w/nuts/washers	__________________________	(#)
Eye bolts, lag screw type	__________________________	(#)
Nico-press crimper w/sleeves	__________________________	
Tie wraps, long	__________________________	
Tie wraps, medium	__________________________	

APPENDIX C LIGHTNING PROTECTION

C.1 BACKGROUND

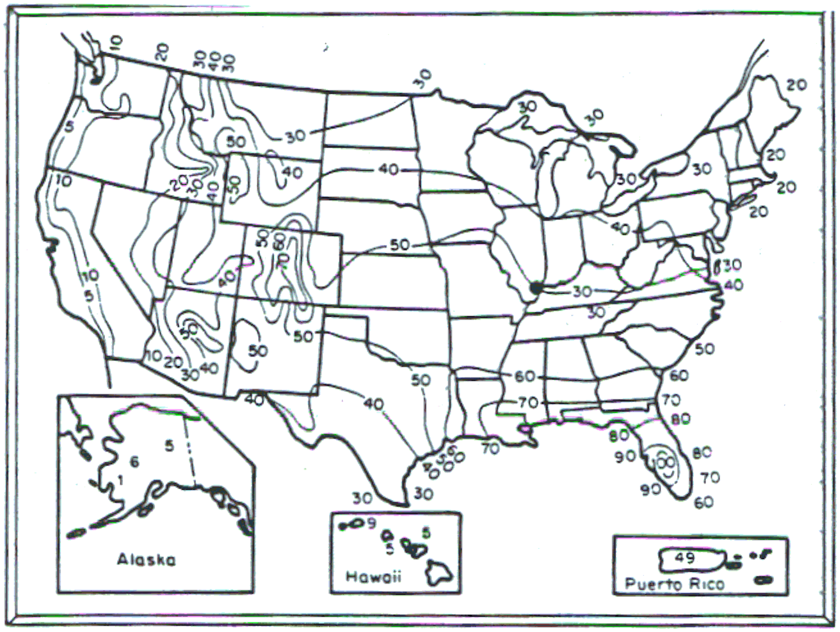
Lightning protection is necessary at some NGWLMS sites in order to protect the instrument shelter and its contents from the thermal, mechanical, and electrical effects resulting from a direct or nearby lightning strike. Protection from lightning and its effects can be provided on two levels. First, if a direct strike is probable, a complete lightning protection system as described below should be installed. Second, if only a nearby strike is probable, an adequate surge suppressor should suffice. The NGWLMS 9000 RTU has a surge suppressor built into the system that should be adequate for all but the most severe strikes. NGWLMS sites can be evaluated for lightning strike potential using the following criteria, and have lightning protection provided, if required.

C.2 SITE EVALUATION

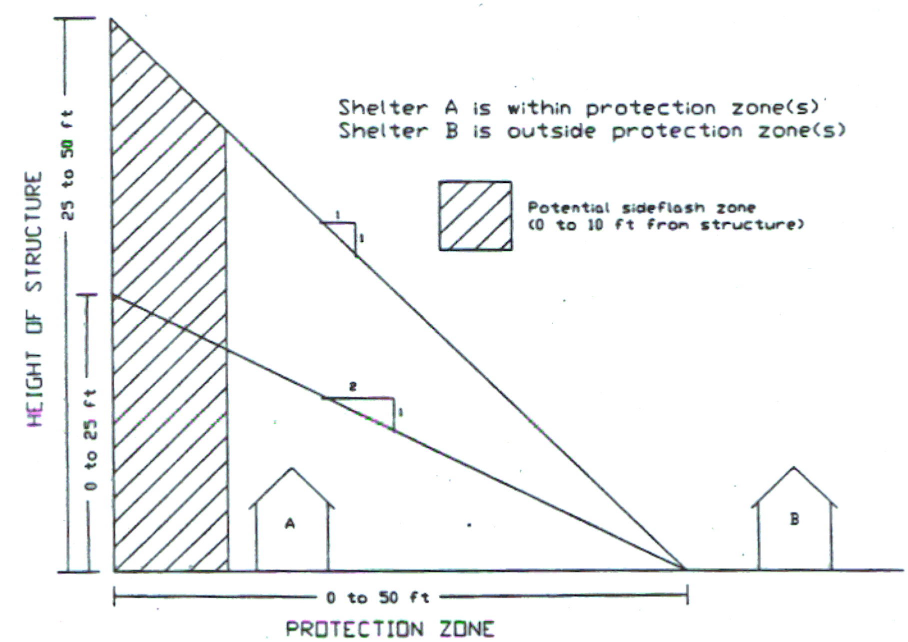
There are two main factors to consider when evaluating the lightning strike potential of a site. One is the geographic location of the site. Figure C-1 has a thunderstorm day map that gives the number of days a year a location experiences lightning. It can be seen that the southeast coastal states have the highest occurrence of storms while the rest of the east coast and great lakes have a lower, but still significant, frequency. The west coast sites, including Alaska and the Pacific island sites have a very low frequency.

Second, the configuration of the site shelter in relation to nearby, elevated, structures is important. Nearby structures that are higher than the shelter will protect the shelter from direct lightning strikes. This must be evaluated on a site by site basis. A shelter is considered protected from a direct lightning strike if it is within a one-to-two zone of protection (see Figure C-1) from a nearby structure that is 0 to 8 m (0 to 25 ft) tall, or a one-to-one zone if the structure is 8 to 15 m (25 to 50 ft) tall. The structure can be a building, a tower, a light standard, etc. Lightning will strike the structure and not the shelter. If the structure, particularly a metal pole or tower, is within 3 m (10 ft) of the shelter the possibility of a sideflash exists. A sideflash occurs when lightning strikes the structure, travels down the exterior, encounters high resistance to finding a ground, and arcs over to another nearby structure (i.e., the shelter). In a situation such as this, the first ten feet of the protected zone can no longer be considered protected, unless the nearby structure has a lightning protection system on it. Should protection be required for the shelter in this case, a lightning protection system should be installed either on the nearby structure, or on the shelter.

Finally, other factors include cost considerations and data priority. Continuous real-time data from some sites may be deemed critical enough to justify protection, even if the risk of lightning induced damage is low.



1. THUNDERSTORM DAY MAP



2. LIGHTNING PROTECTION ZONE

FIGURE C-1
LIGHTNING PROTECTION RISK ASSESSMENT GUIDELINES

C.3 LIGHTNING PROTECTION DESIGN SPECIFICATIONS

A lightning protection system is composed of air terminals, conductors, and grounds. It is designed to intercept the lightning flash, and lead the current flow down along the outside of the protected structure to a grounding system, where it is dissipated harmlessly. An air terminal, which is a pointed solid or hollow tube, is placed at or near the center of the shelter roof. The air terminal is connected by conductors (cable) which provide a path to ground from the air terminal. A ground is provided by rods or plates placed in the earth or underwater. Lightning protection system specifications are provided below and have been adapted from the Lightning Protection Institue Standard of Practice: LPI-175 for application to a typical NOS NGWLMS fiberglass instrument shelter.

1. Air terminals shall be 1/2 inch diameter copper rod or tube with a minimum wall thickness of 1/32 inch. Fittings and attachments shall be copper and of bolted pressure type construction. Conductors shall be cable, made up of multiple strands of 17 gauge copper wire, weighing 187.5 pounds/1000 feet. Ground rods shall be 5/8 inch diameter copper rod at least 3 m (10 ft) long, or 20 gauge copper plate at least 0.2 m^2 (2.0 ft^2) in area.

2. The air terminal shall protrude a minimum of 0.3 m (0.8 ft) above adjacent projections and shall be centered on the roof.

3. Two paths to ground shall be provided by conductors for the air terminal. Branch conductors shall be connected to all metal objects (antennas, sensor masts, etc.) within 2 m (6 ft) of any main conductor and to any metal service conduit entering the shelter. Plastic conduit does not require a connection.

4. The two ground connections shall be spaced as far apart, and as far from the shelter, as possible. Rods shall be used for an earth ground connection and plates for an underwater ground connection. An earth connection is preferred over an underwater connection. Rods should be driven into the earth at least 3 m (10 ft) deep. Permanently moist clayey soil is the most desirable earth type for a ground. Dry sandy soils are the worst. Plates shall be secured to a support structure below the lowest expected water level.

APPENDIX D COEFFICIENT "2A": PRIMARY BENCH MARK (PBM) ABOVE SITE DATUM OF TABULATION

Station Number	Station Name	PBM Stamping	PBM Above Datum Meters	(Feet)
841 0140	Eastport, ME	NO 3 1918	15.685	(51.46)
841 1250	Cutler, ME	1250 K 1978	22.232	(72.94)
841 3320	Bar Harbor, ME	No Stamping (6 1911)	6.383	(20.94)
841 5490	Rockland, ME	5490 K 1976	10.058	(33.00)
841 8150	Portland, ME	ELEV 14.501 FT TIDAL 31	8.406	(27.58)
844 3970	Boston, MA	K 12 MASS G.S. 1936	14.292	(22.50)
844 7930	Woods Hole, MA	11 1932	3.447	(11.31)
844 9130	Nantucket, MA	NO 22 1934	3.685	(12.09)
845 2660	Newport, RI	6 (1943)	2.813	(9.23)
845 4000	Providence, RI	NO 6 RESET 1930	4.493	(14.74)
846 1490	New London, CT	13 1938	4.176	(13.70)
846 7150	Bridgeport, CT	NO 15 1964	4.624	(15.17)
851 0560	Montauk, NY	0560 J 1977	3.618	(11.87)
851 4560	Port Jefferson, NY	4560 B 1981	5.264	(17.27)
851 6990	Willets Point, NY	NO 3 1944	5.115	(16.78)
851 8750	NYC (Battery), NY	NO 5 1973	4.984	(16.35)
851 9483	Bergen Point, NY	9483 A 1981	5.553	(18.22)
853 1680	Sandy Hook, NJ	1680 A 1979	3.578	(11.74)
853 1991	Long Branch, NJ	TIDAL NO 1 1948	10.546	(34.60)
853 4770	Ventnor City, NJ	4770 A 1985	9.376	(30.76)
853 6110	Cape May, NJ	NO 1 1965	4.892	(16.05)
853 9993	Trenton, NJ	TERMINAL	5.169	(16.96)
854 5530	Philadelphia, PA	5530 A 1989	4.688	(15.38)
855 1910	Reedy Point, DE	1910 B 1979	3.685	(12.09)
855 7380	Lewes, DE	NO 20 1975	3.990	(13.09)
857 0280	Ocean City, MD	F 104 1962	3.719	(12.20)
857 1892	Cambridge, MD	1892 D 1980	3.344	(10.97)
857 3364	Tolchester, MD	KNOB 1950	9.470	(31.07)
857 3903	Town Point, MD	NO 5 1972	3.097	(10.16)
857 4070	Havre de Grace, MD	NO 5 1938	9.306	(30.53)
857 4680	Baltimore, MD	25 1919	3.057	(10.03)
857 5512	Annapolis, MD	7 1941	2.877	(9.44)
857 7330	Solomons Island, MD	7330 A 1978	5.172	(16.97)
859 4900	Washington, DC	TIDAL NO 1 1951	4.115	(13.50)

Station Number	Station Name	PBM Stamping	PBM Above Datum Meters	(Feet)
863 1044	Wachapreague, VA	1044 B 1978	4.139	(13.58)
863 2200	Kiptopeke, VA	L-418	4.130	(13.55)
863 5150	Colonial Beach, VA	NO 8 1959	2.926	(9.60)
863 5750	Lewisetta, VA	R 462 1971	2.874	(9.43)
863 6580	Windmill Point, VA	NO 2 1970	2.161	(7.09)
863 7624	Gloucester Point, VA	7624 F 1979	3.917	(12.85)
863 8610	Hampton Roads, VA	6 1927	5.197	(17.05)
863 8660	Portsmouth, VA	No Stamping (5-F9 1913)	3.984	(13.07)
863 8863	Ches. Bay Bridge, VA	NO 2 1975	15.914	(52.21)
865 1370	Duck (Outside) Pier, NC	865 1370 B 1977	10.061	(33.01)
865 4400	Cape Hatteras, NC	NO 1 1973	3.408	(11.18)
865 6483	Duke Marine Lab, NC	NO 12 1964	3.417	(11.21)
865 8120	Wilmington, NC	8120 D 1976	2.454	(8.05)
866 1070	Springmaid Pier, SC	1070 B 1976	12.817	(42.05)
866 1139	Bucksport, SC	NO 7 1975	5.331	(17.49)
866 2746	Winyah Bay, SC	W.B. NO. 1 1975	2.938	(9.64)
866 2799	South Santee River, SC	V 124 1976	7.952	(26.09)
866 4022	General Dynamics, SC	4022 A 1976	3.319	(10.89)
866 5530	Charleston, SC	ELEV NO 13 8.264 FT 1928	4.020	(13.19)
867 0870	Fort Pulaski, GA	5	4.877	(16.00)
872 0030	Fernandina, FL	34 1923	4.770	(15.65)
872 0220	Mayport, FL	BM EDM 15 1942 MSL	3.206	(10.52)
872 1120	Daytona Beach, FL	NO 1 1966	5.907	(19.38)
872 1456	Titusville, FL	Z 131	3.722	(12.21)
872 2621	Palm Beach, FL	A 2621 1976	2.926	(9.60)
872 2670	Lake Worth, FL	Q 317 1970	14.484	(47.52)
872 3080	Haulover Pier, FL	3080 A 1982	2.512	(8.24)
872 3170	Miami Beach, FL	BM NO 6 USE	2.890	(9.48)
872 3962	Key Colony Beach, FL	3962 A 1976	2.758	(9.05)
872 3970	Vaca Key, FL	NO 1 1975	2.073	(6.80)
872 4580	Key West, FL	29 1923 8.140	3.981	(13.06)
872 5110	Naples, FL	NO 7 1974	4.225	(13.86)
872 5520	Fort Myers, FL	5520 C 1978	2.755	(9.04)
872 6520	St. Petersburg, FL	NO 16 1962	2.789	(9.15)
872 6724	Clearwater Beach, FL	LP 10 RM 1	2.234	(7.33)
872 7520	Cedar Key, FL	8 1910	2.347	(7.70)
872 8229	Shell Point, FL	NO 1 1973	2.350	(7.71)
872 8360	Turkey Point, FL	NO 1 1969	2.521	(8.27)
872 8690	Apalachicola, FL	NO 1 1933 14.124	5.669	(18.60)
872 9108	Panama City, FL	L 9108 1977	3.965	(13.01)
872 9210	Dan Russell Pier, FL	9210 C 1989	12.820	(42.06)
872 9678	Navarre Beach, FL	9678 H 1977	11.826	(38.80)
872 9840	Pensacola, FL	8 1923	6.498	(21.32)
873 5180	Dauphin Island, AL	NO 1 1960	6.288	(20.63)
874 7437	Bay Waveland, MS	7437 A 1978	1.871	(6.14)

Station Number	Station Name	PBM Stamping	PBM Above Datum Meters	(Feet)
876 0551	South Pass, LA	N 280 1971	1.100	(3.61)
876 1724	Grand Isle, LA	10	2.810	(9.22)
876 1927	USCG New Canal Sta, LA	1927 A 1982	2.896	(9.50)
876 2928	Cocodrie, LA	2928 A 1986	1.786	(5.86)
877 0570	Sabine Pass North, TX	0570 A 1985	3.264	(10.71)
877 1450	Galveston, Pier 21, TX	ELEV 7.151 U. S. ENG.	2.856	(9.37)
877 1510	Galveston, Pleas. Pier, TX	NO 43 1957	8.605	(28.23)
877 2440	Freeport, TX	2440 A 1980	4.874	(15.99)
877 4770	Rockport, TX	NO 3 1934	3.078	(10.10)
877 5870	Corpus Christi, TX	5870 A 1983	9.098	(29.85)
877 8490	Port Mansfield, TX	1 (1964)	2.396	(7.86)
877 9751	Padre Island, TX	2 1934	2.195	(7.20)
877 9770	Port Isabel, TX	2 1944	4.657	(15.28)
941 0170	San Diego, CA	12 1926	6.325	(20.75)
941 0230	La Jolla, CA	7 1958	12.299	(40.35)
941 0580	Newport Beach, CA	1 NP 1955	4.599	(15.09)
941 0660	Los Angeles, CA	8-14 FT ABOVE MLLW	5.361	(17.59)
941 0840	Santa Monica, CA	4 1940	9.339	(30.64)
941 1340	Santa Barbara, CA	1 1930	5.934	(19.47)
941 2110	Port San Luis, CA	6 1936	5.691	(18.67)
941 3450	Monterey Harbor, CA	NO 2 1924	5.669	(18.60)
941 4290	San Francisco, CA	180 1936	5.794	(19.01)
941 4750	Alameda, CA	NO 8 1939	4.795	(15.73)
941 5020	Point Reyes, CA	BM B243 1949	4.977	(16.33)
941 5144	Port Chicago, CA	5144 H 1976	4.209	(13.81)
941 6841	Arena Cove, CA	6 1945	11.604	(38.07)
941 8767	North Spit (Humboldt), CA	NO 9 1937	9.205	(30.20)
941 9750	Crescent City, CA	TIDAL 20 1959 RESET 1960	5.227	(17.15)
943 1647	Port Orford, OR	6 1937	12.256	(40.21)
943 2780	Charleston, OR	2780 A 1981	5.895	(19.34)
943 5380	South Beach, OR	A 590 1965	6.419	(21.06)
943 9040	Astoria, OR	TIDAL 11 1959	5.934	(19.47)
944 0910	Toke Point, WA	0910 H	6.669	(21.88)
944 3090	Neah Bay, WA	NO 19 1962	6.507	(21.35)
944 4090	Port Angeles, WA	L 467 1974	14.475	(47.49)
944 4900	Port Townsend, WA	NO 9 1952	4.548	(14.92)
944 7130	Seattle, WA	NO 13 1922	8.083	(26.52)
944 9424	Cherry Point, WA	TIDAL 1 1971	11.226	(36.83)
944 9880	Friday Harbor, WA	NO 10 1964	4.892	(16.05)
945 0460	Ketchikan, AK	NO 24 1921	8.946	(29.35)
945 1600	Sitka, AK	TIDAL 26 1974	13.920	(45.67)
945 2210	Juneau, AK	No Stamping (8)	13.036	(42.77)
945 2400	Skagway, AK	NO 11 1969	11.646	(38.21)
945 3220	Yakutat Bay, AK	3220 Z 1986	8.745	(28.69)
945 4050	Cordova, AK	4050 M 1977	9.406	(30.86)
945 4240	Valdez, AK	NO 21 1966	8.327	(27.32)

Station Number	Station Name	PBM Stamping	PBM Above Datum Meters	(Feet)
945 5090	Seward, AK	NO 22 1966	9.458	(31.03)
945 5500	Seldovia, AK	BM 19 1967	11.272	(36.98)
945 5760	Nikishka, AK	NIKISKI 1	12.518	(41.07)
945 5920	Anchorage, AK	NO 15 RESET 1966	13.231	(43.41)
945 7292	Kodiak (Womens Bay), AK	7292 B 1984	14.124	(46.34)
945 9450	Sand Point, AK	5 1943	14.886	(48.84)
946 1380	Adak, AK	NO 18 1957	6.700	(21.98)
946 2620	Unalaska, AK	NO 7 1956	3.597	(11.80)
946 3502	Port Moller, AK	3502 B	15.420	(50.59)
949 7645	Prudhoe Bay STP, Ak	Cell 4 B	16.389	(53.77)
161 1347	Port Allen, HI	1347 A 1988	4.432	(14.54)
161 1400	Nawiliwili, HI	NO 5 1954	2.256	(7.40)
161 2340	Honolulu, HI	BM ELEV 8.06 FEET	3.734	(12.25)
161 2480	Mokuoloe, HI	NO 1 1957	1.969	(6.46)
161 5680	Kahului, HI	2 1929	3.456	(11.34)
161 7433	Kawaihae, HI	BM 6 1968	3.121	(10.24)
161 7760	Hilo, HI	NO 4 1951	4.663	(15.30)
161 9000	Johnston, Island	NO 13 1955	2.850	(9.35)
161 9910	Sand Island, Midway	21 1959	3.243	(10.64)
163 0000	Apra Harbor, Guam	NO 4 1949	2.996	(9.83)
173 2417	Papeete, Tahiti	NU 2 1969	13.826	(45.36)
177 0000	Pago Pago, Am. Samoa	0000 M 1983	4.023	(13.20)
182 0000	Kwajalein	NO 8 1951	2.853	(9.36)
184 0000	Truk Atoll	B 1948	2.454	(8.05)
189 0000	Wake Island	NO 12 1961	4.353	(14.28)
191 0000	Suva, Fiji	1 1989	13.664	(44.83)
212 2060	Darwin, Australia	S79/509/66A	15.228	(49.96)
243 1000	Diego Garcia	1000 D 1990	14.268	(46.81)
269 5535	St. Georges, Bermuda	5535 H 1978	2.444	(8.02)
269 5540	Esso Pier, Bermuda	5540 A 1979	14.807	(48.58)
971 0441	Settlement Pt, Bahamas	0441 A 1985	13.725	(45.03)
975 1224	West Indies Lab, VI	NO 1 1975	2.463	(8.08)
975 1401	Limetree Bay, VI	975-1401 M 1983	13.612	(44.66)
975 1639	Charlotte Amalie, VI	1639 F 1983	3.267	(10.72)
975 5371	San Juan, PR	5371 A 1977	2.600	(8.53)
975 9110	Magueyes Island, PR	TIDAL BM NO 1 1955	4.755	(15.60)

APPENDIX E NGWLMS ANCILLARY SENSOR MANUFACTURER INFORMATION

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- E.1.1 OPERATING INSTRUCTIONS
- E.1.2 MAIN HOUSING TRANSDUCER ASSEMBLY DIAGRAM
- E.1.3 CABLE WIRING DIAGRAM
- E.1.4 GENERAL ASSEMBLY DIAGRAM
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E.2 BAROMETRIC PRESSURE

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E.7 RESERVED FOR WATER CURRENT

E.8 WATER CONDUCTIVITY

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E.9 WATER TEMPERATURE

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E.11 RESERVED FOR ANALOG, FREQUENCY DEVICES

E.12 METEROLOGICAL TOWERS

E.12.1 BRACKETED STEEL TOWER

E.12.1.1 SPECIFICATION SHEET
E.12.1.2 ASSEMBLY/INSTALLATION INSTRUCTIONS
E.12.1.3 TOWER SECTION DIAGRAM
E.12.1.4 BASEPLATE DIAGRAM
E.12.1.5 PARTS LIST
E.12.1.6 WIND LOAD DIAGRAMS

E.12.2 FIBERGLASS POLE

E.12.2.1 SPECIFICATION SHEETS
E.12.2.2 TECHNICAL DATA

E.1 WIND SENSOR

PRECISION METEOROLOGICAL INSTRUMENTS

YOUN

INSTRUCTIONS

MODEL 05103
WIND MONITOR

☑ WIND MONITOR

- SPECIFICATION SUMMARY
- INTRODUCTION
- INITIAL CHECK OUT
- INSTALLATION
- CALIBRATION
- MAINTENANCE
- SECTION VIEW
- PROPELLER CALIBRATION CURVES
- CABLE AND WIRING DIAGRAM
- ASSEMBLY DIAGRAM
- REPLACEMENT PARTS AND ACCESSORIES

☐ SENSOR INTERFACE CARD

☐ LINE DRIVER

☐ WS/WD INDICATOR

☐ RECORDER - TRANSLATOR

☐ ______________________

☐ ______________________

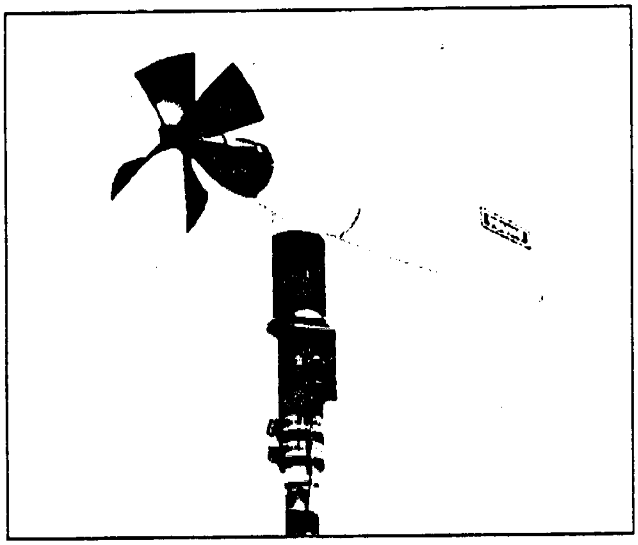
R. M. YOUNG COMPANY

2801 Aero-Park Drive, Traverse City, MI 49684, U. S. A.

PHN 616-946-3980 FAX 616-946-4772 TWX 810-291-3366

MARCH 90

MODEL 05103
WIND MONITOR



WIND SPEED SPECIFICATION SUMMARY:

Range	0 to 60 m/s (130 mph), gust survival 100 m/s (220 mph)
Sensor	18 cm diameter 4-blade helicoid propeller molded of polypropylene
Pitch	29.4 cm
Distance Constant	2.7 m (8.9 ft.) for 63% recovery
Threshold Sensitivity	1.0 m/s (2.2 mph)
Transducer	Centrally mounted stationary coil, 3K ohm nominal DC resistance
Transducer Output	AC sine wave signal induced by rotating magnet on propeller shaft. 70 mV p-p at 60 rpm. 14 V p-p at 12000 rpm.
Output Frequency	3 cycles per propeller revolution (0.098 m/s per Hz)

WIND DIRECTION (AZIMUTH) SPECIFICATION SUMMARY:

Range	360° mechanical, 355° electrical (5° open)
Sensor	Balanced vane, 38 cm (15 in) turning radius.
Damping Ratio	0.25
Delay Distance	1.3 m (4.3 ft) for 50% recovery
Threshold Sensitivity	1.0 m/s (2.2 mph) at 10° displacement 1.5 m/s (3.4 mph) at 5° displacement
Damped Natural Wavelength	7.4 m (24.3 ft)
Undamped Natural Wavelength	7.2 m (23.6 ft)
Transducer	Precision conductive plastic potentiometer, 10K ohm resistance (±20%), 0.25% linearity, life expectancy 50 million revolutions, rated 1 watt at 40° C, 0 watts at 125° C
Transducer Excitation Requirement	Regulated DC voltage, 15 VDC max
Transducer Output	Analog DC voltage proportional to azimuth angle with regulated excitation voltage applied across potentiometer.

INTRODUCTION

The Wind Monitor measures horizontal wind speed and direction. Originally developed for ocean data buoy use, it is rugged and corrosion resistant yet accurate and light weight. The main housing, nose cone, propeller. and other internal parts are injection molded U.V. stabilized plastic. The nose cone assembly threads directly into the main housing contacting an o-ring seal. Both the propeller and vertical shafts use stainless steel precision grade ball bearings. Bearings have light contacting teflon seals and are filled with a low torque wide temperature range grease to help exclude contamination and moisture.

Propeller rotation produces an AC sine wave signal with frequency proportional to wind speed. This AC signal is induced in a stationary coil by a six pole magnet mounted on the propeller shaft. Three complete sine wave cycles are produced for each propeller revolution.

Vane position is transmitted by a 10K ohm precision conductive plastic potentiometer which requires a regulated excitation voltage. With a constant voltage applied to the potentiometer, the output signal is an analog voltage directly proportional to azimuth angle.

The instrument mounts on standard one inch pipe, outside diameter 34 mm (1.34"). An orientation ring is provided so the instrument can be removed for maintenance and reinstalled without loss of wind direction reference. Both the mounting post assembly and the orientation ring are secured to the mounting pipe by stainless steel band clamps. Electrical connections are made at the terminals in a junction box at the base. A variety of devices are available for signal conditioning, display, and recording of wind speed and direction.

INITIAL CHECK-OUT

When the Wind Monitor is unpacked it should be checked carefully for any signs of shipping damage. Remove the plastic nut on the propeller shaft. Install the propeller on the shaft so the letter markings on the propeller face forward (into the wind). Although the instrument is aligned, balanced and fully calibrated before shipment, it should be checked both mechanically and electrically before installation. The vane and propeller should easily rotate 360° without friction. Check vane balance by holding the instrument base so the vane surface is horizontal. It should have near neutral torque without any particular tendency to rotate. A slight imbalance will not degrade performance.

The potentiometer requires a stable DC excitation voltage. Do not exceed 15 volts. When the potentiometer wiper is in the 5° deadband region, the output signal is "floating" and may show varying or unpredictable values. To prevent false readings, signal conditioning electronics should clamp the signal to excitation or reference level when this occurs. Avoid a short circuit between the azimuth signal line and either the excitation or reference lines. Although there is a 1K ohm current limiting resistor in series with the wiper for protection, damage to the potentiometer may occur if a short circuit condition exists.

Before installation, connect the instrument to an indicator as shown in the wiring diagram and check for proper wind speed and azimuth values. Position the vane over a sheet of paper with 30° or 45° crossmarkings to check vane alignment. To check wind speed, temporarily remove the propeller and connect the shaft to a synchronous motor. Details appear in the CALIBRATION section of this manual.

INSTALLATION

Proper placement of the instrument is very important. Eddies from trees, buildings, or other structures can greatly influence wind speed and wind direction observations. To get meaningful data for most applications locate the instrument well above or upwind from obstructions. As a general rule, the air flow around a structure is disturbed to twice the height of the structure upwind, six times the height downwind, and up to twice the height of the structure above ground. For some applications it may not be practical or necessary to meet these requirements.

Initial installation is most easily done with two people during the vane alignment step; one to adjust the instrument position and the other to observe the indicating device. After initial installation, the instrument can be removed and returned to its mounting without re-aligning the vane since the orientation ring preserves the wind direction reference. Install the Wind Monitor following these steps:

> THE MOUNTING POST ON WHICH THE WIND MONITOR IS PLACED MUST BE EARTH GROUNDED.

1. MOUNT WIND MONITOR
   a) Place orientation ring on mounting post. Do Not tighten band clamp yet.
   b) Place Wind Monitor on mounting post. Do Not tighten band clamp yet.

2. CONNECT SENSOR CABLE
   a) Slide junction box cover up.
   b) Connect sensor cable to terminals. See wiring diagram.
   c) Route cable thru strain relief opening at bottom of junction box. Secure cable by tightening packing nut.
   d) Slide junction box cover down.

3. ALIGN VANE
   a) Connect instrument to an indicator.
   b) Choose a known wind direction reference point on the horizon.
   c) Sighting down instrument centerline, point nose cone at reference point on horizon.
   d) While holding vane in position, slowly turn base until indicator shows proper value.
   e) Tighten mounting post band clamp.
   f) Engage orientation ring indexing pin in notch at instrument base.
   g) Tighten orientation ring band clamp.

CALIBRATION

The Wind Monitor is fully calibrated before shipment and should require no adjustments. Recalibration may be necessary after some maintenance operations. Periodic calibration checks are desireable and may be necessary where the instrument is used in programs which require auditing of sensor performance.

A very accurate wind direction calibration requires either a Model 17221 Vane Angle Fixture or a Model 18101 Bench Test Stand with Protractor. Without these devices the following method can yield vane calibration accuracies of ±5° or better if carefully done. Begin by connecting the instrument to a signal conditioning circuit which has some method of indicating azimuth value. This may be a display which shows azimuth values in angular degrees or simply a voltmeter monitoring the output. Hold or mount the instrument so its center of rotation is over the center of a paper which has 30° or 45° crossmarkings. Orient the base so the junction box faces due south. Visually align the vane with the crossmarkings and observe the indicator output. If the vane position and indicator do not agree within 5°, it may be necessary to adjust the potentiometer coupling inside the main housing. Details for making this adjustment appear in the MAINTENANCE potentiometer replacement outline, step 7. It is important to note that while full scale azimuth on signal conditioning electronics may be 360°, full scale azimuth signal from the instrument is 355°. The signal conditioning electronics must be adjusted accordingly. For example, in a circuit where 0 to 1.000 VDC represents 0° to 360°, the output must be adjusted for 0.986 VDC when the instrument is at 355°. (355°/360° X 1.000 volts = 0.986 volts)

Wind speed calibration is determined by propeller pitch and the output characteristics of the transducer. Calibration formulas showing propeller rpm and frequency output vs. wind speed are included in this manual. These formulas are accurate to within 2 percent. For greater accuracy, the propeller must be individually calibrated in comparison with a wind speed standard. Contact the factory or your supplier to schedule a wind tunnel calibration in our facility.

To calibrate wind system electronics using a signal from the instrument, temporarily remove the propeller and connect a synchronous motor to the propeller shaft. Apply the appropriate calibration formula to the calibrating motor rpm and adjust the electronics for the proper value. For example, with the propeller shaft turning at 3600 rpm adjust an indicator to display 39.5 miles per hour. (3600 rpm X 0.01096 mph/rpm = 39.5 mph)

Details on checking bearing torque, which affects wind speed and direction threshold, appear in the following section.

MAINTENANCE

Given proper care, the Wind Monitor should provide years of service. Constructed entirely of non-corrosive materials and using components which are conservatively rated, the instrument requires little maintenance. The only components likely to need replacement due to normal wear are the precision ball bearings and the wind direction potentiometer. Only a qualified instrument technician should perform the replacement. If service facilities are not available, return the instrument to the company. Refer to the drawings to become familiar with part names and locations. The asterisk * which appears in the following outlines is a reminder that maximum torque on all set screws is 80 oz-in.

POTENTIOMETER REPLACEMENT:

The potentiometer has a life expectancy of fifty million revolutions. As it becomes worn, the element may begin to produce noisy signals or become non-linear. When signal noise or non-linearity becomes unacceptable replace the potentiometer as follows: Refer to exploded view drawing.

1. REMOVE MAIN HOUSING
   a) Unscrew nose cone from main housing. Do not lose o-ring seal.
   b) Gently push main housing latch.
   c) While pushing latch, lift main housing up and remove it from vertical shaft bearing rotor.

2. UNSOLDER TRANSDUCER WIRE
   a) Slide junction box cover up, exposing circuit board.
   b) Remove screws holding circuit board.
   c) Unsolder three potentiometer wires (white, green, black) and two wind speed coil wires (red, black) from top of board.

3. REMOVE POTENTIOMETER
   a) Loosen set screw on potentiometer coupling and remove it from potentiometer adjust thumbwheel.
   b) Loosen set screw on potentiometer adjust thumbwheel and remove it from potentiometer shaft extension.

c) Loosen two set screws at base of transducer assembly and remove it from vertical shaft.
d) Unscrew potentiometer housing from potentiometer mounting & coil assembly.
e) Push potentiometer out of potentiometer mounting & coil assembly by applying firm but gentle pressure on potentiometer extension shaft.
f) Loosen set screw on potentiometer extension shaft and remove it from potentiometer shaft.

4. INSTALL NEW POTENTIOMETER
   a) Place potentiometer extension shaft on new potentiometer (Gap 0.040") and tighten set screw*.
   b) Push new potentiometer into potentiometer mounting & coil assembly.
   c) Feed potentiometer and coil wires through hole in bottom of potentiometer housing.
   d) Screw potentiometer housing onto potentiometer mounting & coil assembly.
   e) Gently pull transducer wires through bottom of potentiome ter housing to take up any slack. Apply a small amount of silicone sealant around hole.
   f) Install transducer assembly on vertical shaft allowing 0.5 mm (0.020") clearance from vertical bearing. Tighten set screws* at bottom of transducer assembly.
   g) Place potentiometer adjust thumbwheel on potentiometer extension shaft and tighten set screw*.
   h) Place potentiometer coupling on potentiometer adjust thumbwheel. Do Not tighten set screw yet.

5. RECONNECT TRANSDUCER WIRES
   a) Using needle-nose pliers or a paper clip bent to form a small hook, gently pull transducer wires through hole in junction box.
   b) Solder wires to circuit board according to wiring diagram. Observe color code.
   c) Secure circuit board in junction box using two screws removed in step 2b.

6. REPLACE MAIN HOUSING
   a) Place main housing over vertical shaft bearing rotor. Be careful to align indexing key and channel in these two assemblies.
   b) Place main housing over vertical shaft bearing rotor until potentiometer coupling is near top of main housing.
   c) Turn potentiometer adjust thumbwheel until potentiometer coupling is oriented to engage ridge in top of main housing. Set screw on potentiometer coupling should be facing the front opening.
   d) With potentiometer coupling properly oriented, continue pushing main housing onto vertical shaft bearing rotor until main housing latch locks into position with a "click".

7. ALIGN VANE
   a) Connect excitation voltage and signal conditioning electronics to terminal strip according to wiring diagram.
   b) With mounting post held in position so junction box is facing due south, orient vane to a known angular reference. Details appear in CALIBRATION section.
   c) Reach in through front of main housing and turn potentiometer adjust thumbwheel until signal conditioning system indicates proper value.
   d) Tighten set screw* on potentiometer coupling.

8. REPLACE NOSE CONE
   a) Screw nose cone into main housing until o-ring seal is seated. Be certain threads are properly engaged to avoid cross-threading.

*Max set screw torque 80 oz-in

FLANGE BEARING REPLACEMENT:

If anemometer bearings become noisy or wind speed threshold increases above an acceptable level, bearings may need replacement. Check anemometer bearing condition using a Model 18310 Anemometer Bearing Torque Disk. Without it, a rough check can be performed by adding an ordinary paper clip (0.5 gm) to the tip of a propeller blade. Turn the blade with the paper clip to the "three o'clock" or "nine o'clock" position and gently release it. Failure to rotate due to the weight of the paper clip indicated anemometer bearings need replacement. Repeat this test at different positions to check full bearing rotation. If needed bearings are replaced as follows.

1. REMOVE OLD BEARINGS
   a) Unscrew nose cone. Do not lose o-ring seal.
   b) Loosen set screw on magnet shaft collar and remove magnet.
   c) Slide propeller shaft out of nose cone assembly.
   d) Remove front bearing cap which covers front bearing.
   e) Remove both front and rear bearings from nose cone assembly. Insert edge of a pocket knife under bearing flange and lift it out.

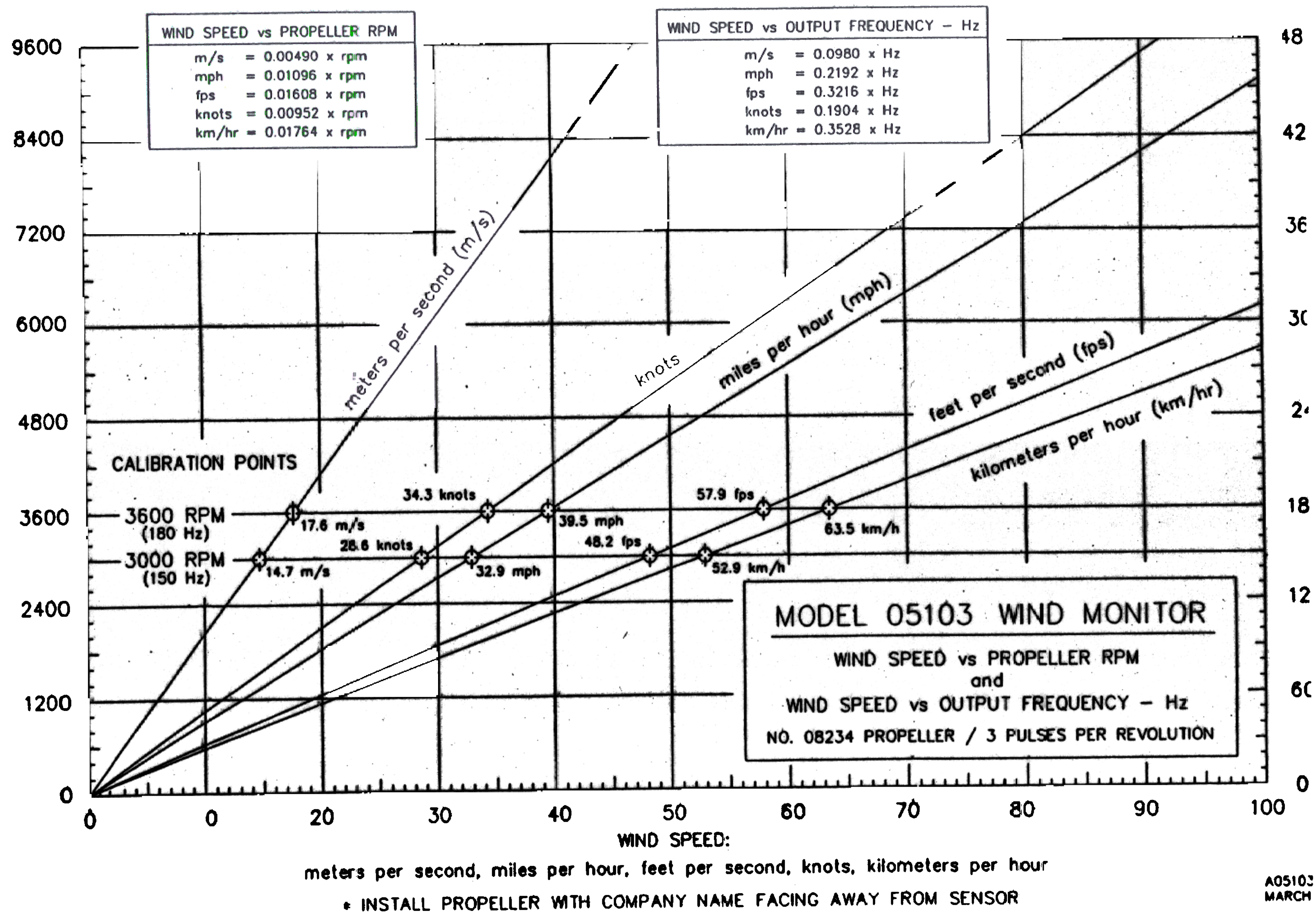
2. INSTALL NEW BEARINGS
   a) Insert new front and rear bearings into nose cone.
   b) Replace front bearing cap.
   c) Carefully slide propeller shaft thru bearings.
   d) Place magnet on propeller shaft allowing 0.5 mm (0.020") clearance from rear bearing.
   e) Tighten set screw* on magnet shaft collar.
   f) Screw nose cone into main housing until o-ring seal is seated. Be certain threads are properly engaged to avoid cross-threading.

VERTICAL SHAFT BEARING REPLACEMENT:

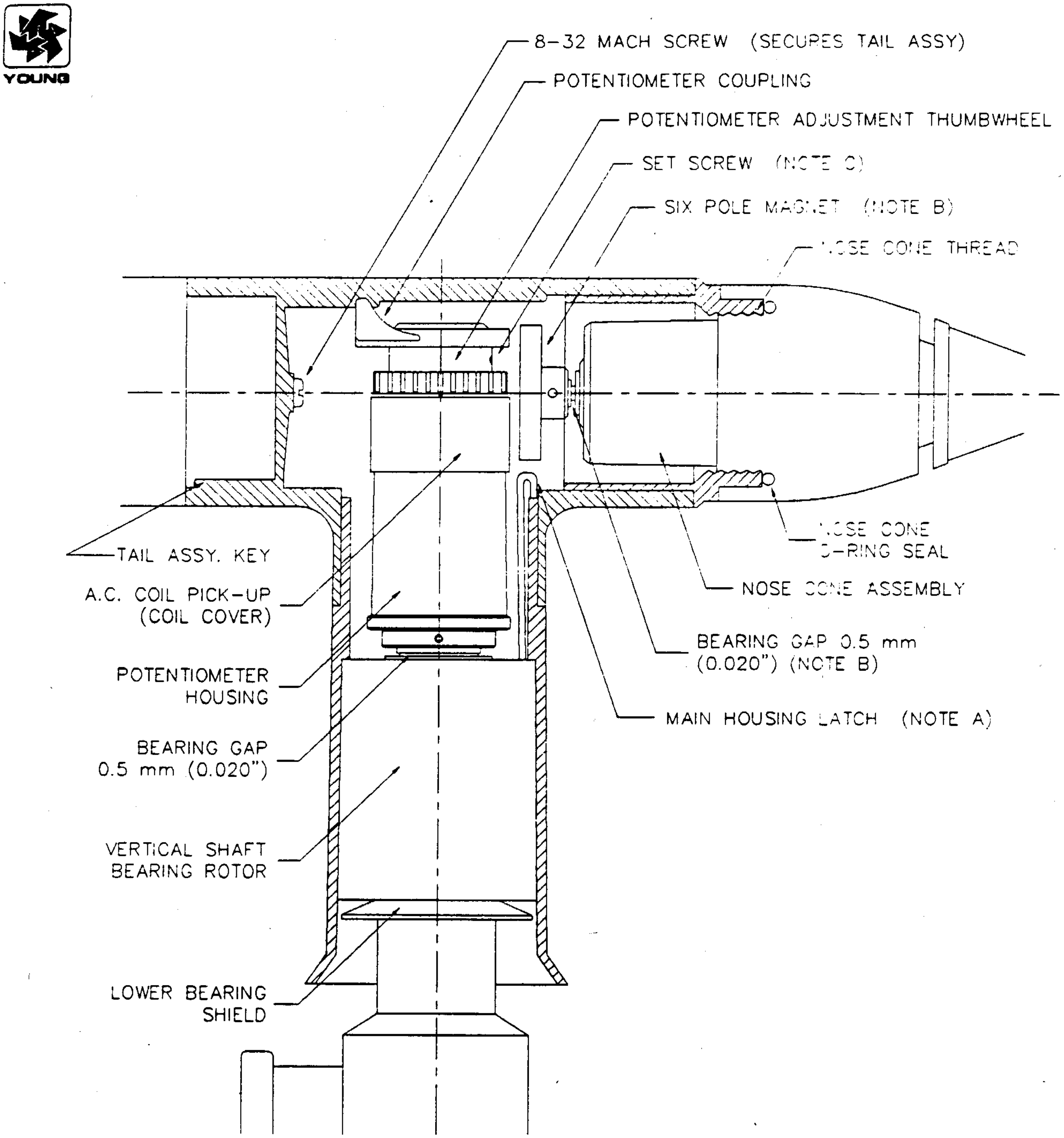
Vertical shaft bearings are much larger than the anemometer bearings and are not as critical for proper instrument performance. Ordinarily, these bearings will not require replacement at the same interval as anemometer bearings. Check bearing condition using a Model 18330 Vane Bearing Torque Gauge. Without it, a rough check can be performed by holding the instrument with the vane horizontal and placing a 3 gm weight near the aft edge of the fin. A U.S. penny weights about 3 gm and is convenient for this check. Failure to rotate downward indicates the vertical bearings need replacement. Repeat this test at different positions to check full bearing rotation.

Since this procedure is similar to POTENTIOMETER REPLACEMENT, only the major steps are listed here.

1. REMOVE MAIN HOUSING
2. UNSOLDER TRANSDUCER WIRES AND REMOVE TRANSDUCER ASSEMBLY
   Loosen set screws at base of transducer assembly and remove entire assembly from vertical shaft. Remove vertical shaft bearing rotor by sliding it upward off vertical shaft.
3. REMOVE OLD VERTICAL BEARINGS AND INSTALL NEW BEARINGS
   Be careful not to apply pressure to bearing shields.
4. REPLACE TRANSDUCER & RECONNECT WIRES
5. REPLACE MAIN HOUSING
6. ALIGN VANE
7. REPLACE NOSE CONE



WIND SPEED vs PROPELLER RPM
m/s = 0.00490 x rpm
mph = 0.01096 x rpm
fps = 0.01608 x rpm
knots = 0.00952 x rpm
km/hr = 0.01764 x rpm
WIND SPEED vs OUTPUT FREQUENCY – Hz
m/s = 0.0980 x Hz
mph = 0.2192 x Hz
fps = 0.3216 x Hz
knots = 0.1904 x Hz
km/hr = 0.3528 x Hz
meters per second (m/s)
knots
miles per hour (mph)
feet per second (fps)
kilometers per hour (km/hr)
CALIBRATION POINTS
3600 RPM (180 Hz)
3000 RPM (150 Hz)
17.6 m/s
14.7 m/s
34.3 knots
28.6 knots
39.5 mph
32.9 mph
57.9 fps
48.2 fps
63.5 km/h
52.9 km/h
MODEL 05103 WIND MONITOR
WIND SPEED vs PROPELLER RPM
and
WIND SPEED vs OUTPUT FREQUENCY – Hz
NO. 08234 PROPELLER / 3 PULSES PER REVOLUTION
9600
8400
7200
6000
4800
3600
2400
1200
0
48
42
36
30
24
18
12
6
0
0
10
20
30
40
50
60
70
80
90
100
WIND SPEED:
meters per second, miles per hour, feet per second, knots, kilometers per hour
* INSTALL PROPELLER WITH COMPANY NAME FACING AWAY FROM SENSOR
A05103
MARCH



NOTE:

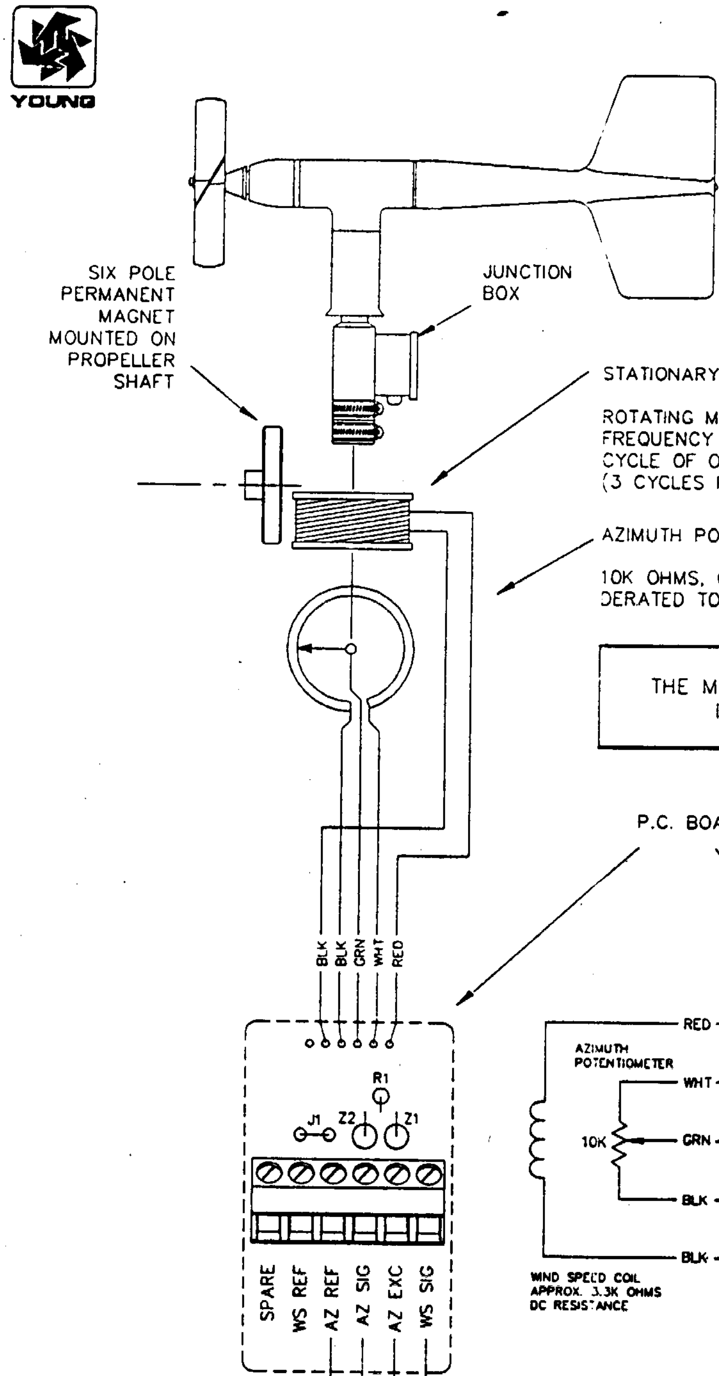
A. TO REMOVE MAIN HOUSING – UNTHREAD NOSE CONE ASSEMBLY, PUSH MAIN HOUSING LATCH, LIFT UPWARD.

B. TO REPLACE ANEMOMETER BEARINGS – UNTHREAD NOSE CONE, REMOVE SIX POLE MAGNET, SLIDE PROPELLER SHAFT AND HUB ASSEMBLY FORWARD. AFTER BEARING REPLACEMENT, SET BEARING GAP TO 0.5mm (0.020")

C. TO ADJUST POTENTIOMETER OUTPUT SIGNAL – REMOVE NOSE CONE, LOOSEN SET SCREW IN POTENTIOMETER COUPLING, ADJUST OUTPUT SIGNAL BY MEANS OF POTENTIOMETER ADJUSTMENT THUMBWHEEL, RE-TIGHTEN SET SCREW

MODEL 05103/05305/05[illegible]	DWG A	PRD 02-90
WIND MONITOR – SECTION VIEW	DWN KL	DWG 02-90
MAIN HOUSING TRANSDUCER ASSY	CHK KS	M05103M
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

MODEL 05103 WIND MONITOR
MODEL 05305 WIND MONITOR-AQ
MODEL 05701 WIND MONITOR-RE



STATIONARY WIND SPEED TRANSDUCER COIL:

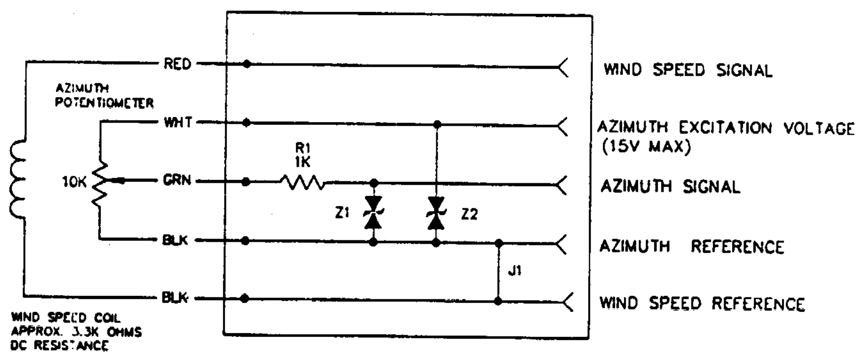
ROTATING MAGNET ON PROPELLER SHAFT INDUCES AC SIGNAL WITH FREQUENCY DIRECTLY PROPORTIONAL TO WIND SPEED. EACH FULL CYCLE OF OUTPUT REPRESENTS 9.8cm OF WIND PASSAGE (3 CYCLES PER REVOLUTION)

AZIMUTH POTENTIOMETER

10K OHMS, 0.25% LINEARITY, 355° FUNCTION ANGLE, 1 WATT @ 40°C, DERATED TO 0 WATTS @ 125° C

THE MOUNTING POST ON WHICH THE WIND MONITOR IS PLACED MUST BE EARTH GROUNDED.

P.C. BOARD MOUNTED IN JUNCTION BOX



NOTES:

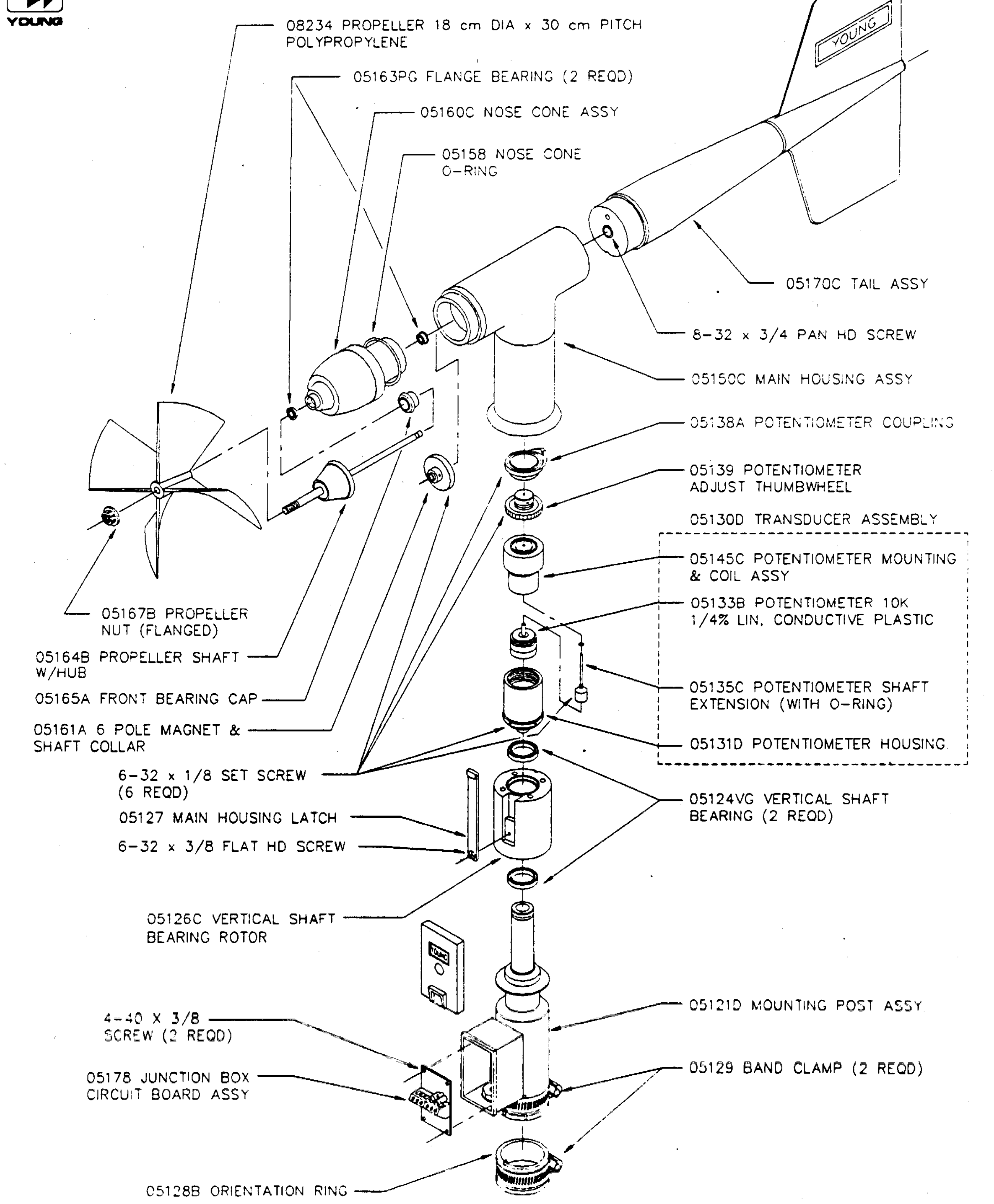
1. JUMPER J1 CONNECTS THE AZIMUTH AND WIND SPEED REFERENCES. IN APPLICATIONS WHERE THE TWO REFERENCES NEED TO REMAIN SEPARATE, JUMPER J1 MUST BE OMITTED OR CUT.
2. Z1 AND Z2 ARE TRANSZORB TRANSIENT PROTECTION DEVICES.

MULTI-CONDUCTOR CABLE

RED	WIND SPEED SIGNAL
WHT	AZIMUTH EXCITATION VOLTAGE (15V MAX)
GRN	AZIMUTH SIGNAL
BLK	REFERENCE

MODEL 05103/05305/05701	DWG A	PRD 03-90
WIND MONITOR/-AQ/-RE	DWN KL	DWG 03-90
CABLE & WIRING DIAGRAM	CHK AP	W05103
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

MODEL 05103 WIND MONITOR



MODEL 05103 WIND MONITOR	DWG A	PRD 03-90
GENERAL ASSEMBLY & REPLACEMENT PARTS	DWN KL	DWG 03-90
	CHK LG	E05103
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

YOUNG

ENGINEERING CHANGE NOTICE

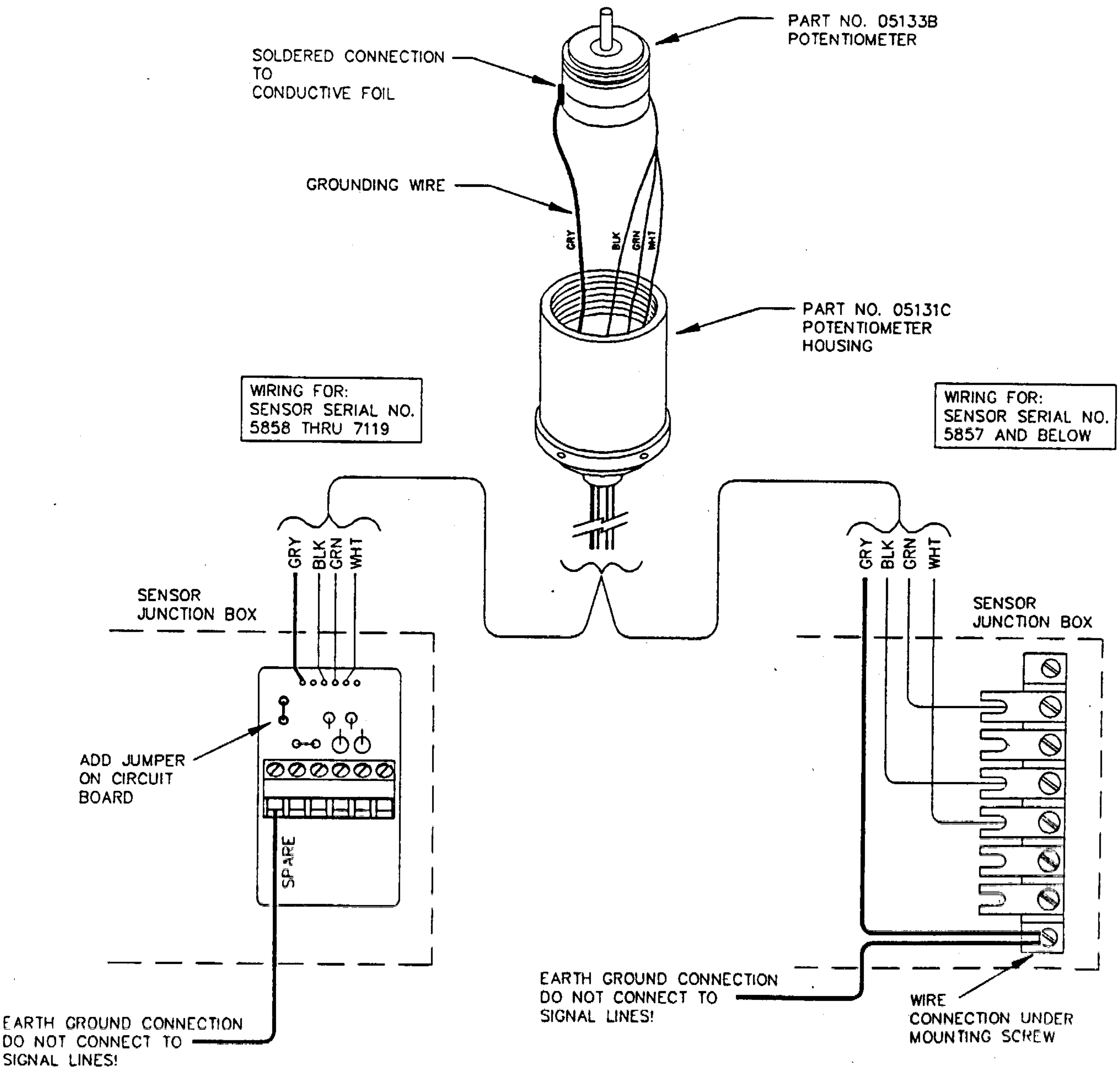
PART NO. 05133B – POTENTIOMETER
MAY 1990

CHANGE: REPLACEMENT POTENTIOMETERS ARE SUPPLIED WITH A GROUNDING WIRE CONNECTED TO THE POTENTIOMETER CASE. THE WIRE IS RUN THROUGH THE SENSOR JUCTION BOX AS DETAILED BELOW, AND THEN CONNECTED TO EARTH GROUND. DO NOT CONNECT TO SIGNAL LINES! REFER TO COMPLETE WIRING DIAGRAM IN INSTRUCTION MANUAL.

THIS MODIFICATION IS BEING IMPLEMENTED TO REDUCE POSSIBLE POTENTIOMETER DAMAGE DUE TO LIGHTNING OR OTHER TRANSIENTS.

PLEASE RETAIN THIS DRAWING IN THE SENSOR INSTRUCTION MANUAL FOR FUTURE REFERENCE.

NOTE: ON SENSOR SERIAL NUMBER 7120 AND ABOVE, THE USE OF CONDUCTIVE PLASTIC CONSTRUCTION MAKES THE GROUNDING WIRE UNNECESSARY.



ENGINEERING CHANGE NOTICE	DWG A	PRD 05-90
PART NO. 05133B POTENTIOMETER	DWN KL	DWG 05-90
	CHK J.C.	W05133B
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

WIND MONITOR
MODEL 05103
REPLACEMENT PARTS

PART NO.	PART NAME	PRICE (US)
05121D	MOUNTING POST ASSY	$ 74.00
05124VG	VERTICAL SHAFT BEARING - 2 REQD	17.00
05126C	VERTICAL SHAFT BEARING ROTOR	19.00
05127	MAIN HOUSING LATCH	3.80
05128B	ORIENTATION RING	9.00
05129	BAND CLAMP - 2 REQD	1.20
05130D	TRANSDUCER ASSY	176.00
05131D	POTENTIOMETER HOUSING	14.00
05133B	POTENTIOMETER - 10K 1/4% LIN COND PLASTIC	88.00
05135C	POTENTIOMETER SHAFT EXTENSION (WITH O-RING)	13.00
05138A	POTENTIOMETER COUPLING	8.60
05139	POTENTIOMETER ADJUST THUMBWHEEL	7.80
05145C	POTENTIOMETER MOUNTING AND COIL ASSY	42.00
05150C	MAIN HOUSING ASSY	54.00
05158	NOSE CONE O-RING	2.40
05160C	NOSE CONE ASSY	48.00
05161A	6 POLE MAGNET & SHAFT COLLAR	13.00
05163PG	FLANGE BEARINGS - 2 REQD	6.20
05164B	PROPELLER SHAFT W / HUB	19.00
05165A	FRONT BEARING CAP	1.60
05167B	PROPELLER NUT (FLANGED)	1.80
05170C	TAIL ASSY	72.00
05176	JUNCTION BOX CIRCUIT BOARD ASSY	25.00
08234	PROP - 18 cm DIA x 30 cm PITCH-POLYPROPYLENE	30.00
05103-90	INSTRUCTION MANUAL	8.00

CALIBRATION ACCESSORIES

17221	VANE ANGLE FIXTURE - AZ	664.00
18112	VANE ANGLE BENCH STAND	166.00
18310	ANEMOMETER BEARING TORQUE DISC - PROPELLER SHAFT	36.00
18330	VANE BEARING TORQUE GAUGE	54.00
18801	SELECTABLE SPEED ANEMOMETER DRIVE	542.00
27232	CALIBRATING UNIT - 3600 RPM - 115 V / 60Hz	274.00

BECAUSE OF CONTINUALLY CHANGING COSTS PRICES ON THIS PARTS LIST ARE SUBJECT TO CHANGE. IF EXACT PRICING IS REQUIRED PLEASE CONTACT US.

R. M. YOUNG COMPANY

2801 AERO-PARK DRIVE, TRAVERSE CITY, MI 49684, U.S.A.

PHN 616-946-3980 TWX 810-291-3366 FAX NO. 616-946-4772

Feb 1990

E.2 BAROMETRIC PRESSURE

Setra Systems, Inc.

PRESSURE TRANSDUCERS AND TRANSMITTERS

Model 270
HIGH ACCURACY

Barometric Pressure: 600-1100 millibar
800-1100 millibar
Absolute Pressure: 0 to 10, 20, 50 100 psia
Gage Pressure: 0 to 5, 10, 20, 50, 100 psig
Gas or Liquid Media

Features

- SETRACERAM™ sensor
- High accuracy: ± 0.05% FS
- Repeatability within 0.01% FS
- Excellent long-term stability
- Low power consumption
- Instant warm-up
- Fast response

Options

- -13°F to 150°F temperature compensation range with ±0.13%FS/100°F zero and span effect.
- ±0.03% FS accuracy with ±0.027% FS E.P. linearity.

Applications

- High accuracy barometric pressure
- Barometric pressure compensation for the wavelength of laser beams
- Weather and Environmental Data
- Databuoys and remote weather stations (rugged, low power consumption and instant warm-up)
- Engine test cells
- High accuracy transfer standard for laboratory, factory and field calibration of pressure instrumentation

Description

The Model 270 pressure transducer is a complete system for the accurate pressure measurement of gas or liquid media compatible with aluminum, alumina ceramics, gold, and elastomer sealant. The high level output signal, excellent stability and accuracy, combined with fast dynamic response make this unit ideal for many environmental, industrial, laboratory and aerospace applications. Unique Setra electronic circuitry is combined with the rugged SETRACERAM™ sensor in this transducer. This high output transducer requires no additional signal conditioning.

Operation

SETRACERAM™ Sensor

Setra's variable-capacitance ceramic sensor approaches the ultimate in design simplicity. Its a symmetrical ceramic capsule which deforms proportionally to applied pressure. The reference space inside the capsule is sealed under high vacuum for sensing absolute pressure or vented to atmosphere for sensing gage pressure. The excellent thermal expansion coefficient and low mechanical hysteresis of the SETRACERAM™ sensor contribute significantly to the high performance and long-term stability of the Model 270.

Gold electrodes on the inside surfaces of the ceramic capsule create a variable capacitor. As pressure exerted on the capsule increases, the electrodes move closer to each other, increasing the capacitance. The capacitance is detected and converted to a highly accurate linear DC signal by Setra's custom integrated circuit which utilizes a charge balance principle.

U.S. Patent Nos 4168518, 4054833

Model 270 Specifications

Pressure Ranges and Media

	Pressure Range	Maximum Pressure
Barometric	800 to 1100 millibar 600 to 1100 millibar	20 psia
Absolute Pressure	0 to 10, 20, 50, 100 psia	1.5 x rated pressure
Gage Pressure	0 to 5, 10, 20, 50, 100 psig	1.5 x rated pressure

Pressure Media: Typically, dry or wet air, water, or other media compatible with aluminum, alumina ceramics, gold and fluorocarbon elastomer sealant.

Accuracy Data

Non-Linearity	± 0.05% FS (end-point method) ± 0.03% FS (BFSL method)
Hysteresis	0.01% FS
Non-Repeatability	0.01% FS
Resolution	Infinite, limited only by output noise level (0.005% FS)
Thermal Effects	(30° to 120°F)
Thermal zero shift	
Barometric	< ± 0.2% FS/100°F
Other ranges	< ± 0.1% FS/100°F
Thermal coef. sensitivity	< ± 0.1% FS/100°F
Accuracy*	< ± 0.05% FS
Long Term Stability	< ± 0.1% FS over 6 months at 70°F
Static Acceleration Effect	< ± 0.01% FS/G
Warm-up	< ± 0.04% FS shift after turn-on for 20 minutes at constant temperature and pressure.
Time Constant	< 10 milliseconds to reach 90% final output with step function pressure input.

* Accuracy as RSS of non-linearity, hysteresis, and non-repeatability. Higher accuracy units available on special order.

Environmental and Dimensional Data

Temperature	0°F to 175°F operating –65°F to 250°F storage
Vibration	2 g from 5Hz to 500Hz
Acceleration	10 g maximum
Shock	50 g operating
Pressure fitting	1/8" -27 NPT internal
Electrical connection	2 foot multiconductor cable
Weight (approx.)	9 ounces (0.25 Kgm)

Ordering Information

Order as Model 270 pressure transducer containing SETRACERAM™ sensor.

Specify:

Pressure range
Electrical output

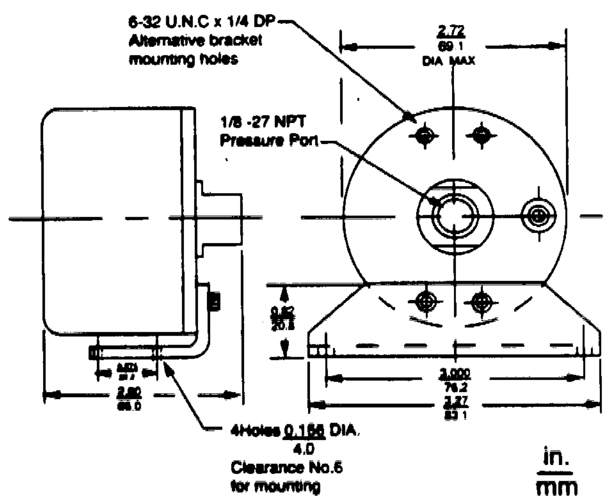
Electrical Data

Full Scale Output**	5.00 VDC, internally adjustable, factory set within ± 5 mV. As an option, barometric range (800 to 1100 millibar) units may be ordered with special 8.00 to 11.00 VDC output.
Zero Pressure Output	0 mV, internally adjustable, factory set within ± 5 mV.
Excitation Power	Nominal 24 VDC, 8 milliamperes (0.2 watts), 20 to 32 VDC. Fully protected against miswiring. Internal regulation minimizes effect of excitation variation, with < ± 0.005% FS output change. Will operate on 28 VDC aircraft power per MIL-STD-704A and not be damaged by emergency power conditions.
Electrical Circuit***	Four-terminal circuit for units with 0 to 5 VDC output. Three terminal circuit for units with 8 to 11 VDC output.
Isolation	The insulation resistance between all signal leads tied together and case ground is 100 megohms minimum at 25 VDC.
Output Impedance	< 5 ohms (effective).
Output Noise	< 200 microvolts RMS (0 Hz to 100 Hz).

** Calibrated into 50K ohm load, operable into loads of 5000 ohms or greater. You can attenuate output to match your data system.

*** For best performance, either negative excitation or negative output should be connected to case. Unit calibrated at the factory with negative excitation connected to case.

Outline Drawing



Specifications subject to change without notice.

setra

45 Nagog Park, Acton, Massachusetts 01720/Telephone 1-800-257-3872, In MA (508) 263-1400

Printed in USA SSP 270 1/90

setra

Operating Instructions

Model 270 Pressure Transducer

General Information

Your Setra transducer has been carefully calibrated before shipment to you and, it should be handled with the same care given any precision instrument. Pressure range and dimensions are reported on the specifications bulletin for the transducer.

Ambient Conditions

Do not use in ambient conditions corrosive to anodized aluminum, or submerge in liquids or subject to spray or vibration environment.

Electrical Connections:

Function	Standard "Belden" Cable Lead	Optional* "Tensolite" Cable Lead
positive excitation	Red	White
positive output	Green	Yellow
negative output	White	Brown
negative excitation	Black	Black
case	Shield	Shield

**Other leads in the Tensolite cable are not used in the Model 270 pressure transducer.*

Electrical

The electrical circuit is equivalent to a 4-terminal network which can be grounded at only one point, either at the negative excitation or the negative signal output lead but, must not be commoned or grounded at more than one point.

The pressure transducer must be operated with the case connected either to the negative excitation terminal or to the negative output terminal. Failure to do this may result in damage to or unsatisfactory operation of the unit. This connection may be made by connecting shield and black (negative excitation) leads, or alternatively by connecting the shield and brown leads together. Best shielding against noise will be obtained by connecting the shield and negative excitation leads.

Circuit is reversed voltage protected for at least 5 minutes. Internal transient suppression network is provided for short duration transients to 150 volts.

In some instances, use of long cables (several hundred feet length) may introduce enough cable capacitance into the output circuit to cause output oscillation. If encountered, this oscillation may be eliminated by connecting a100 ohm resister (1/8th watt or larger) in series in each of the output leads at the end of the 2 foot transducer cable. These series resistors of course add to the output resistance.

Adjustments (with cover removed)

CAUTIONS:

1. **Before making any adjustments, determine which circuit board diagram on Page 3 matches the circuit board in your transducer.**
2. **Turn off excitation power during cover removal or replacement.**
3. **Touching any adjustments other than zero or span may necessitate recalibration and voids the warranty.**

ZERO OUTPUT

Output can be adjusted to zero by potentiometer as shown in dia gram. Unit factory adjusted to zero output (±5mV).

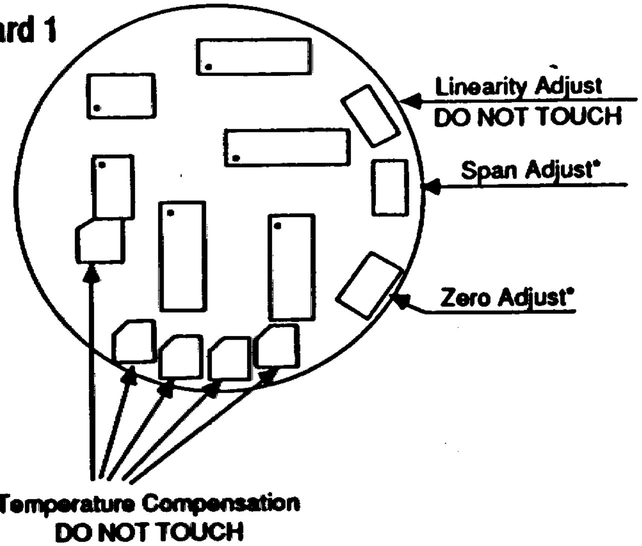
SPAN

Can be adjusted by potentiometer as shown in diagram. Unit factory adjusted to 0 to 5.00 VDC full scale output (±5mV).

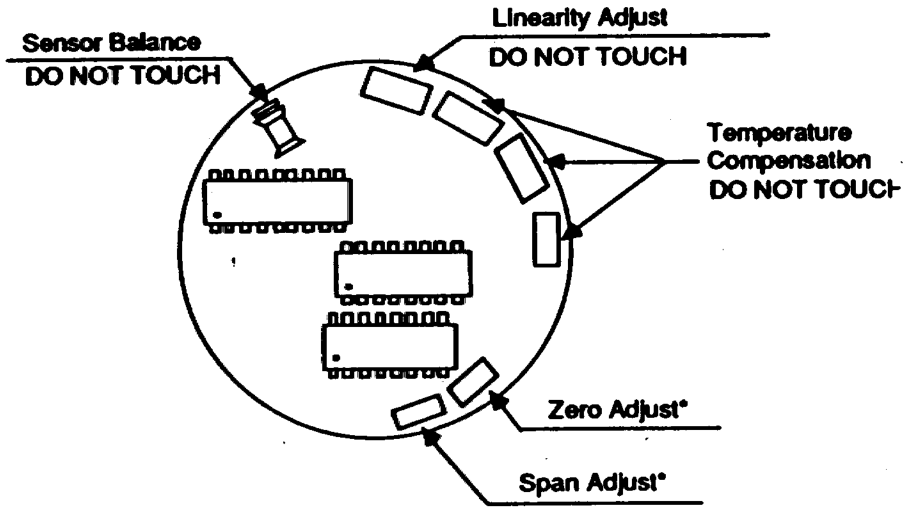
LINEARITY-DO NOT TOUCH

Factory adjusted for best linearity.

Circuit Board 1



Circuit Board 2



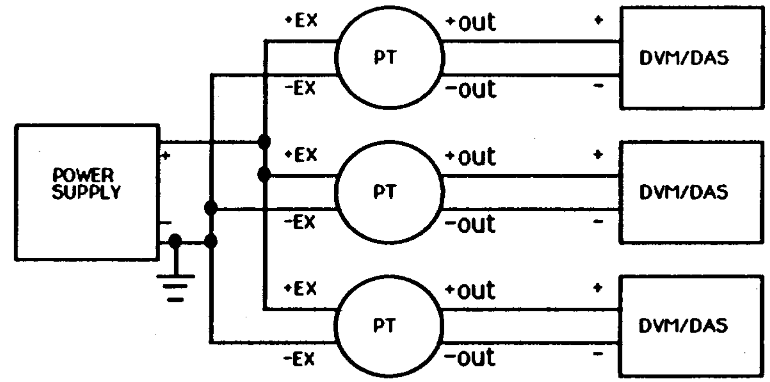
NOTE: When circuit cover is removed, a zero shift can be noticed. The zero will return by the same amount when the cover is replaced. This displacement of the output should be taken into account when making adjustments or during recalibration.

*Adjustments: Due to the high accuracy of this transducer, adjustments to zero and span should only be made with the use of primary pressure standards of known accuracy.

INSTALLATION INSTRUCTIONS FOR MULTIPLE HOOK-UP OF 4-WIRE SETRA PRESSURE TRANSDUCERS

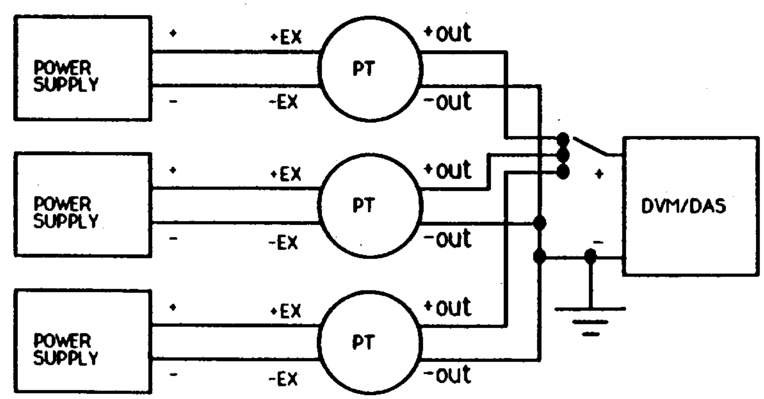
OPTION #1

Uses a single, ground referenced power supply for excitation and separate, isolated (not ground referenced), readout or "differential input" to a



OPTION #2

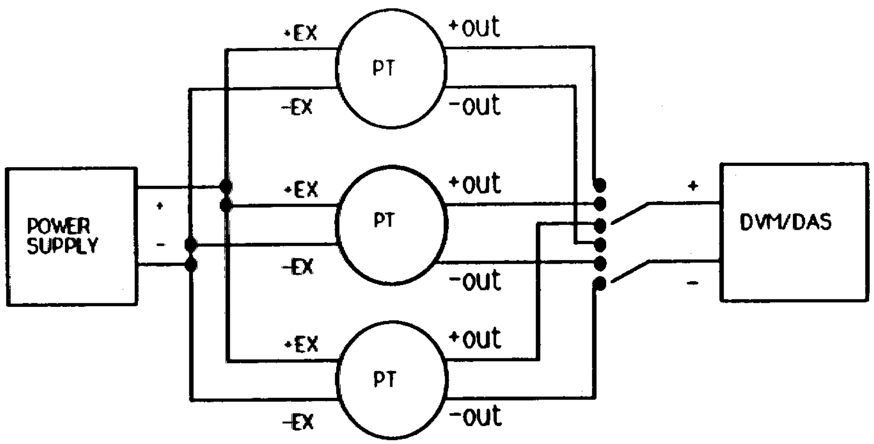
Uses a separate, isolated power supply for each pressure transducer's excitation and a single, ground referenced readout or "single ended input" to a data acquisition system for all of the outputs.



Power Supply (Nominal 24 VDC)
PT - Pressure Transducer (4 Wire Circuit)
DVM/DAS - Digital Volt Meter or Data Acquisition System

OPTION #3

Uses a single, ground referenced power supply for excitation and either a single, isolated readout with a bipolar switch that "breaks before makes" both the + output and - output of each pressure transducer, or a single data acquisition system with a multiplexer (MUX).



NOTE: The shield is internally commoned to the case and pressure port of the transducer.

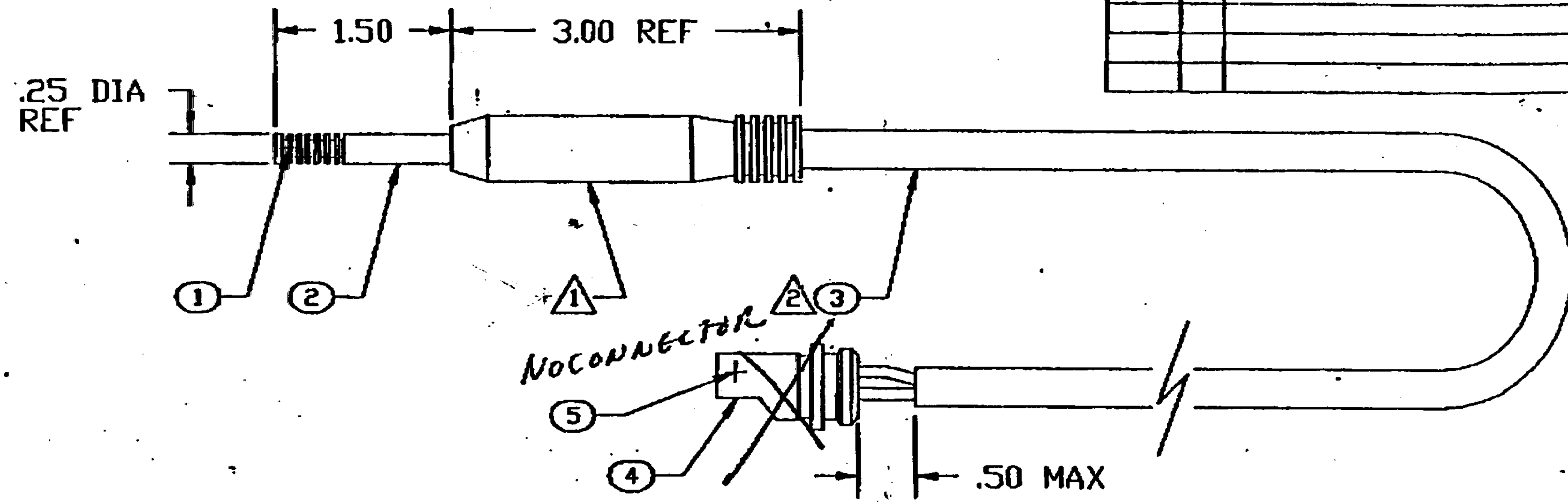
When the shield is connected to ground the case and pressure port of the transducer will also be commoned to that ground.

45 Nagog Park, Acton, Massachusetts 01720/Telephone (617) 263-1400 setra

E.3 AIR TEMPERATURE

REVISIONS

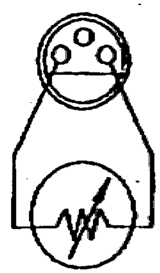
E.O. NO.	REV	DESCRIPTION	DR	DATE	APVD
XXXX	A	RELEASE			



NOTES

1 - WRAP WITH (6) AND MOLD 071 STYLE 9/16" DIA.

2 - CABLE LENGTH (L2) IS 50 FT



-5	-4	-3	-2	-1	U/M	FIND ITEM	PART NO.	PART NAME	ITEM NO.
				AR	XX	6	COM'L	TAPE, NEOPRENE, UNVULCANIZED, #103	090106
				~~2~~	~~EA~~	~~5~~	~~COM'L~~	~~CONN, SOCKET, 44 SERIES~~	~~054209~~
				~~1~~	~~EA~~	~~4~~	~~COM'L~~	~~CONN, PLUG, 3 COND, 44 SERIES, ENVIRON~~	~~054208~~
				50	FT	3	COM'L	CABLE, SJO-2, 2 COND, 18 AWG, RUBBER INS	090036
				1	EA	2	B 19785-10	SHEATH, 19785	054218
				1	EA	1	B 44032	44032 THERM	895304
				X			B 19785-00	PROBE, 19785	SP19785

DASH NO.	NEXT ASSY	END ITEM	QTY
	------	19785	

APPLICATION

UNLESS OTHERWISE SPECIFIED: REMOVE BURRS, BREAK EDGES .010

TOLERANCES

.X ±.030
.XX ±.015
.XXX ±.005
ANGLES ±1/2

YSI Incorporated

Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio 45387 USA

MATERIAL:

FINISH:

SCALE: NA

MAT'L NO.

SHEET 1 OF 1

DO NOT SCALE DWG

DRAWN:

DATE

APVD.

DATE

APVD.

DATE

PART NAME: PROBE, 19785

PART NUMBER: B 19785-00

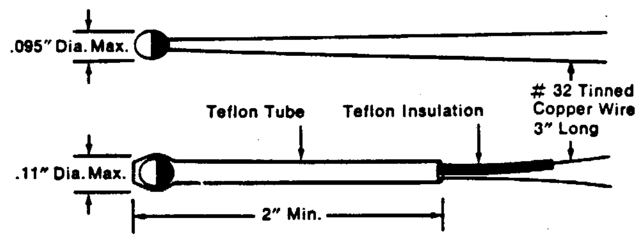
REV A

COMPUTER GENERATED DRAWING: UPDATE COMPUTER FILE WHEN CHANGING

YSI 44000 Series Precision Interchangeable Thermistors

YSI thermistors provide highly accurate and stable temperature sensing for applications of temperature measurement, control, indication and compensation. Typical uses include precise measurements without the necessity of individual circuit calibration and with the advantage of precision interchangeability of sensors. Precise cold junction compensation of thermocouples may be designed directly without "bread boarding" after mathematically deriving the circuit because of the superior interchangeability of YSI precision thermistors.

Two interchangeability tolerances and two thermistor configurations are offered. Teflon encased thermistors allow exposure to hostile environments such as conductive or corrosive liquids and particulate suspensions. A stiff wire placed in the tube also allows the thermistor leads to be formed to various shapes with slight finger pressure.



	Ordering Part Numbers Standard	Ordering Part Numbers Teflon Encased	Resistance Ohms @ 25°C	Power Tolerance % R 0 to 70°C	Resistance Ratio 25 to 125°C	Maximum Working Temperature °C	Storage Temperature and Working Temperature For Best Stability °C	Color Code Body	Color Code End
±0.2°C Interchangeability Tolerance 0 to 75°C	44001A	—	100	±1.0%	10.87	100	−80 to +50	Black	Brown
	44002A	—	300	±1.0%	15.15	100	−80 to +50	Black	Red
	44003A	—	1000	±1.02%	17.33	100	−80 to +50	Black	Orange
	44035	—	1000	±1.02%(−40 to +150)	17.33	100	−80 to +50	Orange	Green
	44004	44104	2252	±1.02%	29.26	150	−80 to +120	Black	Yellow
	44005	44105	3000	±1.02%	29.26	150	−80 to +120	Black	Green
	44007	44107	5000	±1.02%	29.26	150	−80 to +120	Black	Violet
	44017	—	6000	±1.02%	29.26	150	−80 to +120	Brown	Violet
	44016	—	10K	±1.02%	29.26	150	−80 to +120	Brown	Blue
	44006	44106	10K	±1.0%	23.51	150	−80 to +120	Black	Blue
	44008	44108	30K	±1.0%	29.15	150	−80 to +120	Black	Gray
	44011	44111	100K	±1.03%	34.82	150	−80 to +120	Brown	Brown
	44014	44114	300K	±1.1%	46.02	150	−80 to +120	Brown	Yellow
	44015	44115	1MEG	±1.2%	61.96	150	−80 to +120	Brown	Green
±0.1°C Interchangeability Tolerance 0 to 75°C	44033	—	2252	±0.51%	29.26	75	−80 to +75	Orange	Orange
	44030	—	3000	±0.56%	29.26	75	−80 to +75	Orange	Black
	44034	—	5000	±0.56%	29.26	75	−80 to +75	Orange	Yellow
	44036	—	10K	±0.51%	29.26	75	−80 to +75	Orange	Blue
	44037	—	6K	±0.51%	29.26	75	−80 to +75	Orange	Violet
	44031	—	10K	±0.51%	23.51	75	−80 to +75	Orange	Brown
	44032	—	30K	±0.51%	29.15	75	−80 to +75	Orange	Red

TIME CONSTANT: The time required for a thermistor to indicate 63% of a newly impressed temperature is the time constant. For a thermistor suspended by its leads in a well-stirred oil bath it is 1 sec. max for standard thermistor, and 2.5 sec. max. for Teflon encased thermistors. In still air it is 10 sec. max. for standard thermistors, and 25 sec. max. for Teflon encased thermistors.

DISSIPATION CONSTANT: The power in milliwatts required to raise a thermistor 1°C above surrounding temperature is the dissipation constant. For all thermistors suspended by their leads in a well-stirred oil bath it is 8mW/°C min., or 1mW/°C in still air.

STABILITY: YSI thermistors are chemically stable and not significantly affected by aging or exposure to strong nuclear radiation.

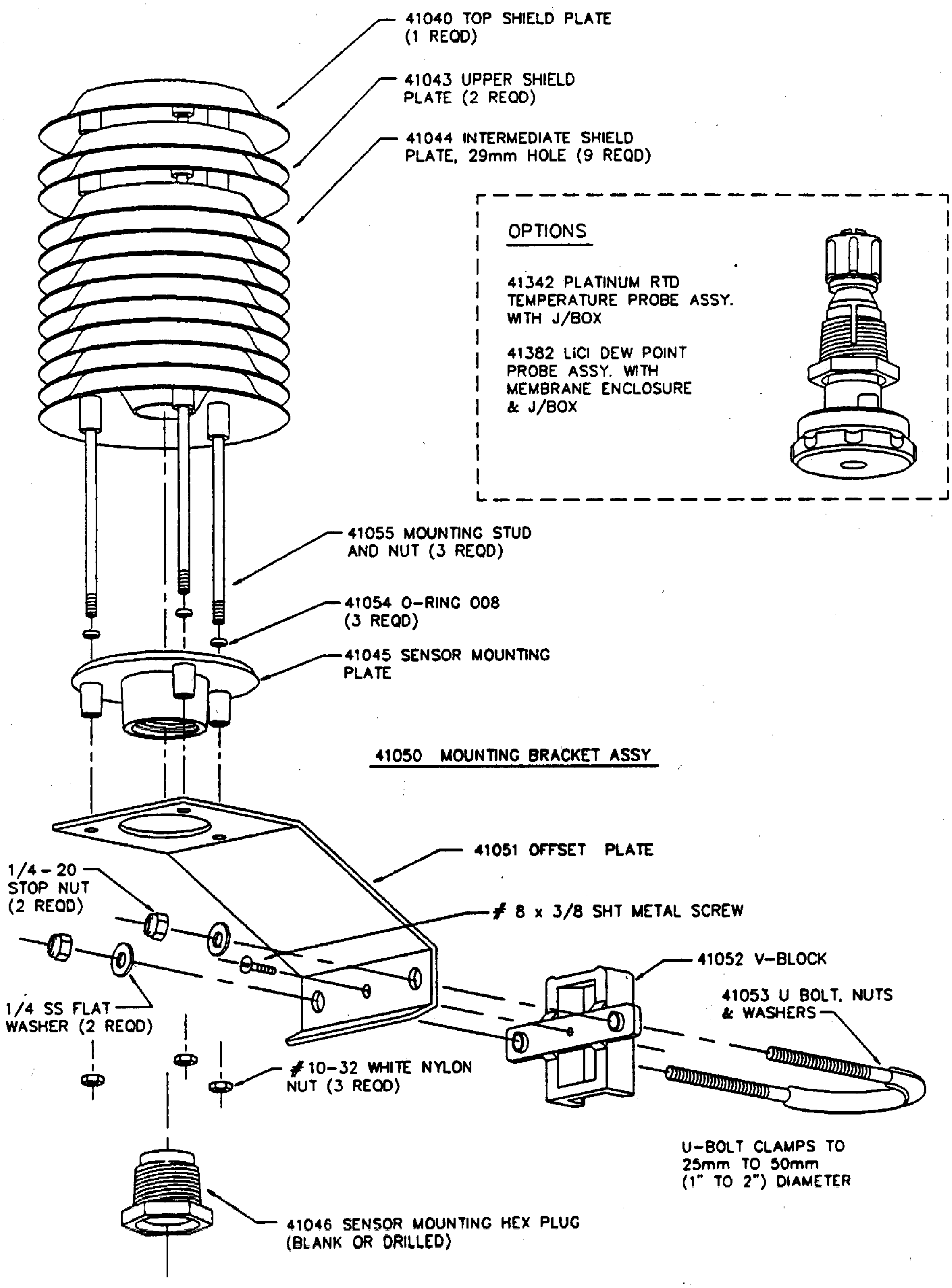
TOLERANCE CURVES AND TABLES: Data indicating conformance to resistance/temperature values as a maximum interchangeability error expressed both as temperature and as a % of resistance are shown on page 7.

RESISTANCE/TEMPERATURE DATA: Tables indicating the predicted performance of YSI precision thermistors in °C and in °F are shown on pages 10 through 12. This data may be used directly in design of R/T networks and temperature measurement systems.

HOW TO ORDER

Use the above part numbers.

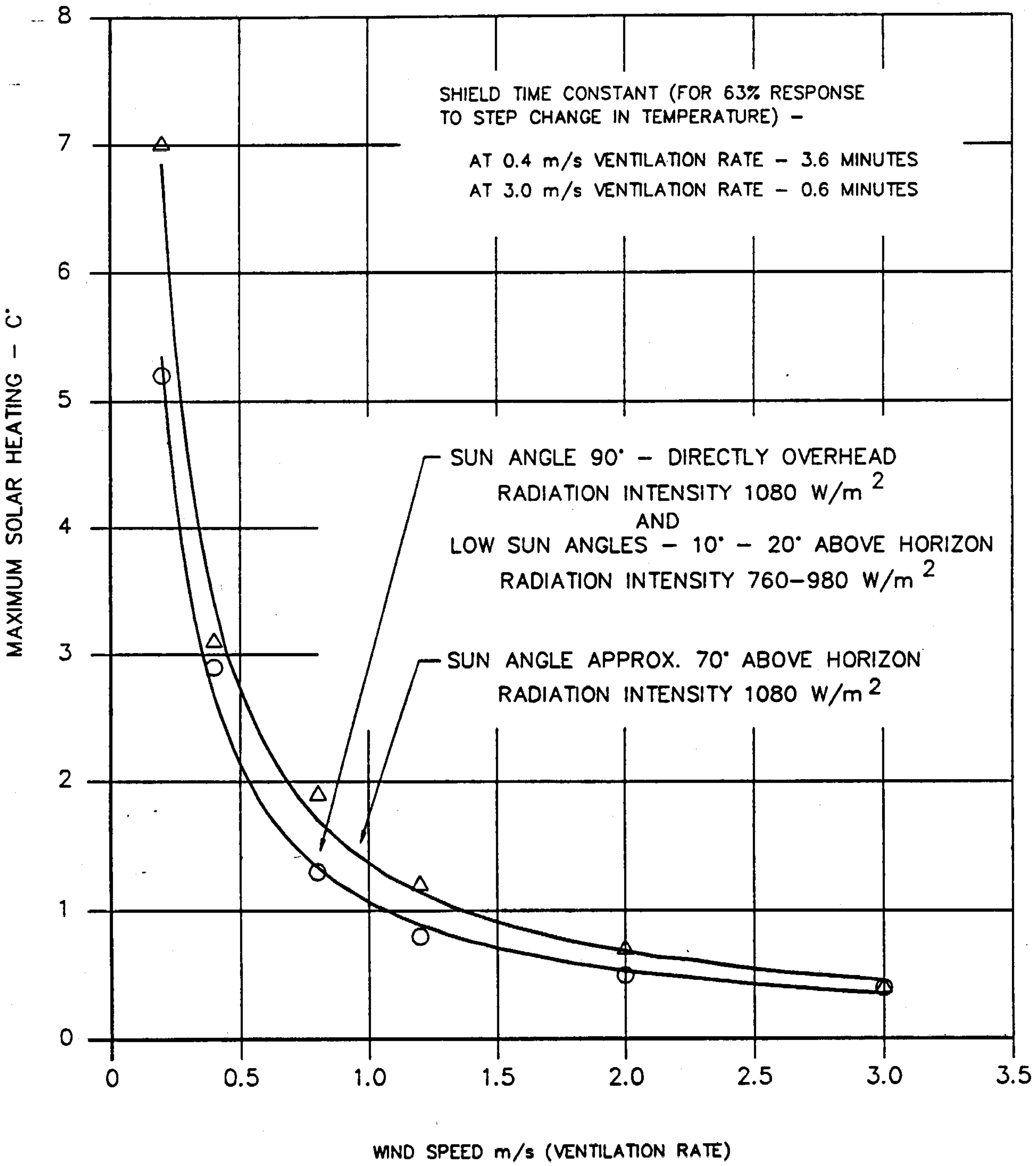
MODEL 41002 GILL MULTI-PLATE RADIATION SHIELD



MODEL 41002	DWG A	PRD 03-87
GILL MULTI-PLATE RADIATION SHIELD	DWN KL	DWG 05-89
REPLACEMENT PARTS DRAWING	CHK J.C.	E41002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

MODEL 41002 MULTI-PLATE RADIATION SHIELD

INFLUENCE OF VENTILATION RATE AND
SUN ANGLE ON INTERNAL TEMPERATURE



DATA SUMMARIZED FROM "COMPARISON TESTING OF SELECTED NATURALLY VENTILATED RADIATION SHIELDS" BY GERALD C. GILL, SEPTEMBER 1983.

JAN. 1987
A41002A.DWG

E.8 WATER CONDUCTIVITY

CONDUCTIVITY SENSOR SBE 4

DESCRIPTION

The **SBE 4** conductivity sensor is modular and self-contained, permitting easy installation, service, and calibration. The sensor has a frequency output of approximately 3 to 12 kHz corresponding to conductivity from 0 to 7 Siemens/meter [S/m] (optionally 0 to 0.6 S/m), covering the full range of fresh water and oceanic applications. The cell design confines electric fields to the inside of the cell, making measurements and instrument calibration independent of the calibration bath size or proximity to protective cages or other objects; a distinct advantage over inductively coupled or "open" external field cells. 3,400 meter depth capability is standard. Optional housings provide 6,800 or 10,500 meter capability. The power/signal cable and mounting hardware for Sea-Bird CTDs are available separately.

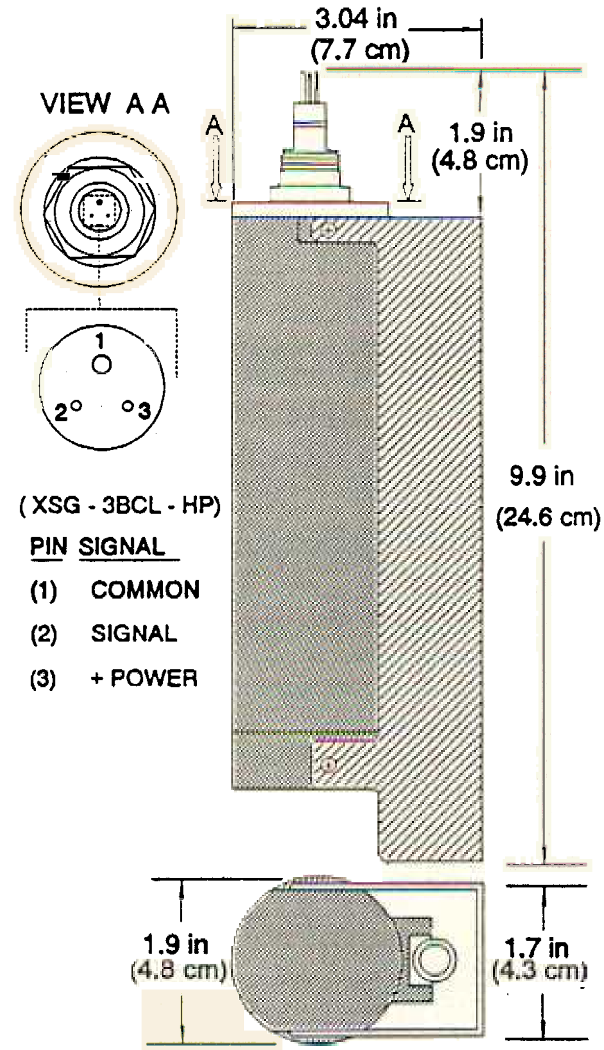
APPLICATION

The SBE 4 is an ideal sensor for vertical profiling with lowered systems or horizontal profiling with towed systems. Its small size is well suited for moorings, portable CTD systems, underwater vehicles or through-the-ice work. It has a proven record of reliability and accuracy with 17 years of field use and calibrations by the Northwest Regional Calibration Center (an independent U.S. government contractor).

The SBE 4 is a primary sensor for Sea-Bird's SBE 9 CTD Underwater Unit and SBE 25 Sealogger CTD and is also easily adapted to custom applications. The SBE 4's low noise characteristics allow the use of hybrid frequency measuring techniques to obtain rapid sampling with very high resolution. A published article [1] describes how a resolution of 1×10^{-5} S/m may be obtained at a 6 Hz sampling rate.

OPERATION

The flow-through sensing element is a glass tube (cell) with 3 internal platinum electrodes. The resistance measured between the center electrode and end electrode pair is determined by the cell geometry and the specific conductance (conductivity) of the fluid within the cell. The cell resistance controls the output frequency of a patented Wien Bridge circuit [2]. An internally-fixed conductivity offset enables measurements down to 0 conductivity.



Power required: 10 - 20 VDC, 10 ma
Signal output: 0.7 V (rms) sine wave
Materials (3400/6800 m): Anodized aluminum (6061-T6 or 7075-T6)
Materials (10,500 m): Titanium (6Al4V)
Weight (Aluminum): 0.7 kg (1.6 lbs) in air; 0.34 kg (.75 lbs) in water
Weight (Titanium): 1.1 kg (2.4 lbs) in air; 0.7 kg (1.5 lbs) in water

SPECIFICATIONS[1]

Measurement Range: 0.0 to 7 Siemens/meter (S/m) (0.0 to 70 mmho/cm)

Resolution:[2] 0.00004 S/m @ 24 samples per second

Accuracy/Stability: ± 0.0003 S/m/month (typical); ± 0.001 S/m/month (guaranteed)[3]

Time Response[4] (pumped): 0.085 sec. (0.5 m/s drop); 0.070 sec. (1.0 m/s drop)
(no pump): 0.170 sec. (2.0 m/s tow)

1 Typical specifications, referenced to NBS-traceable calibration, and applying over the entire oceanographic range.
2 Achieved with Sea-Bird's SBE 9 CTD. In custom applications, resolution will depend on the frequency measuring technique used.
3 Not applicable in areas of high biofouling activity, highly contaminated waters or if procedures in Application Bulletin 2D are not followed.
4 Time to reach 63% of final value following a step change in conductivity.

SBE SEA - BIRD ELECTRONICS, INC. Telephone (206) 643-9866
1808 136th Place NE, Bellevue, WA. 98005 USA Telex 292915 SBEI UR Fax (206) 643-9954

The approximate relationship between output frequency and conductivity is given by:

$$f = H\,(\sigma + d)^{0.5} \qquad \text{[Hz]},$$

where f is output frequency, H is a constant determined by the cell geometry and circuit components ($H \approx 4400$), σ is conductivity in [S/m] and d is the conductivity offset ($d \approx 0.4$).

The sensitivity of the circuit is approximately: $\partial f/\partial\sigma = 0.5\,H/(\sigma + d)^{0.5}$ [Hz per S/m] and varies from 2700 [Hz per S/m] at 0 S/m to 850 [Hz per S/m] at 6 S/m.

CALIBRATION

All instruments are calibrated from approximately 1.5 to 6 S/m by the Northwest Regional Calibration Center (NRCC), operating under contract to NOAA. Using a least squares fitting technique, the following equation is fitted to the NRCC data and the instrument's zero conductivity frequency:

$$\text{Conductivity} = \frac{af^m + bf^2 + c + dt}{10\,[1 - (9.57\times10^{-8})\,p]} \qquad \text{[S/m]}$$

where f is the instrument frequency [kHz], t is temperature [°C], p is pressure [decibars] and a, b, c, d, & m are coefficients listed on the calibration certificate. Residuals are typically less than 0.0003 S/m. A published article [3] describes user experience and also discusses instrument noise level, cell maintenance and calibration methods. Users have since improved performance by using anti-foulant to protect the cell from biological growth. After a 5 month mooring at depths of 80 to 290 meters, four SBE4s with anti-foulant protection showed drifts of <0.0015 S/m over a year's interval between calibrations. An optional anti-foulant device, specifically developed for moorings, consists of anti-foulant impregnated cylinderical attachments at each end of the cell. These anti-foul cylinders are effective for 3 to 12 months in waters with high rates of bio-fouling growth.

SAMPLE CALIBRATION DATA

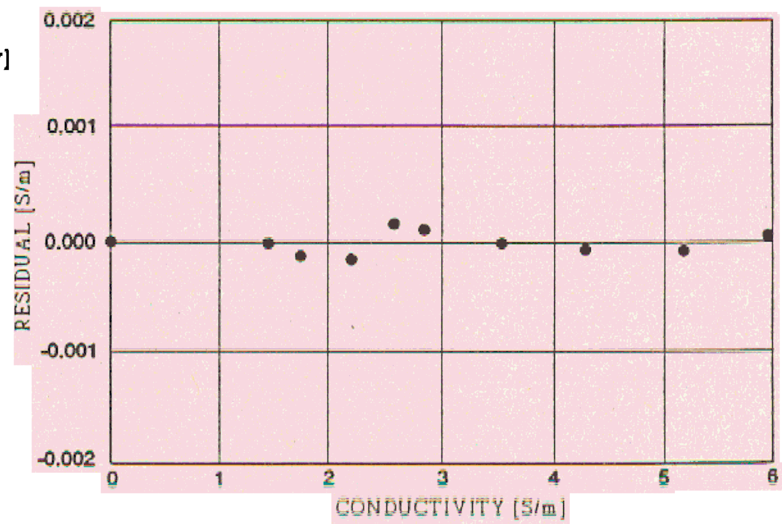
CALIBRATION DATA FOR SENSOR SERIAL NUMBER = 677

CALIBRATION DATE: 9-29-89

Practical Salinity Scale 1978: C(35,15,0) = 4.2914 [Siemens/meter]

a = 2.10166389e-05 b = 3.92391126e-01
c = -3.79740447e+00 d = 1.53484144e-05
m = 3.9

BATH TEMP [°C]	BATH SAL [ppt]	BATH COND [S/m]	INST FREQ [kHz]	INST COND [S/m]	RESIDUAL (INST - BATH) [S/m]
27.1023	15.0408	2.57988	8.67094	2.58007	0.00019
19.1355	15.0404	2.18995	8.08073	2.18980	-0.00015
11.0895	15.0392	1.81543	7.47017	1.81531	-0.00012
3.0062	15.0389	1.46[illegible]	6.84567	1.46294	0.00000
31.0877	35.0571	5.96006	12.66879	5.96011	0.00005
23.0432	35.0782	5.11331	11.79726	5.11322	-0.00009
14.9669	35.0776	4.29664	10.88952	4.29660	-0.00004
6.8513	35.0768	3.52152	9.95016	3.52154	0.00002
-1.0729	35.0762	2.81736	9.01093	2.81747	0.00011
0.0000	0.0000	0.00000	3.11027	0.00003	0.00003



REFERENCES

[1] A.M. Pederson, "A Modular High Resolution CTD System with Computer-Controlled Sample Rate", proceedings of International STD Conference and Workshop, pp. 41-47, 1984.

[2] U.S. Patent No. 3,675,484

[3] A.M. Pederson and M.C. Gregg, "Development of a Small In-Situ Conductivity Instrument", IEEE Journal of Ocean Engineering, Vol. OE-4, No. 3,pp. 69-75, July 1979.

SBE SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005
Telephone: (206) 643-9866 Fax: (206) 643-9954 Telex: 292915 SBEI UR

APPLICATION NOTE NO. 2D

Revised April 1990

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

Since any conductivity sensor's output reading is proportional to its dimensions, it is important to keep the cell clean of internal coatings. Also, cell electrodes contaminated with oil, biological growths, or other foreign material, will cause low conductivity readings.

If the cell is allowed to dry out between usage, salt crystals may form on (and in) the platinized electrode surfaces. When the instrument is next used, there will be a delay before these crystals are dissolved -- in the meantime, sensor accuracy may be affected. Therefore, we recommend that the cell be kept filled with distilled or de-ionized water between uses. A length of 7/16" ID Tygon tubing is provided for this purpose, to be connected in such a way that any air entrapped will be in the Tygon tube rather than in the cell.

An additional important benefit of keeping the cell ends closed with Tygon is to keep air-borne contaminants (of which there are an abundance on most research vessels) from entering the cell.

If it is not practical to keep the cell filled with distilled water between use (for example, in Arctic environments where freezing is a hazard), flush the cell with clean fresh water (preferably distilled or de-ionized) and close the cell with Tygon. Also, remember to keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

Experience indicates that in normal intermittent use (such as in CTD profiling operations), drift rates of 0.0003 S/m (0.003 mmho/cm) or less per month can be expected without any cleaning if the procedures described above are followed.

PRECAUTIONS!!!!!!

The conductivity cell is primarily made of glass, and therefore is subject to breakage if mishandled. It is especially important to use the right size Tygon tubing, since if you use tubing with a too small ID, it will be difficult to remove the tubing, and the cell end may be broken if excessive force is used. **The correct size tubing for all instruments produced since 1980 is 7/16" ID, 9/16" OD (1/16" wall).** Instruments shipped prior to 1980 had smaller retaining ridges at the ends of the cell, and 3/8" ID Tygon is the right size for these older instruments. It is better to use Tygon than other plastic tubing, since it tends to remain flexible over a wide temperature range and with age.

Do not probe the interior of the cell with a Q-tip or other object, since if the platinized electrode surface is touched it will be necessary to replatinize the cell.

If your instrument is filled with distilled water, do not subject it to low temperatures which will freeze the water and break the cell. **Remove the water before shipment during the winter, or to Arctic regions at any season.** No adverse affects have been observed as a result of temporary "dry" storage, particularly if the cell is rinsed with fresh water before storage.

The anti-foulant used is a biological poison. Unnecessary handling of treated surfaces should be avoided, and your hands thoroughly washed after contact.

CELL CLEANING

Routine Cleaning (inside of cell not visibly dirty)

Fill the cell with a 1% solution of Triton X-100* and let soak for 30 minutes. This is most easily done by using a length of 7/16" ID Tygon tubing to form a closed loop including the cell. After the soak, drain and flush with warm (not hot) fresh water for 1 minute. Refill the cell with distilled water until the next usage.

Cleaning Severely Fouled Cells (visible deposits or marine growths on the inside of the cell)

Clamp the instrument so that the cell is vertical, and attach a length of 7/16" Tygon tubing to the lower end of the cell. Use masking or other tape to secure the open end of the Tygon about even with the top end of the cell. Pour Muriatic Acid (37% HCl) into the open end of the Tygon until the cell is filled to near the top and let soak for 1 to 2 minutes only. **Avoid breathing the acid fumes!!** Drain the acid from the cell and flush for 5 minutes with warm (not hot) fresh water. Also rinse the exterior of the instrument to remove any spilled acid from the surface. Then fill the cell with 1% Triton* solution, let stand for 5 minutes, and flush with warm fresh water for 1 minute. Refill with distilled water until the next usage.

If this process does not remove the visible deposits, it will be necessary to mechanically clean the cell with a small (0.275" diameter) soft-bristled nylon bottle brush and 1% Triton solution. **However, extreme care must be exercised, since the electrodes could be damaged if too large or too stiff a brush is used. Also, it is absolutely essential that the electrodes be replatinized after "brush" cleaning.** Our service department will clean and replatinize your cell for a nominal fee.

ANTI-FOULANT ATTACHMENTS

SBE 4-05 anti-foulant attachments are optional, and are recommended for moored applications where biological activity is anticipated. These small porous cylinders are impregnated with a toxic material, and are attached to each end of the conductivity cell, so that any water which enters the cell is treated. The SBE 4-05 attachments are effective for 6 months to 1 year, depending upon biological activity and upon water flow velocity past the instrument.

*Triton X-100 (a trade name of J. T. Baker, Inc) is a concentrated liquid non-ionic detergent available at most chemical or scientific supply stores. Other liquid detergents can probably also be used, but scientific grades are preferable because of their known composition. It is better to use a non-ionic detergent since conductivity readings taken immediately after use are less likely to be affected by any residual detergent left in the cell.

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<u>APPLICATION NOTE NO. 3</u> <u>(Revised March 1989)</u>

DISASSEMBLY INSTRUCTIONS
FOR TEMPERATURE AND CONDUCTIVITY INSTRUMENTS

TEMPERATURE INSTRUMENT

Remove thermistor guard -- unscrews counter-clockwise.

Use wrench or vise on "flats" of the end cap (at thermistor end of the instrument) to unscrew the end cap -- unscrews counter-clockwise. Use tape to pad wrench surfaces to prevent scratching the anodized surface, and use extreme care not to damage the now unguarded thermistor sheath. When reassembling, use care to avoid "cross-threading".

CONDUCTIVITY INSTRUMENT

Remove cell guard -- 8 screws

Remove 2 screws and spacer block at the underwater connector end of the conductivity cell tray.

Remove 4 screws holding the end cap to the main pressure housing. Leave cell tray attached to the end cap.

Remove the end cap. This is most easily done by placing the end cap in a padded vise and pulling on the main pressure housing with a back-and-forth twisting motion. Use care to avoid excessive motion when the pressure case slips off the end cap O-ring, since a sudden reduction in pulling force is required. Also, too quick an opening can result in salt water trapped by the O-ring being sucked into the instrument onto the circuit boards.

If it is desired to further disassemble the cell, unsolder and lift the 2 leads attached to the front of the oscillator board. Note and mark which lead goes to each terminal, since they must not be interchanged (the outer cell electrodes must be connected to the terminal closest to the 180uf capacitors). Then remove the 2 screws which secure the cell tray to the end cap and carefully separate the two, using a back-and-forth twisting motion.

REASSEMBLY INSTRUCTIONS FOR TEMPERATURE AND CONDUCTIVITY INSTRUMENTS

Clean and re-grease all O-ring surfaces. In general, it is not necessary to remove O-rings from their grooves, since cleaning and re-greasing the exposed part of the O-ring is usually sufficient.

Each instrument case should be filled with dry nitrogen before closing. For this procedure we use a regulator to reduce the bottled Nitrogen pressure to 20 psi, and use a 10-inch long, 1/8 inch ID Tygon tube plumbed to the regulator. With the instrument almost closed, the tube can be slipped down along the outside of the circuit boards toward the bottom of the case. Allow nitrogen to flush air out for several seconds, then quickly pull out the tube and close the case. This procedure can more easily be done with 2 people.

O-Ring Sizes

5000 psi cases:	Conductivity Cell:	Parker TPO 01*
	Conductivity End Cap:	Parker 2-219N674-70
	Temperature End Cap:	Parker 2-220N674-70
10,000 psi cases:	T-Rings are used rather than O-rings	
	Conductivity Cell:	Parker TPO 01
	Conductivity End Cap:	Parker TPO 20
	Temperature End Cap:	Parker TPO 21
Connectors (all pressures):	Parker 2-017N674-70 with Impulse XSG-3BCL-HP (1/2-20 thread as used on all current shipments).	
	Previous standard was Parker 2-019N674-70 as used with Advanced A306 (3/4-16 thread black aluminum-body connectors).	
	Parker 2-213N674-70 was used on older instruments with plastic hex-based connectors.	

* Instruments manufactured before 1988 used Parker 2-010N674-70 at this position.

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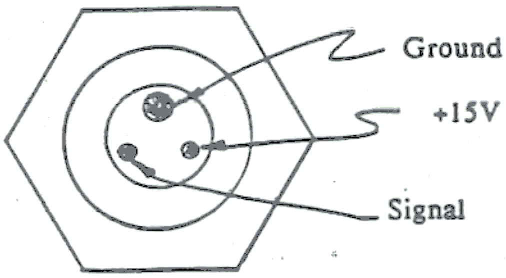
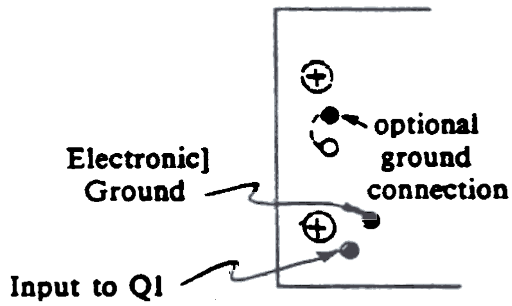
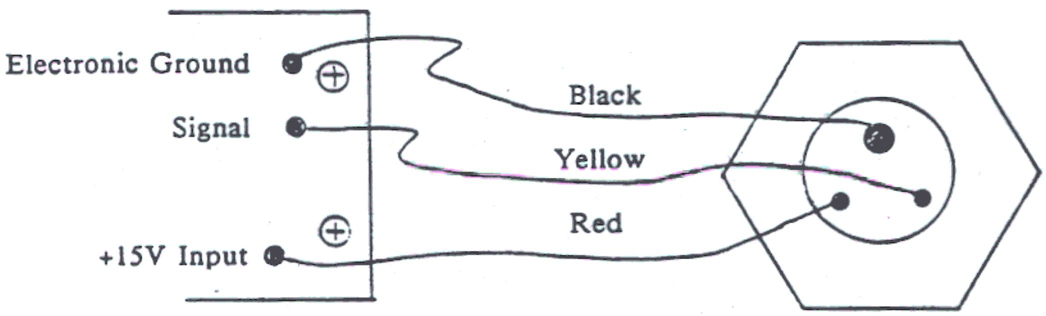
APPLICATION BULLETIN NO. 4

HOOKUP INSTRUCTIONS
FOR SBE-3 & SBE-4 INSTRUMENTS



Outside view of Connector





Inside View of Connector

To minimize chances of corrosion, avoid metal-to-metal contact of the instrument case with the mounting device -- e.g., use insulating tape or head-shrink tubing over stainless steel hose clamps if they are used to mount the instrument. Unless we have been instructed otherwise, all units are shipped with the pressure case connected to electrical ground through a 1.5 uf capacitor. In applications subject to extremely high RF noise it may be necessary to connect the press cases directly to electrical ground. This may be done by installing a jumper wire as shown in the sketch (optional ground connection). For the conductivity instruments, this grounding point is not readily accessible, and the optional ground connection may more easily be made by installing a jumper wire across the leads of the 1.5 uf capacitor (blue color, located on the other circuit board). For instruments with cases hardwired to electrical ground it may be necessary to use an isolated power supply (DC-Dc converter or battery) to prevent galvanic corrosion. A single power source may be used to supply a mixed group of temperature and conductivity instruments.

The instrument case is filled with dry nitrogen. If it is necessary to open the case at any time, it would be a good idea to refill the case with nitrogen to prevent possible condensation at low temperatures. Application Bulletin No. 3 contains instructions for opening and closing the instrument cases, and for filling them with nitrogen.

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IMPORTANT NOTE

The conductivity instrument in this shipment is different from earlier units in that it has a special modification which allows the instrument to read conductivity over the entire range from 0 to 60 + mmhos/cm. We expect that this change will be standard in future units. A precision 5000 ohm resistor (with 1 ppm T.C.) has been added in parallel with the conductivity cell. The result of this change is that the instrument oscillator will never see greater than 5000 ohms resistance, even when no water or fresh water is in the cell. Thus the minimum instrument frequency will never be less than about 2500 to 3000 Hz, well within the optimum frequency range of the oscillator. The calibration sheet shows the frequency of the instrument after being flushed several times with distilled water and then read with no water in the cell.

The health of the instrument oscillator can be checked by the customer at any time by testing under similar conditions. If the frequency is more than 2 or 3 Hz different than that shown in the calibration sheet, the oscillator may be defective. Note that if the instrument is tested with water in it, it will have to be flushed several times with distilled water in order for the frequency to approach the test frequency. In fact, our tests indicate that even when well flushed, the frequency with distilled water will always be a few Hz higher than our test frequency, so the test should actually be done with no water in the cell. We also find that de-ionized water has a lower conductivity than distilled water, approaching no-water conditions. The test frequency will <u>not</u> give you any indication about whether the conductivity cell needs cleaning or not.

We have also devised a new conductivity curve fitting equation using a "least squares" program for the IBM PC. The new equation, almost without exception, will give a better fit than our old equation. The equation is:

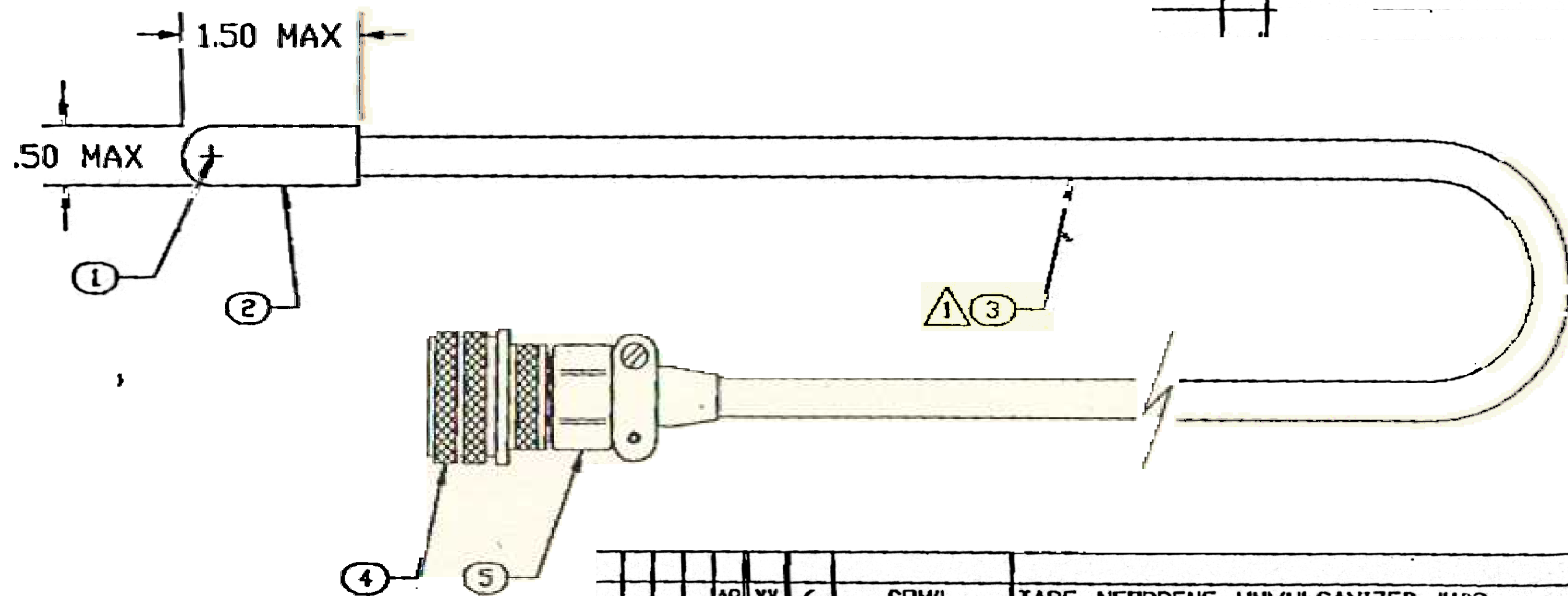
$$\text{Conductivity} = \frac{(af^m + bf^2 + c + dt)}{10\,(1-9.57e^{-8}\,p)} \quad \text{Siemens per meter}$$

where Conductivity is in Siemens/meter, f is the instrument frequency in kHz, t is the temperature in degrees C, and a, b, c, d & m are constants determined by the program. A handy feature of the equation is that it can be used for both the old and new versions of the SBE-4 instrument--"c" is very small for the old instruments which do not have the conductivity offset resistor in them. The program initially picks a value of "m" and then does a "least squares" calculation to determine the a, b, c & d values. The program then iterates "m" by 0.1 and computes a, b, c & d again. It continues to do this until it finds a minimum in the quantity "sum of the absolute value of the fitting errors". The whole calculation takes a couple of seconds if the PC system has the 8087 co-processor. A separate file is created for each instrument. This file contains all calibrations for that instrument, so that it is easy to plot several calibrations on the same sheet, showing instrument drift over time. Thus, when instruments are recalibrated, data sheets can easily be created to show drift relative to the previous calibration.

E.9 WATER TEMPERATURE

REVISIONS

E.O. NO.	REV	DESCRIPTION	DR	DATE	APVD



NOTES

1 - CABLE LENGTH (L2) IS 33 FT

-5	-4	-3	-2	-1	U/M	FIND NO.	PART NO.	PART NAME	
				AR	XX	6	COM'L	TAPE, NEOPRENE, UNVULCANIZED, #103	090106
				1	EA	5	COM'L	CONN, CLAMP, WATERPROOF, 9767-14-6	054214
				1	EA	4	COM'L	CONN, PLUG, 2 COND, MS3106A-14S-02P-417	054212
				50	FT	3	COM'L	CABLE, SJO-2, 2 COND, 18 AWG, RUBBER INS	090036
				1	EA	2	S090701	CAP, SHRINK	090701
				1	EA	1	B 44032	44032 THERM	895304
				X			B 19786-00	PROBE, 19786	SP19786

UNLESS OTHERWISE SPECIFIED:
REMOVE BURRS
BREAK EDGES .010
TOLERANCES
.X ±.030
.XX ±.015
.XXX ±.005
ANGLES ±1/2

YSI Incorporated
Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio 45387 USA

MATERIAL:
FINISH:
SCALE: NA
MAT'L NO.
SHEET 1 OF 1
DO NOT SCALE DWG
DATE
APVD.
DATE
APVD.
DATE

DASH NO.	NEXT ASSY	END ITEM	QTY
	9786		

APPLICATION

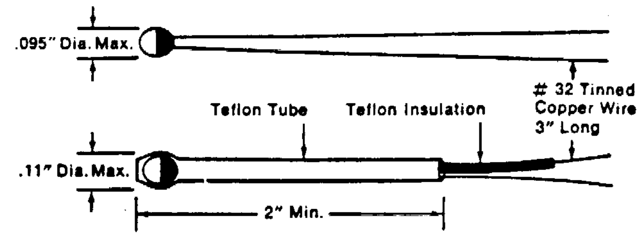
PART NAME: PROBE, 19786
PART NUMBER: B 19786-00
REV A

COMPUTER GENERATED DRAWING UPDATE COMPUTER FILE WHEN CHANGING

YSI 44000 Series Precision Interchangeable Thermistors

YSI thermistors provide highly accurate and stable temperature sensing for applications of temperature measurement, control, indication and compensation. Typical uses include precise measurements without the necessity of individual circuit calibration and with the advantage of precision interchangeability of sensors. Precise cold junction compensation of thermocouples may be designed directly without "bread boarding" after mathematically deriving the circuit because of the superior interchangeability of YSI precision thermistors.

Two interchangeability tolerances and two thermistor configurations are offered. Teflon encased thermistors allow exposure to hostile environments such as conductive or corrosive liquids and particulate suspensions. A stiff wire placed in the tube also allows the thermistor leads to be formed to various shapes with slight finger pressure.



	Ordering Part Numbers Standard	Ordering Part Numbers Teflon Encased	Power Resistance Ohms @ 25°C	Tolerance % R 0 to 70°C	Resistance Ratio 25 to 125°C	Maximum Working Temperature °C	Storage Temperature and Working Temperature For Best Stability °C	Color Code Body	Color Code End
±0.2°C Interchangeability Tolerance 0 to 75°C	44001A	—	100	±1.0%	10.87	100	−80 to +50	Black	Brown
	44002A	—	300	±1.0%	15.15	100	−80 to +50	Black	Red
	44003A	—	1000	±1.02%	17.33	100	−80 to +50	Black	Orange
	44035	—	1000	±1.02%(−40 to +150)	17.33	100	−80 to +50	Orange	Green
	44004	44104	2252	±1.02%	29.26	150	−80 to +120	Black	Yellow
	44005	44105	3000	±1.02%	29.26	150	−80 to +120	Black	Green
	44007	44107	5000	±1.02%	29.26	150	−80 to +120	Black	Violet
	44017	—	6000	±1.02%	29.26	150	−80 to +120	Brown	Violet
	44016	—	10K	±1.02%	29.26	150	−80 to +120	Brown	Blue
	44006	44106	10K	±1.0%	23.51	150	−80 to +120	Black	Blue
	44008	44108	30K	±1.0%	29.15	150	−80 to +120	Black	Gray
	44011	44111	100K	±1.03%	34.82	150	−80 to +120	Brown	Brown
	44014	44114	300K	±1.1%	46.02	150	−80 to +120	Brown	Yellow
	44015	44115	1MEG	±1.2%	61.96	150	−80 to +120	Brown	Green
±0.1°C Interchangeability Tolerance 0 to 75°C	44033	—	2252	±0.51%	29.26	75	−80 to +75	Orange	Orange
	44030	—	3000	±0.56%	29.26	75	−80 to +75	Orange	Black
	44034	—	5000	±0.56%	29.26	75	−80 to +75	Orange	Yellow
	44036	—	10K	±0.51%	29.26	75	−80 to +75	Orange	Blue
	44037	—	6K	±0.51%	29.26	75	−80 to +75	Orange	Violet
	44031	—	10K	±0.51%	23.51	75	−80 to +75	Orange	Brown
	44032	—	30K	±0.51%	29.15	75	−80 to +75	Orange	Red

TIME CONSTANT: The time required for a thermistor to indicate 63% of a newly impressed temperature is the time constant. For a thermistor suspended by its leads in a well-stirred oil bath it is 1 sec. max for standard thermistor and 2.5 sec. max. for Teflon encased thermistors. In still air it is 10 sec. max. for standard thermistors, and 25 sec. max. for Teflon encased thermistors.

DISSIPATION CONSTANT: The power in milliwatts required to raise a thermistor 1°C above surrounding temperature is the dissipation constant. For all thermistors suspended by their leads in a well-stirred oil bath it is 8mW/°C min., or 1mW/°C in still air.

STABILITY: YSI thermistors are chemically stable and not significantly affected by aging or exposure to strong nuclear radiation.

TOLERANCE CURVES AND TABLES: Data indicating conformance to resistance temperature values as a maximum interchangeability error expressed both as temperature and as a % of resistance are shown on page 7.

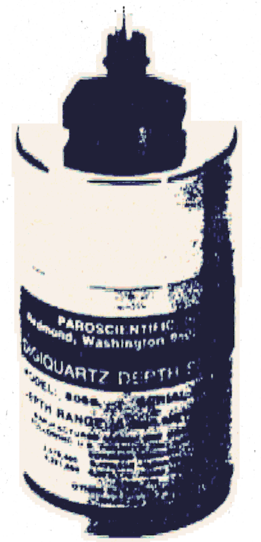
RESISTANCE TEMPERATURE DATA: Tables indicating the predicted performance of YSI precision thermistors in °C and in °F are shown on pages 10 through 12. This data may be used directly in design of R/T networks and temperature measurement systems.

HOW TO ORDER

Use the above part numbers.

E.10 WATER PRESSURE

DIGIQUARTZ® DEPTH SENSORS



FEATURES
- FULLY SUBMERSIBLE
- LOW POWER CONSUMPTION
- LONG LINE DRIVING CAPABILITY
- QUARTZ CRYSTAL FREQUENCY OUTPUTS
- CALIBRATED OVER WIDE TEMPERATURE RANGE

APPLICATION AREAS
- OCEANOGRAPHY
- RESERVOIR LEVEL
- TSUNAMI DETECTION
- WAVE AND TIDE GAUGES
- UNDERWATER PIPE LAYING
- OFFSHORE PLATFORM LEVELING

MODEL	RANGE (meters of water)
8010	0 to 10
8020	0 to 20
8060	0 to 60
8130	0 to 130
8200	0 to 200
8270	0 to 270
8600	0 to 600
8B1400	0 to 1400
8B2000	0 to 2000
8B4000	0 to 4000
8B7000	0 to 7000

The SERIES 8000 DIGIQUARTZ® DEPTH SENSORS incorporate the PAROSCIENTIFIC quartz crystal pressure transducers in a self-contained submersible arrangement. These high performance water level sensors have a sensitivity of better than a millimeter of water at depths of thousands of meters. They are well suited for remote and ship deployed oceanographic applications because of their high accuracy, long term stability, low power consumption, and long line driving capability.

The depth sensor consists of a sealed pressure case, fabricated from 316 stainless steel, which houses a pressure transducer in a protective shock mount. The transducer is wired internally to the depth sensor's underwater connector. Pressure inputs are transmitted either by connecting to the pressure port or by total submersion. An internal, flexible, oil filled tube transmits pressure directly to the transducer and avoids the need for an isolation diaphragm.

The depth sensor may be used for real-time data acquisition or in logging systems where hydrostatic pressure is recorded digitally on magnetic tape or in solid state memory. Application areas include monitoring of reservoir, lake, and river levels, tidal and sea slope measurements, as well as tsunami, wave, and seiche studies. Pipe laying and platform leveling can be accomplished using multiple depth sensors.

Integral electronics include protection against power surges and electrical transients. The low impedance pressure output signal is capable of driving cable lengths of several thousand meters. A quartz crystal frequency output temperature signal may be used for thermal compensation of pressure information. These frequency signals are easily interfaced to the SERIES 700 DIGIQUARTZ® PRESSURE COMPUTER providing a system capable of reading out in your choice of depth or pressure units.

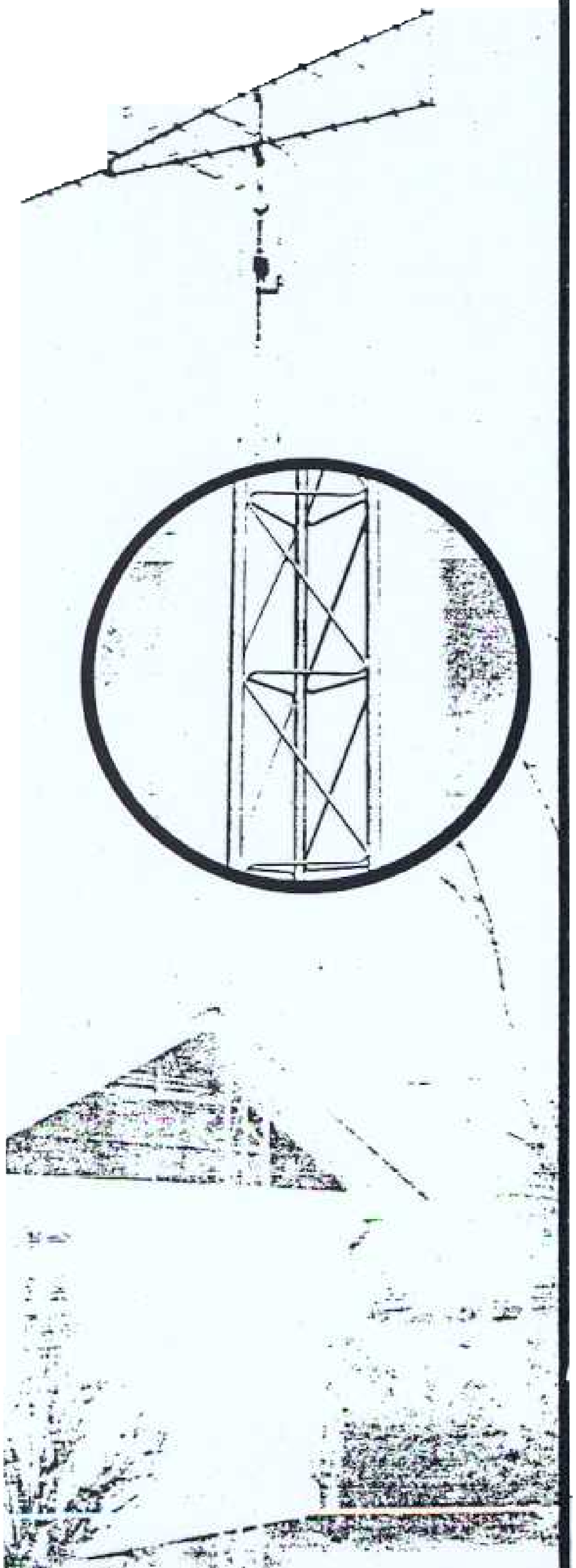
Paroscientific, Inc.
4500 148th AVENUE N.E. REDMOND, WA 98052
(206) 883-8700 TELEX: 152901 (PARO RDMD)

Product defined by Specification Control Drawing. Manufactured under one or more of the following U.S. Patents: 3,470,400 - 3,479,536 - 4,089,058 - 4,215,570 - 4,321,500 - 4,372,173 4,382,385 - 4,384,495 - 4,406,966 - 4,454,770 - 4,455,874 - 4,479,391 - 4,531,073 - 4,592,663 Other patents pending

E.12 METEROLOGICAL TOWERS

E.12.1 BRACKETED STEEL TOWER

ROHN® 25G TOWER



HOT DIP GALVANIZED

GENERAL USE
General Purpose Communication or Heavy-Duty TV Tower. T
satisfy a tremendously wide range of tower needs.
DESIGN
Built on a 12½" equilateral triangular design with continuous st
cross-bracing entirely electric welded and fabricated in prec
ment. The 8 "zig-zag" braces per 10' section mean more than us
CONSTRUCTION
Unequalled Sturdiness . . . Extra heavy-duty 1¼" steel tubing
side rails, resulting in far greater strength and sturdiness th
found in this size tower. SUPERIOR STRENGTH . . . has alway
most in ROHN towers. This is achieved by setting rigid high s
the steel used. These standards are constantly maintained
testing according to accepted laboratory procedures so quality i
It's a natural conclusion that when quality ingredients are co
precision manufacturing and proven design the result is a hi
product!
FINISH
Famous ROHN Hot-Dip Galvanized long-life finish . . . the n
coating ever known. Rust-proofs and gives an always attractive
Every inch, including *inside* of entire tower, evenly and comple
with zinc *after* fabrication.
ENGINEERING DATA
ROHN superior engineering means advanced design . . . this r
best tower for the needs of today! This is proven because her
at least 33% stronger and more durable than similar size and
found on the market today. At the same time, the ROHN produ
means lower costs . . . giving you a tower actually costing less
towers. Get the best . . . look at the No. 25G carefully and you'
SPECIAL FEATURES
The No. 25G uses double-bolted joints . . . proven the best me
ing tower sections for sturdiness and dependability. The e
of the No. 25G allows it to be self-supporting provided a hou
used and can go 35 feet above this bracket under normal cor
instruction sheet) Under most guyed conditions the No. 25C
to heights of 200 feet! Where special conditions or unusual a
ing requirements must be met, we suggest you contact the
Department for complete information. ***Assembly bolts and nut***
within 1 leg of each tower section.

SELF-SUPPORTING HEIGHTS FOR 25G TOWE

WIND LOAD	Factor of Safety—1.5 No. Ant.	2 Ft²	Factor No
10.0 PSF (50 MPH)	72.4'	64.8'	58.
14.4 PSF (60 MPH)	60.4'	52.9'	48.
20.0 PSF (70.7 MPH)	51.3'	43.8'	41.

*see Installatio

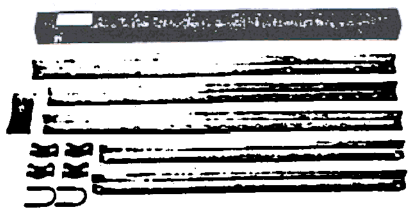
**Recommende

ROHN®

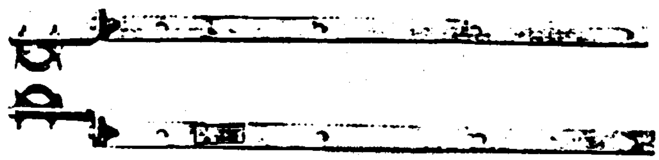
6718 West Plank Road
P.O. Box 2000 • Peoria, Illinois 61656
Phone: 309-697-4400
TWX 910-652-0646

ROHN®

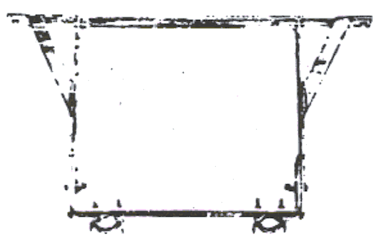
BRACKETS



HBU
UNIVERSAL HOUSE BRACKET



EB2525G
UNIVERSAL EAVE BRACKET

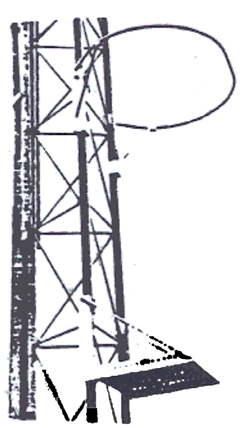


HB25AG 0-15"
HB25BG 0-24"
(not shown)
HB25CG 0-36"
(not shown)
ADUSTABLE HOUSE BRACKET

GA25G
GUY ASSEMBLY
with torque bars

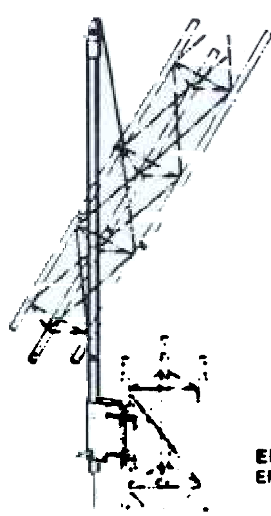
GB25G
GUY BRACKET ONLY
without torque bars

SAFETY



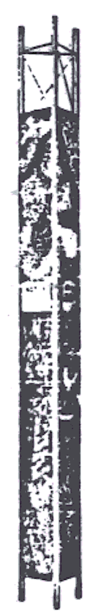
SR 245
SAFETY RING

WP25G
WORK PLATFORM



For lifting
1 - 10' section
at a time

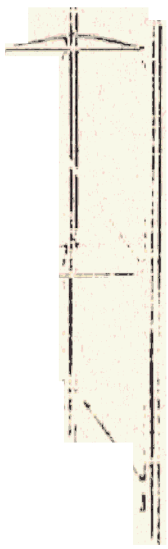
EF 25 45
ERECTION FIXTURE



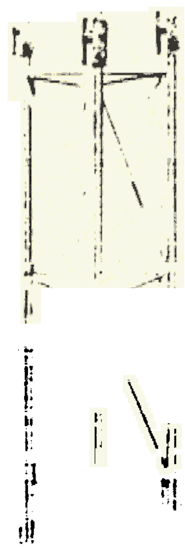
25ACL
ANTI-CLIMB SECTION

25G

BASES

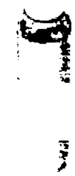


SB25G
3'4" SHORT BASE
section for concrete

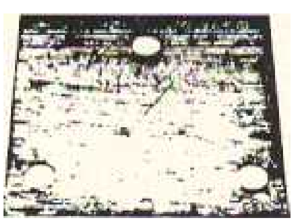


SBH25G*
3'4" HINGED SHORT BASE
section for concrete

DR25G *
2' DRIVE RODS
set of 3

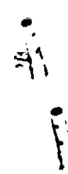


DT25
DRIVE TOOL
for DR 25G

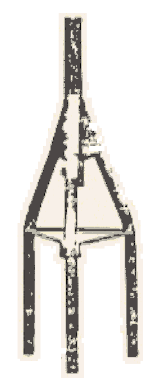


BP25G*
BASE PLATE
(for use with drive rods)

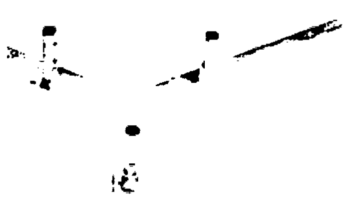
BPH25G*
HINGED BASE PLATE
for concrete



BPC25G*
CONCRETE BASE PLATE

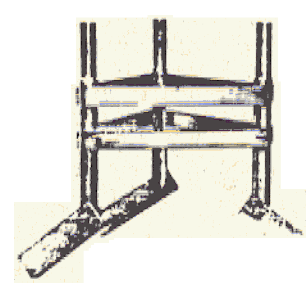


20BG
3' TOP SECTION



FR25G*
FLAT ROOF MOUNT

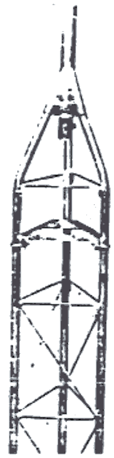
SDB25G*
SINGLE DRIVE-IN BASE



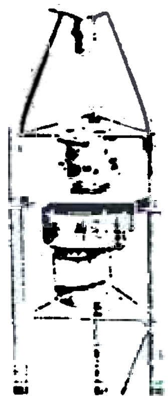
PR25G*
PEAK ROOF MOUNT

**Note: Towers mounted on these bases must be bracketed or guyed*

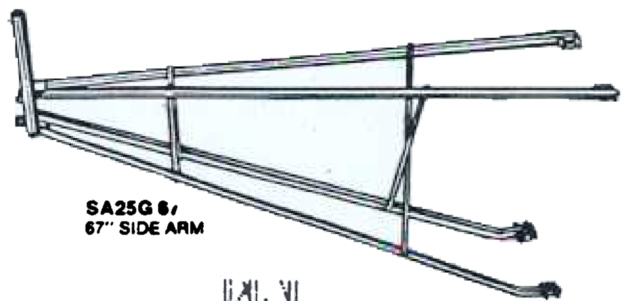
ACCESSORIES



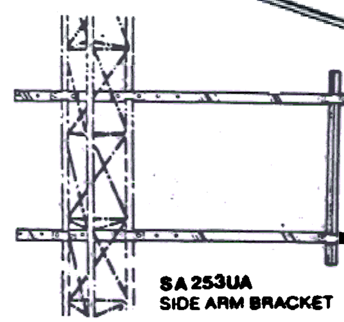
RP25G
ROTOR POST



AS25G on 25AG
Top Section with Hy Gain Model 400 Rotor
(must be reanilled.)

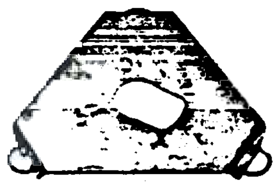


SA25G 67
67" SIDE ARM



SA 253UA
SIDE ARM BRACKET

RP25G CM
SPECIAL ROTOR POST



AS25G
ACCESSORY SHELF
(for mounting Ham-M rotor.)

TB50 1¼" ID, 2" OD
TOWER BUSHING
for use in 20AG or 25AG Top Section
TB75 1½" ID, 2" OD
(not shown)

TB3
THRUST BEARING
2" O.D. TUBING

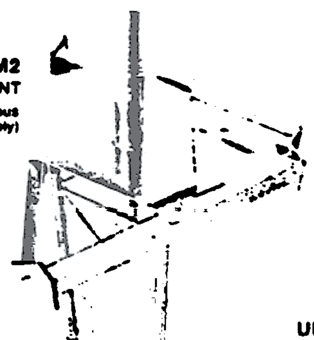
TB4
THRUST BEARING
3" O.D. TUBING
(not shown)

AB
HARDWOOD BEARING
for use on 25AG-4 Top Section
for 2" OD tubing

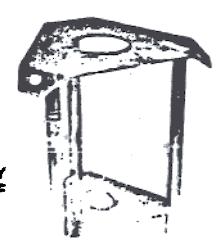
DM25G 2
FACE DISH MOUNT
for 4 foot grid dish maximum

APL25G
TOP BEACON PLATE

25TDM2
TOP DISH MOUNT
(see drawing Page C-760785 for various sizes and assembly)



BAS25G
BEARING/ACCESSORY SHELF



UHF25G
SIDE ARM MOUNT
for UHF & FM antennas

ADDITIONAL INFORMATION

Do not install towers and masts near power lines. All towers or masts should be installed twice the height of the installation away from power lines since every electrical wire must be considered dangerous.

ROHN recommends anti-climb sections on all towers to prevent unauthorized persons from climbing towers.

All towers and masts should be installed and dismantled by experienced and trained personnel.

All types of antenna installations should be thoroughly inspected by qualified personnel and remarked with hazard and warning labels at least twice a year to insure safety and proper performance.

All antenna installations must be grounded per local and national codes.

The mixing of so called interchangeable copies of ROHN products is dangerous and voids all engineering or warranty data supplied by ROHN. Materials used by the so-called copies are not the same quality and have not been tested or engineered by ROHN to conform to the same quality standards. Mixing of non-ROHN items may endanger the lives of your customers and cause serious tower failures and financial implications for all concerned.

Form 84-1393

PRINTED IN U S

SHEET D-1740
(Replaces D-1425)

July 1, 1980

REFERENCE SHEET AND INSTALLATION INFORMATION

#25 BRACKETED TOWERS, NON-GUYED

INSTALLATION: Select a tower location sufficiently clear and out of falling distance of power lines since every electrical and telephone wire should be considered dangerous. The only safe distance from power lines is at least twice the height of tower, mast, and antenna. Tower should be installed by experienced and trained personnel. All antenna installations must be grounded per local or national codes.

BASE: The size of the concrete base for a 50' #25 tower, with a house bracket 12' aboveground, is 3' deep by 18" square. For cases of loose soil, etc., the base must be larger. Spread about 2" of gravel in bottom of hole prior to setting base assembly. The base assembly should be attached to the first 10' section prior to setting into gravel. After setting base assembly on gravel, fill another 3" with gravel around legs of base. This allows the tower base legs to extend the required amount below the base of the concrete, thus allowing for drainage of moisture into the gravel. The base assembly and first 10' section should be leveled, plumbed, and temporarily guyed or braced while pouring the concrete. This will insure a plumb tower after installation. Check tower to assure it is plumb and level after pouring concrete. Do not pull base up into the concrete to level it and do not drive it hard into ground as this plugs leg holes and prevents moisture drainage. Crown the top of the concrete slightly to prevent water accumulation. Do not use drive rods as a base for tower when set in concrete.

HEIGHT OF TOWER & BRACKET USES: House brackets must be used and must be mounted at least 12' aboveground to be effective. The #25 tower should not extend more than 33' above a house bracket. (Note: Two house brackets are to be used, equally spaced, on the 80' tower.) To secure the house bracket, use lag screws no smaller than 3/8" x 2". A special effort should be made to locate the house bracket such that the lag screws go through the siding into a stud. Brackets fastened to the siding only will not hold in a high wind. Tighten the house bracket U-bolts only enough to prevent looseness. Do not dent or flatten the tower upright members by excessively tightening U-bolts.

BOLTS: Nuts and bolts are located in tower legs. Installers are urged to use a 10" lining-up punch that tapers from about 1/2" to 5/32" diameter over a 6-1/2" length. If bolts cannot be pushed through the holes with the heel of the hand while rocking the tower, do not hammer them through. Carefully drive the punch into the hole just enough to slightly enlarge it. The leg bolt hole should be just large enough to admit the bolt. Never drill out the holes. Be sure to tighten all leg bolts until they partially flatten the sleeves, causing the sleeves to actually grip the legs inside. Always replace stripped bolts. Upon completing an installation, there should be no vertical movement between tower sections at the joints when the tower is deliberately swayed from side to side.

MISCELLANEOUS: Installation is greatly hastened and simplified by the use of an erection fixture. Do not use it to lift more than the weight of one tower section at a time. Anti-climb sections are recommended for all towers to prevent unauthorized persons from climbing tower.

CAUTION: ... Be sure hinge bolts on hinged type accessories are loosened before attempting to hinge tower over. Hinge up no more than 33' of #25 tower only. All hinged type bases are recommended to be used to raise tower only without antenna. When raising and lowering tower on any type of hinge base or hinge section, the loads applied for hinging the tower must be applied equally on both sides of tower in order to reduce the possibility of twist on tower and hinges at the base. Special care must be taken to avoid the use of raising and lowering methods which may cause damage to tower or hinges.

All information is based upon antennas with not more than 2 square feet of area in a 20 psf (70 mph) wind load and a safety factor, with antenna installed at tower apex.

See Chart B-691119 for more information on non-guyed towers.

NOTE: All types of antenna installations should be thoroughly inspected by qualified personnel at least twice a year and remarked with hazard and warning labels to insure safety and proper performance.

Dismantling of any tower should be done by professional and experienced installers a section at a time with the use of an erection fixture.

PART NUMBER	
25G030BRKT	30' Complete Bracketed Tower
25G040BRKT	40' Complete Bracketed Tower
25G050BRKT	50' Complete Bracketed Tower
25G060BRKT	60' Complete Bracketed Tower
25G070BRKT	70' Complete Bracketed Tower
25G080BRKT	80' Complete Bracketed Tower

Refer to alphabetical/numerical price list for reference sheet prices on Complete #25G bracketed Towers.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

UNR-ROHN

Assembly Information

Bracketed #20 and #25 Towers, Non-Guyed

SITE SELECTION: Select a tower location sufficiently clear and out of falling distance of power lines since every electrical and telephone wire should be considered dangerous. The only safe distance from power lines is at least twice the height of tower, mast, and antenna combined. Tower should be installed and dismantled by experienced and trained personnel. All antenna installations must be grounded per local or national codes.

BASE: The size of the concrete base for a bracketed #20 tower, with a house bracket 12' aboveground, is 3' deep by 18" square. The base for a bracketed #25 tower is 3' deep by 18" square. For cases of loose soil, etc., the base must be larger. Spread about 2" of gravel in bottom of hole prior to setting base assembly. The base assembly should be attached to the first 10' section prior to setting into gravel. After setting base assembly on gravel, fill another 3" with gravel around legs of base. This allows the tower base legs to extend the required amount below the base of the concrete, thus allowing for drainage of moisture into the gravel. The base assembly and first 10' section should be leveled, plumbed, and temporarily guyed or braced while pouring the concrete. This will insure a plumb tower after installation. Check tower to assure it is plumb and level after pouring concrete. Do not pull base up into the concrete to level it and do not drive it hard into ground as this plugs leg holes and prevents moisture drainage. Crown the top of the concrete slightly to prevent water accumulation. Do not use drive rods as a base for tower when set in concrete.

HEIGHT OF TOWER & BRACKET USES: House brackets must be used and should be mounted at least 12' aboveground to be effective. The #20 tower should not extend more than 28' (maximum) above a house bracket and the #25 tower should not extend more than 33' (maximum) above a house bracket. (Note: Two house brackets are to be used, equally spaced, on the 80' #25 tower.) To secure the house bracket, use lag screws no smaller than 3/8" x 2". A special effort should be made to locate the house bracket such that the lag screws go through the siding into a stud. Brackets fastened to the siding only will not hold in a high wind. Tighten the house bracket U-bolts only enough to prevent looseness. Do not dent or flatten the tower upright members by excessively tightening U-bolts.

BOLTS: Nuts and bolts are located in tower leg. Installers are urged to use a 10" lining-up punch that tapers from about 1/2" to 5/32" diameter over a 6-1/2" length. If bolts cannot be pushed through the holes with the heel of a hand while rocking the tower, do not hammer them through. Carefully drive the punch into the hole just enough to slightly enlarge it. The leg bolt hole should be just large enough to admit the bolt. Never drill out the holes. Be sure to tighten all leg bolts until they partially flatten the sleeves, causing the sleeves to actually grip the legs inside. Always replace stripped bolts. Upon completing an installation, there should be no vertical movement between tower sections at the joints when the tower is deliberately swayed from side to side.

MISCELLANEOUS: Installation is greatly hastened and simplified with the use of an erection fixture. Do not use it to lift more than the weight of one tower section at a time. If the antenna is to be fixed and a set screw used in the mast housing, or if a rotator is to be mounted on a short length of mast above the tower top section, install a TB50 tower bushing at bottom of the mast housing to center the mast in the mast housing. These bushings are "peened" in place. If the rotator is to be mounted inside the top section of the tower, do not install a TB50 tower bushing at bottom of mast housing. Anti-climb sections are recommended on all towers to prevent unauthorized persons from climbing tower.

CAUTION ... Be sure hinge bolts on hinged type accessories are loosened before attempting to hinge tower over. Hinge up no more than 33' of #25 or 28' of #20 tower only. All hinged type bases are recommended to be used to raise tower only without antenna. When raising and lowering tower on any hinged type base or hinge section, the loads applied for hinging the tower must be applied equally on both sides of the tower in order to reduce the possibility of twist on tower and hinges at the base. Special care must be taken to avoid the use of raising and lowering methods which may cause damage to tower or hinges. Hinged bases and roof mounted towers should only be installed and dismantled by professional and experienced installers.

All types of antenna installations should be thoroughly inspected by qualified personnel at least twice a year and remarked with hazard and warning labels to insure safety and proper performance.

Dismantling of any tower should be done by professional and experienced installers a section at a time with the use of an erection fixture.

All information is based upon average antennas, with no more than 2 square feet of area in a 20 psf (70 mph) wind load and a safety factor, with antenna installed at tower apex.

THESE ARE FACTORY TESTED INSTRUCTIONS. PLEASE FOLLOW CAREFULLY.

"WARNING: INSTALLATION OR DISMANTLING OF THIS PRODUCT NEAR POWER LINES IS DANGEROUS. FOR YOUR SAFETY, FOLLOW THE SAFETY DIRECTIONS."

INSTALLATION AND DISMANTLING SAFETY INSTRUCTIONS -- YOU, YOUR ANTENNA, AND SAFETY

Each year hundreds of people are killed, mutilated, or receive severe permanent injuries when attempting to install or dismantle an antenna. In many of these cases, the victim was aware of the dangers of electrocution and failure but did not take adequate steps to avoid the hazard.

For your safety and to help you achieve a good installation, please READ and FOLLOW the safety precautions below. THEY MAY SAVE YOUR LIFE!

1. If you are installing or dismantling an antenna for the first time, please, for your own safety as well as others, seek PROFESSIONAL ASSISTANCE. Consult your dealer. He can explain which mounting or dismantling method to use for the size and type antenna you are about to install or dismantle.

2. Select your installation site with safety, as well as performance, in mind. (See information on Site Selection.) REMEMBER: POWER LINES AND PHONE LINES LOOK ALIKE. FOR YOUR SAFETY, ASSUME THAT ANY OVERHEAD LINES CAN KILL YOU.

3. Call your power company. Tell them your plans and ask them to look at your site. This is little inconvenience, considering YOUR LIFE IS AT STAKE.

4. Before you begin, plan your installation or dismantling procedure carefully. Successful installation or dismantling of a mast or tower is largely a matter of coordination. Each person should be assigned to a specific task and should know what to do and when to do it. One person should be designated as the "boss" to call out instructions and watch for signs of trouble.

5. When installing or dismantling your antenna, REMEMBER: DO NOT use a metal ladder. DO NOT work on a wet or windy day or if a thunderstorm is approaching. DO dress properly -- shoes with rubber soles and heels, rubber gloves, long sleeve shirt or jacket.

6. If the assembly starts to drop, get away from it and let it fall. REMEMBER: The antenna, mast, cable, and metal guy wires are all excellent conductors of electrical current. Even the slightest touch of any of these parts to a power line completes an electrical path through the antenna and the installer -- THAT'S YOU!

7. If any part of the antenna system should contact a power line -- DON'T TOUCH IT OR TRY TO REMOVE IT YOURSELF. CALL YOUR LOCAL POWER COMPANY. They will remove it safely.

8. If an electrical accident should occur -- DON'T grab hold of the person in contact with the power line or you too will be electrocuted. Use a DRY board, stick or rope to push or pull the victim away from the antenna. If the victim has stopped breathing, administer artificial respiration -- and stay with it. Have someone call for medical help.

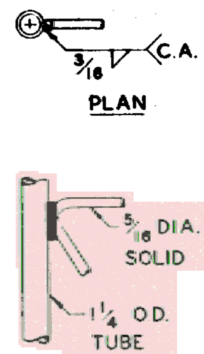
SITE SELECTION: Before attempting to install your antenna, think where you can best place your antenna for safety and performance. To determine a safe distance from wires, power lines, and trees: 1) Measure the height of your antenna; 2) Add this length to the length of your tower or mast; and then, 3) Double this total for the minimum recommended safe distance.

If you are unable to maintain this safe distance, STOP! GET PROFESSIONAL HELP. Generally, the higher the antenna is aboveground, the better it performs. Good practice is to install your antenna above the roof line and away from power lines and obstructions. Remember that the FCC limits your CB antenna height. If possible, find a mounting place close to your set, where the antenna wire can take a short, vertical drop on the outside of the house for entry through a wall or window near the set. Your dealer carries a complete line of installation hardware.

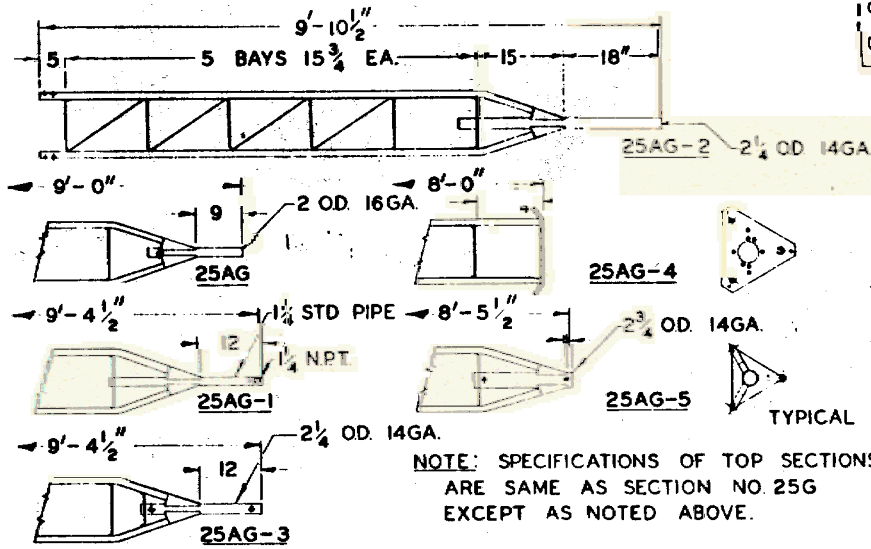
C-630625

Tower Specifications

Distance between side rails (center to center)	11¼"
Overall length of section	10'-0"
Weight per section	40 Lbs.
Side rail diameter and gauge	1¼" O.D. 16 GA.
Cross sectional area - one leg	.2420 Sq. In.
Gross allowable vertical load on the bottom tower section	18,960 Lbs.
Maximum allowable axial compression of the cross section of one side rail	6,320 Lbs.
Measured tensile strength of one side rail	16,120 Lbs.
Measured tensile strength of one bolted leg joint	13,280 Lbs.
Maximum allowable tension in each bolted leg joint	5,310 Lbs.
Safe moment of restraint	5,130 Ft.-Lbs.
L - unbraced length of side rail (distance between crosspieces)	15¾"
R - radius of gyration of side rail	.420"
L/R for main leg member	37.5
Wind load per lineal foot of tower at the horizontal wind pressures (per square foot of flat surface) listed below:	
30 Lbs	7.62
40 Lbs	10.16
50 Lbs	12.70

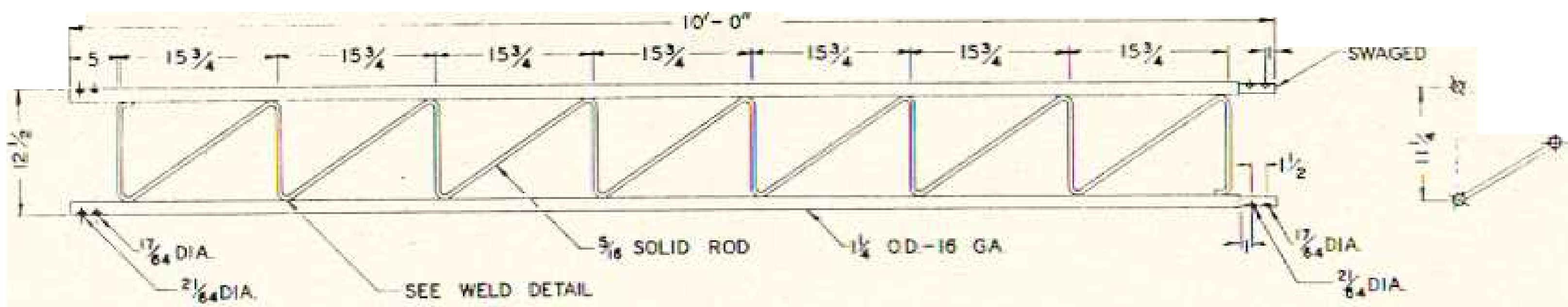


WELD DETAIL



NOTE: SPECIFICATIONS OF TOP SECTIONS ARE SAME AS SECTION NO. 25G EXCEPT AS NOTED ABOVE.

STANDARD TOP SECTIONS



NO. 25G SECTION

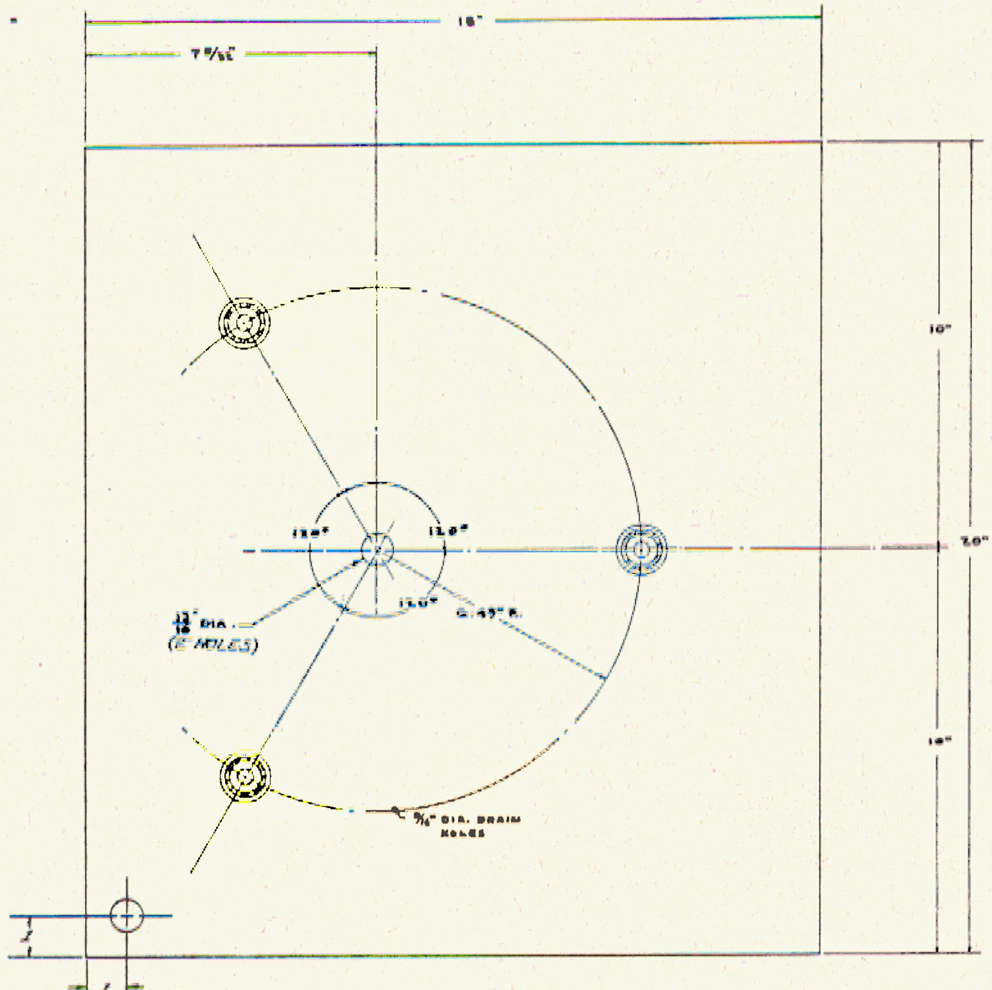
3 - ¼" DIA. X 1½" LG. NF BOLTS
3 - 5/16" DIA. X 1½" LG. NF BOLTS

NOTE: ALL DIMENSIONS IN INCHES EXCEPT AS NOTED

R3 6-15-77 J.R.D.
REVISED 4-20-61
R3 3-28-72
R4 3-26-73

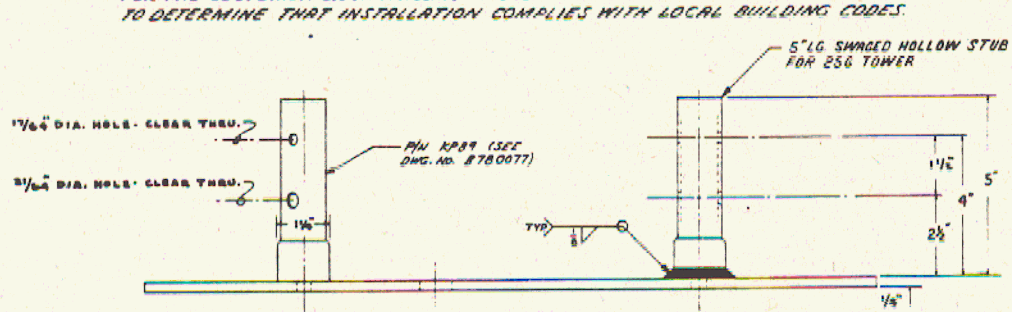
DRAWN A.M.	CUSTOMER	TITLE MODEL 25 TOWER SECTION
CHECKED		
APPROVED		
DATE 6-25-63	ROHN MANUFACTURING PEORIA, ILLINOIS	DRAWING NO. C-630625-R
SCALE NONE		

R5 REVISED 25AG4



PLAN

R_4 NOTE: DUE TO VARIABLES INVOLVED IN ROOF AND OTHER INSTALLATIONS, IT SHALL BE THE CUSTOMER'S OR INSTALLER'S RESPONSIBILITY TO PROVIDE STRUCTURALLY ADEQUATE SUPPORTS FOR PIER & ANCHOR CONNECTIONS. IT MAY ALSO BE NECESSARY FOR THE CUSTOMER OR INSTALLER TO SECURE THE SERVICE OF A LOCAL ENGINEER TO DETERMINE THAT INSTALLATION COMPLIES WITH LOCAL BUILDING CODES.



ELEVATION

BASE PLATE FOR CONCRETE PIER (BPC 25G)

NOTE:
FOR USE WITH GUYED AND BRACKETED TOWERS ONLY.

R1 REVISED 8-22-73 D.M.
R REVISED 6-3-64 GH

R_6	DELETE EXCESS HOLES	8-31-79	WRL
R_5	CHANGED STUB FROM 16 GA. TO 14 GA., ADDED P/N	7-26-78	AED
R_4	ADDED NOTE	7-6-76	OH
R_3	REVISED STUB & ADDED WELD SYMBOL	1-9-75	RDB
R_2	ADDED NOTE & REMOVED SCALE	11-26-73	JEK

	CUSTOMER	TITLE
DRAWN ck		BASE PLATE FOR MODEL 25 TOWER
CHECKED RAK		
APPROVED ck		DRAWING NO.
DATE 8-31-61	ROHN MFG. PEORIA, ILLINOIS	C-610831 R_6
SCALE ~		

SHEET D-2071
(Replaces D-1739)

April 1, 1983

#25 TOWER

PART NUMBER		WT.
25G	10' tower section	40
20BG	3' top section for use as home TV top section	8-1/2
25AG	9' top section for use as home TV top section	31
/ ST25AG /	5' short top section for use as home TV top section	18
/ 25AG1 /	Top section for use with communication antenna. Mast support tube is 1-1/4" galv. pipe, threaded on top and projecting 12" above apex of side rails.	31
25AG2	Top section for use with communication antenna. Mast support tube is 2-1/4" O.D. tubing, 36" total length, extending 18" above apex of side rails.	31
25AG3	Top section for use with communication antenna. Mast support tube is 2-1/4" O.D. tubing, extending 12" above apex of side rails. A 2" O.D. antenna stub will fit snugly inside support tube.	31
25AG4	8' top section for use with communication antenna. Upper end terminates in 11" dia. flat, circular plate with 2-1/4" dia. hole in center.	
/ 25AG5 /	Top section for use with communication antenna. Mast support tube is 2-3/4" O.D. and 2-9/16" I.D. tubing, 18" total length.	
25TG	10' tapered base section	60
*25RG	10' insulator section for 25G tower (includes three #10470 post insulators)	74
25ACL	10' anti-climb section (for #25 and #20 towers)	115
/ 25ACL3 /	3 anti-climb metal sheets for attaching to tower section	65
25JBK	Joint bolt kit	1/2
APL25G	Beacon plate	14
SB25G	3'4" short base section for concrete	10
*SBH25G	3'4" hinged short base section for concrete	14
*SDB25G	Single drive base	20
*BPC20G	Concrete base plate	13
*BPC25G	Concrete base plate	27
3/4X12PP	Pier pin (for BPC20G, BPC25G, or 25TG - one required)	1
*BPH25G	Hinged base plate for concrete	21
1/2X12BB	Concrete base bolt with double nuts (for BPH25G - four required)	1/2
*FR25G	Flat roof mount	24
*PR25G	Peak roof mount	14
*BP25G	Base plate (for use with drive rods)	7
*DR25G	2' drive rods (set of 3)	6
DT25	Drive tool	1
RP25G	Rotor post	3
RP25GCM	Rotor post	2
AS25G	Accessory shelf. Triangular plate for mounting Ham "M" rotor or mast bearing. Mounts inside of tower. When using Model 400 Rotor, plate must be redrilled.	4
GA25G	Guy assembly (bracket with torque bars)	10
GB25G	Guy bracket only	6
HB25AG	Adjustable house bracket (0 to 15")	8
HB25BG	Adjustable house bracket (0 to 24")	11
HB25CG	Adjustable house bracket (0 to 36")	17
HBU	Universal house bracket (6" to 30")	15
EB2525G	Eave bracket (universal)	7
TB50	Tower bushing for 25AG and ST25AG tops (1-1/4" I.D. x 2" O.D.)	1/2
TB75	Tower bushing for 25AG and ST25AG tops (1-1/2" I.D. x 2" O.D.)	1/2
AB	Amateur bearing for use with 25AG4 top (2" x 4" x 10" hardware)	1
TB3	Heavy duty thrust bearing, recommended for 2" O.D. tubing	2-1/2
TB4	Heavy duty thrust bearing, recommended for 3" O.D. tubing	3
BAS25G	Bearing/accessory shelf section for mounting AB, TB3, or TB4 bearing and rotor	18
UHF25G	Side arm mount for UHF and FM antennas	4
SA253UA	Side arm assembly, 2-1/2' to 3' extension, with 2-1/4" O.D. support tube	28
SAB25G2	Discontinued (Replaced by SA253UA)	15
SA25G224	Discontinued (Replaced by SA253UA)	22
SA25G67	67" side arm with 1-1/4" I.D. support tube for mounting TV receiving antenna (not recommended and must be guyed to resist twist)	25
/ **TA25 /	Torque arm stabilizer assembly	35
/ **25TDM2 /	Top dish mount w/2" O.D. mast (extends 2' above top plate)	40
/ **25TDM2SP /	Top dish mount w/2" standard pipe (extends 3' above top plate)	50
/ **25TDM2EH /	Top dish mount w/2" EH pipe (extends 3' above top plate)	60
/ **25TDM25SP /	Top dish mount w/2-1/2" standard pipe (extends 3' above top plate)	65
/ **DM25G2 /	Face dish mount w/2" (2-3/8" O.D.) 5' long standard pipe	42
WP25G	Work platform (for #25 and #20 towers)	10
SR245	Safety ring	8
EF2545	Aluminum erection fixture, 12' long (fits all models with 1-1/4" side rails) (use to raise one 10' section at a time)	18
P2545	Pole only for EF2545	10
H2545	Head only for EF2545	8

*Towers mounted on these bases must be bracketed or guyed.

**This item is not to be used without proper design consideration.

/ Available by special order only. Allow 60 days for delivery. /

The #20 tower is not recommended for commercial, ham, CB or guyed installations.

NOTE: The price on #25 sections will be higher on shipments to the following states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Refer to alphabetical/numerical price list for current prices.

F.O.B. PEORIA, ILLINOIS - or - BIRMINGHAM, ALABAMA.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

PARTS LIST P-453
(Replaces P-421)

March 1, 1986

PARTS LIST #25G GUYED TOWER

Zone "A" Wind Load

6 Sq. Ft. of Allowable Load

Tower Height	25G	25AG2	BPC25G with 3/4"x12" PP	APL25G and SA253UA	GA25G	G.W. 3/16" E.H.S.	C.C.M. 3/16"	TH. 1/4"	T.B. 3/8"x6" E&E	GAC 253	GAC 255
40'	3	1	1		2	300'	36	12	6	3	
50'	4	1	1		2	375'	36	12	6	3	
60'	5	1	1		2	450'	36	12	6	3	
70'	6	1	1		2	500'	36	12	6	3	
80'	7	1	1		3	825'	54	18	9	3	
90'	8	1	1		3	900'	54	18	9	3	
100'	9	1	1		3	1100'	54	18	9	3	
110'	10	1	1		4	1500'	72	24	12		3
120'	11	1	1		4	1600'	72	24	12		3
130'	12	1	1		4	1700'	72	24	12		3
140'	13	1	1		4	1850'	72	24	12		3
150'	14	1	1		5	2500'	90	30	15		3
160'	16		1	1	5	2575'	90	30	15		3
170'	17		1	1	5	2775'	90	30	15		3
180'	18		1	1	6	2875'	108	36	18	6	
190'	19		1	1	6	3100'	108	36	18	6	
200'	20		1	1	6	3275'	108	36	18	6	

Items shown above are necessary for complete "ground" guyed towers

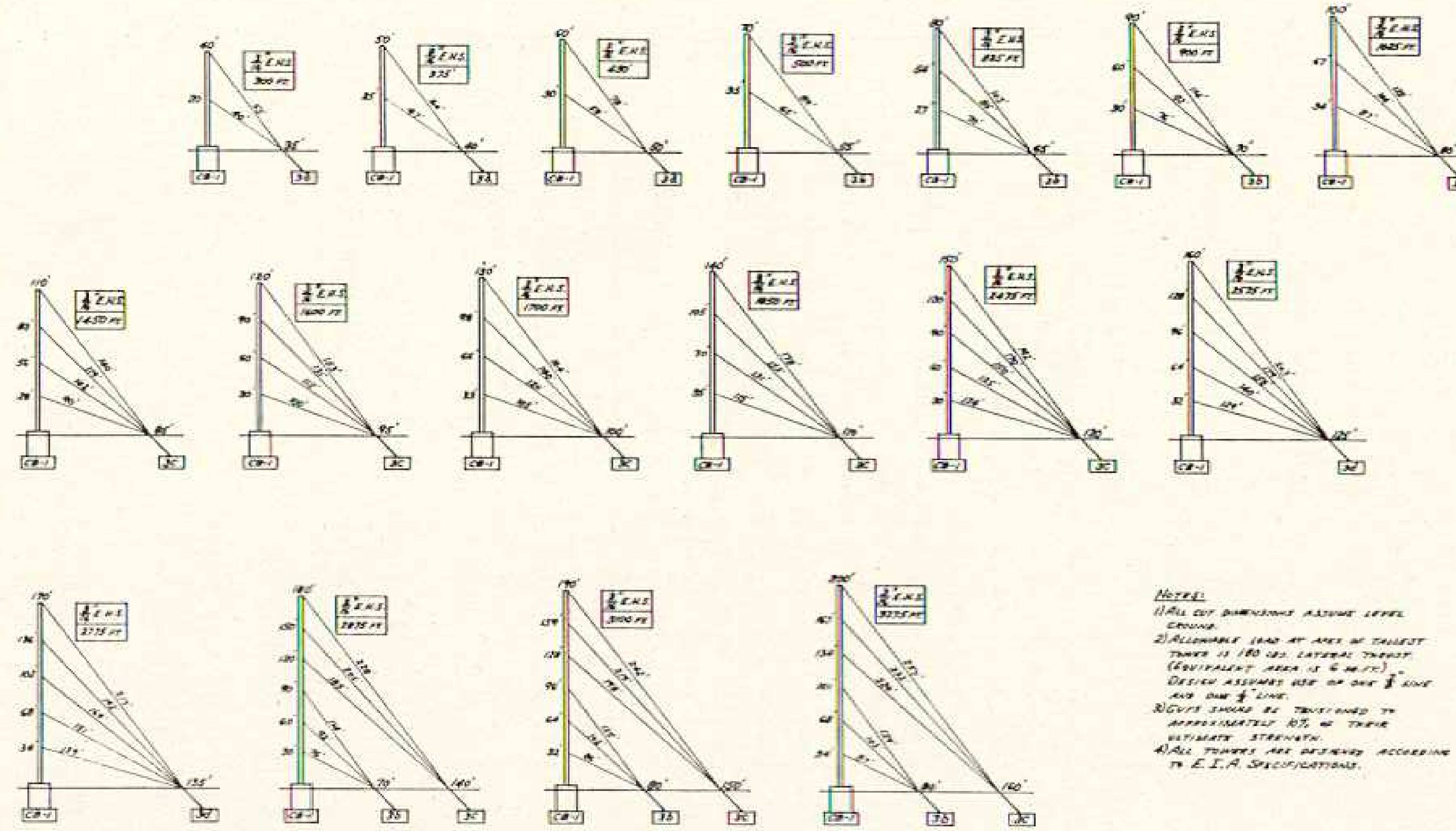
For "roof" towers a flat roof mount (FR25G) is substituted for the concrete base plate (BPC25G) and wall anchors (GAWP25) are substituted for the concrete anchors (GAC25).

When ordering specify "roof" or "ground".

Anchor grounding (AGKE) and base grounding (BGKE), as recommended by EIA, are included in tower material. However, extra copper wire may be required for roof installations. See appropriate sheet for grounding material and order extra copper wire as a separate item.

All types of antenna installations should be thoroughly inspected by qualified personnel and remarked with hazard and warning labels at least twice a year to insure safety and proper performance.

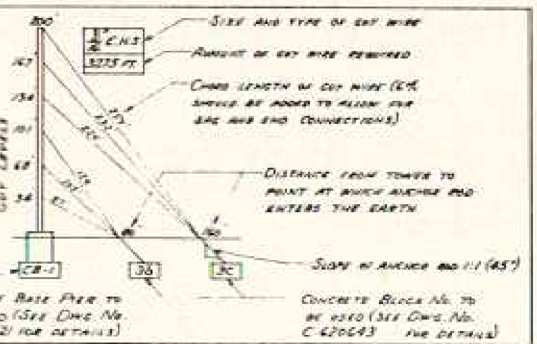
C 640603

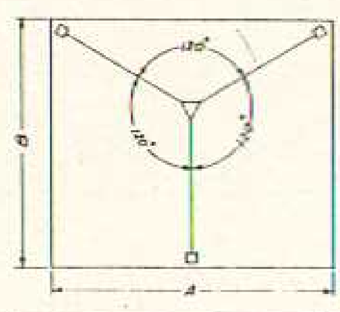


NOTES:

1) ALL GUY DIMENSIONS ASSUME LEVEL GROUND.
2) ALLOWABLE LOAD AT APEX OF TALLEST TOWER IS 180 LBS. LATERAL THRUST. (EQUIVALENT AREA IS 6 SQ. FT.) DESIGN ASSUMES USE OF ONE $\frac{3}{8}$" LINE AND ONE $\frac{1}{4}$" LINE.
3) GUYS SHOULD BE TENSIONED TO APPROXIMATELY 10% OF THEIR ULTIMATE STRENGTH.
4) ALL TOWERS ARE DESIGNED ACCORDING TO E.I.A. SPECIFICATIONS.

EXPLANATION OF CHART





FOR SPACE REQUIREMENT REFER TO DWG. NO. C640531

NO.	DESCRIPTION	DATE	BY
R3	0-200' WAS 0-300'		
R2	ADDED EIA DESIGNATION TO TITLE BLOCK		
1	H.S. GUY WIRE TO E.H.S. GUY WIRE		

REVISIONS

		TITLE
DRAWN AED	WIND LOAD - EIA ZONE "A" 0-200' = 30 PSF	GUYING DETAILS FOR MODEL 25 TOWER
CHECKED CL		
APPROVED RAF		DRAWING NO.
DATE 6-25-64	ROHN MANUFACTURING PEORIA, ILLINOIS	C 640603 R3
SCALE NONE		

PARTS LIST P-454
(Replaces P-422)

March 1, 1986

PARTS LIST #25G GUYED TOWER

Zone "B" Wind Load

6 Sq. Ft. of Allowable Load

Tower Height	25G	25AG2	BPC25G with 3/4"x12" PP	APL25G and SA253UA	GA25G	G.W. 3/16" E.H.S.	C.C.M. 3/16"	TH. 1/4"	T.B. 3/8"x6" E&E	GAC 253	GAC 255
40'	3	1	1		2	300'	36	12	6	3	
50'	4	1	1		2	375'	36	12	6	3	
60'	5	1	1		2	500'	36	12	6	3	
70'	6	1	1		3	725'	54	18	9	3	
80'	7	1	1		3	825'	54	18	9	3	
90'	8	1	1		3	900'	54	18	9	3	
100'	9	1	1		4	1325'	72	24	12		3
110'	10	1	1		4	1500'	72	24	12		3
120'	11	1	1		4	1600'	72	24	12		3
130'	12	1	1		5	2125'	90	30	15		3
140'	13	1	1		5	2275'	90	30	15		3
150'	14	1	1		5	2500'	90	30	15		3
160'	16		1	1	6	2600'	108	36	18	6	
170'	17		1	1	6	2775'	108	36	18	6	
180'	18		1	1	6	2875'	108	36	18	6	

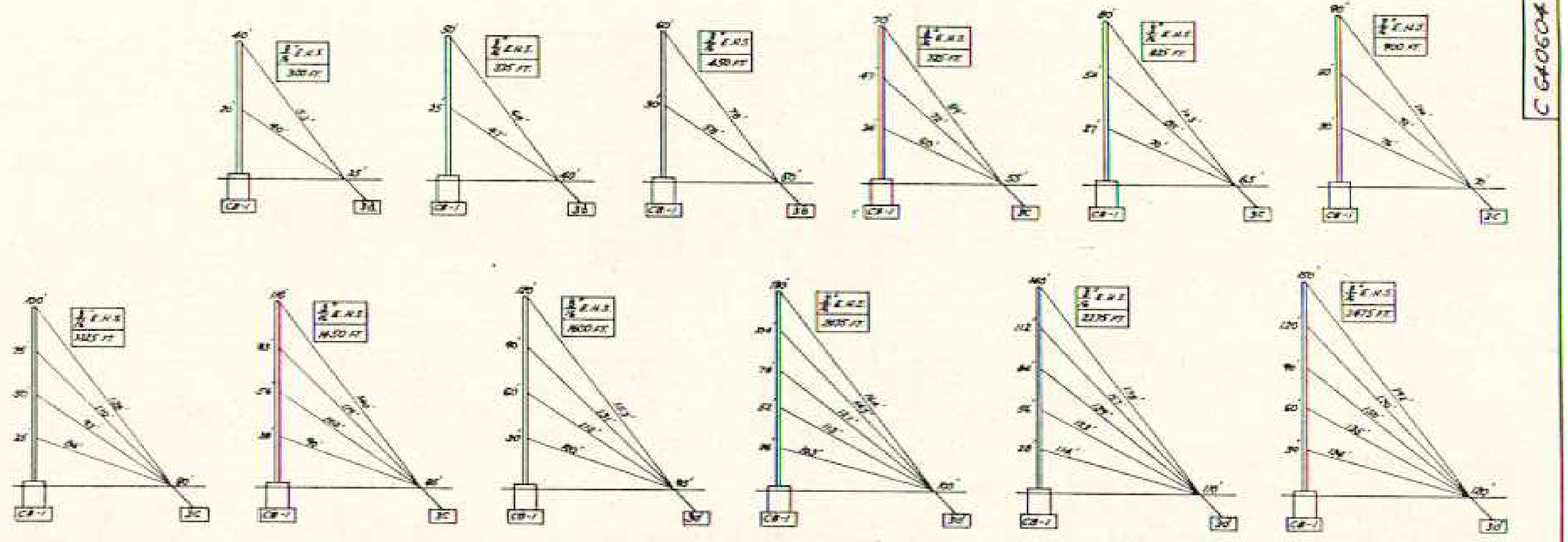
Items shown above are necessary for complete "ground" guyed towers

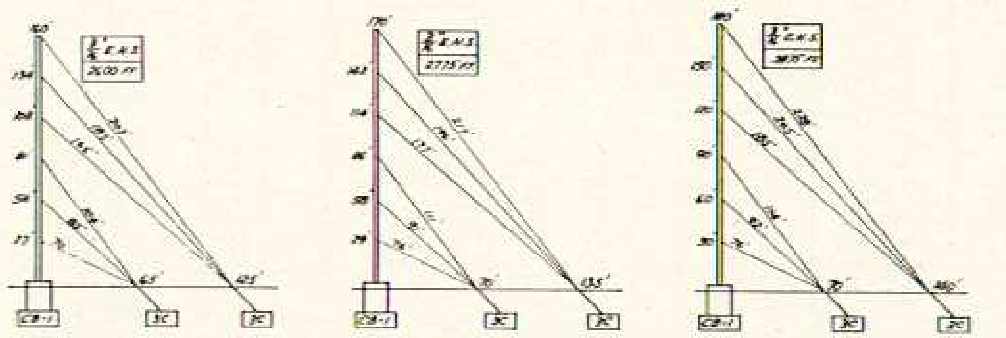
For "roof" towers a flat roof mount (FR25G) is substituted for the concrete base plate (BPC25G) and wall anchors (GAWP25) are substituted for the concrete anchors (GAC25).

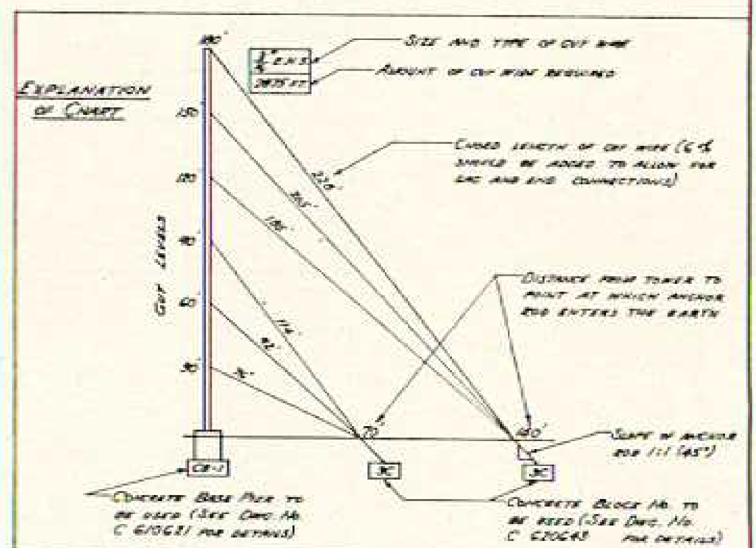
When ordering specify "roof" or "ground".

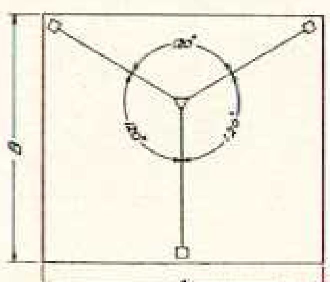
Anchor grounding (AGKE) and base grounding (BGKE), as recommended by EIA, are included in tower material. However, extra copper wire may be required for roof installations. See appropriate sheet for grounding material and order extra copper wire as a separate item.

All types of antenna installations should be thoroughly inspected by qualified personnel and remarked with hazard and warning labels at least twice a year to insure safety and proper performance.









NOTES:

1) ALL GUY DIMENSIONS ASSUME LEVEL GROUND.
2) ALLOWABLE LOAD AT APEX OF TALLEST TOWER IS 240 LBS. LATERAL THRUST. (EQUIVALENT AREA IS 6 SQ. FT.) DESIGN ASSUMES USE OF ONE 3/8" LINE AND ONE 1/4" LINE.
3) GUYS SHOULD BE TENSIONED TO APPROXIMATELY 10% OF THEIR ULTIMATE STRENGTH.
4) ALL TOWERS ARE DESIGNED ACCORDING TO E.I.A. SPECIFICATIONS.

FOR SPACE REQUIREMENT REFER TO DWG. NO. C 640531

R2	0-180' WAS 0-300'	1-10-86 JRB/R.	ADDED EIA DESIGNATION TO TITLE BLOCK 2-17-76

DRAWN AED	WIND LOAD - E.I.A. ZONE "B" 0-180' - 40 PSF	TITLE: GUYING DETAILS FOR MODEL 25 TOWER
CHECKED C.K.		
APPROVED R.A.K.		DRAWING NO.
DATE 6-29-64	ROHN MANUFACTURING PEORIA, ILLINOIS	C 640604 R2
SCALE NONE		

PARTS LIST P-455
(Replaces P-338)

March 1, 1986

PARTS LIST #25G GUYED TOWER

Zone "C" Wind Load

6 Sq. Ft. of Allowable Load

Tower Height	25G	25AG2	BPC25G with 3/4"x12" PP	GA25G	G.W. 3/16" EHS	G.W. 1/4" EHS	C.C.M. 3/16"	C.C.M. 1/4"	TH. 1/4"	T.B. 3/8"x6" E&E	T.B. 1/2"x12" E&E	GAC 253	GAC 255
40'	3	1	1	2	300'		36		12	6		3	
50'	4	1	1	2		375'		36	12		6	3	
60'	5	1	1	3	625'		54		18	9		3	
70'	6	1	1	3	725'		54		18	9		3	
80'	7	1	1	4	1075'		72		24	12			3
90'	8	1	1	4	1175'		72		24	12			3
100'	9	1	1	4		1325'		72	24		12		3
110'	10	1	1	5	1775'		90		30	15			3
120'	11	1	1	5	2000'		90		30	15			3
130'	12	1	1	6	2125'		108		36	18		6	
140'	13	1	1	6	2250'		108		36	18		6	
150'	14	1	1	6		2425'		108	36		18	6	

Items shown above are necessary for complete "ground" guyed towers.

For "roof" towers a flat roof mount (FR25G) is substituted for the concrete base plate (BPC25G) and wall anchors (GAWP25) are substituted for the concrete anchors (GAC25).

When ordering specify "roof" or "ground"

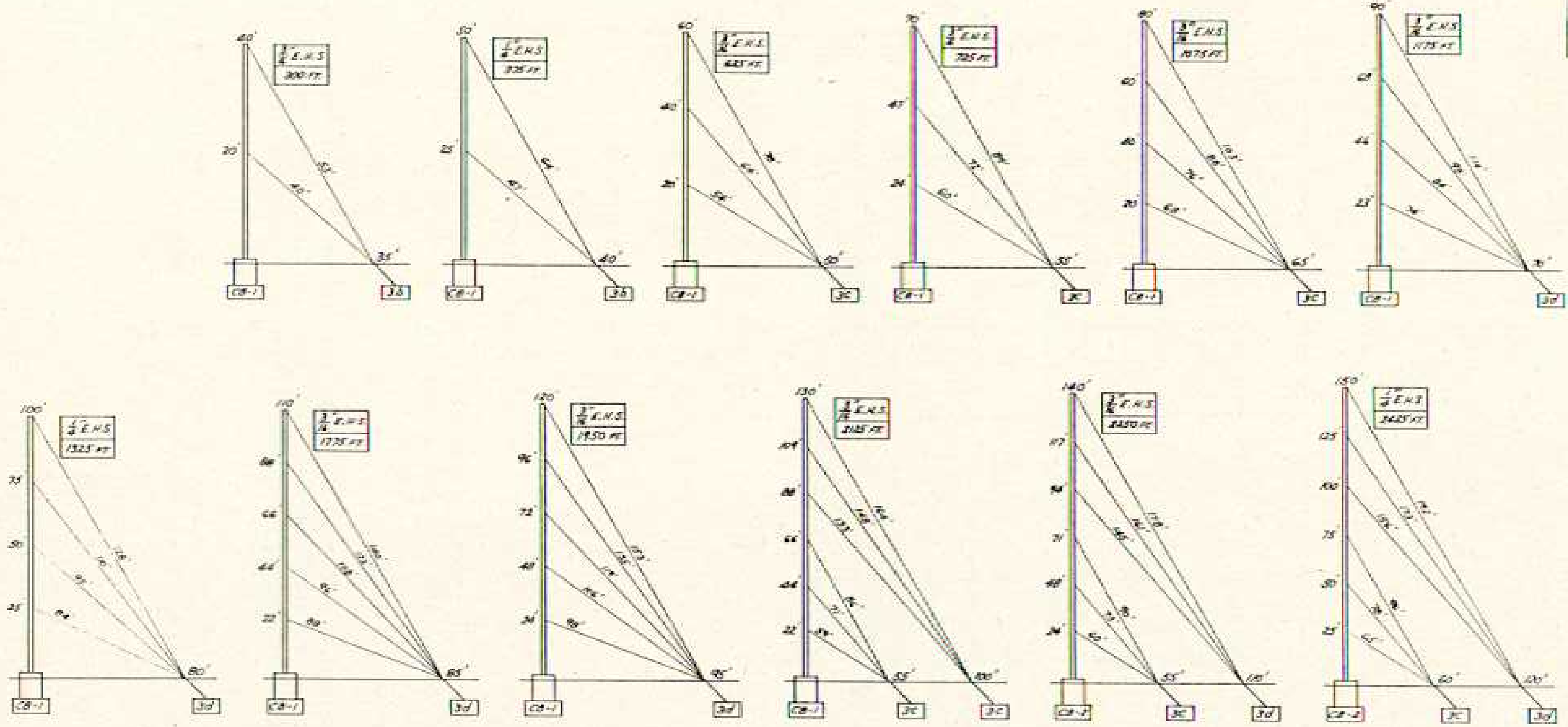
Anchor grounding (AGKE) and base grounding (BGKE), as recommended by EIA, are included in tower material. However, extra copper wire may be required for roof installations. See appropriate sheet for grounding material and order extra copper wire as a separate item.

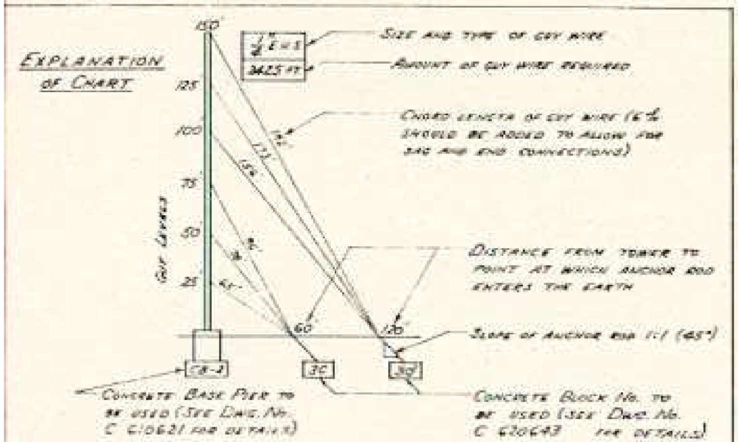
All types of antenna installations should be thoroughly inspected by qualified personnel and remarked with hazard and warning labels at least twice a year to insure safety and proper performance.

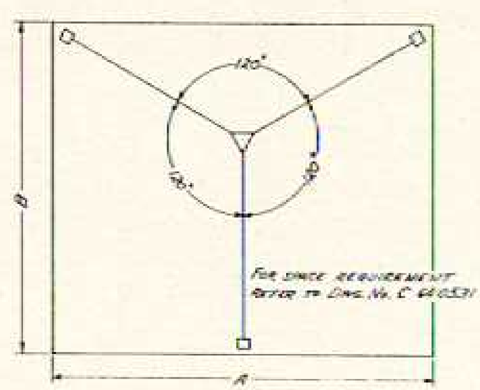
R3	0-150' WAS 0-300'	1-13-06	JKO	
R2	ADDED EIA DESIGNATION TO TITLE BLOCK	2-17-76	WC	
1	H.S. GUY WIRE TO E.H.S. GUY WIRE	8-21-71	AED	
NO	DESCRIPTION	DATE	BY	

REVISIONS

C 640605







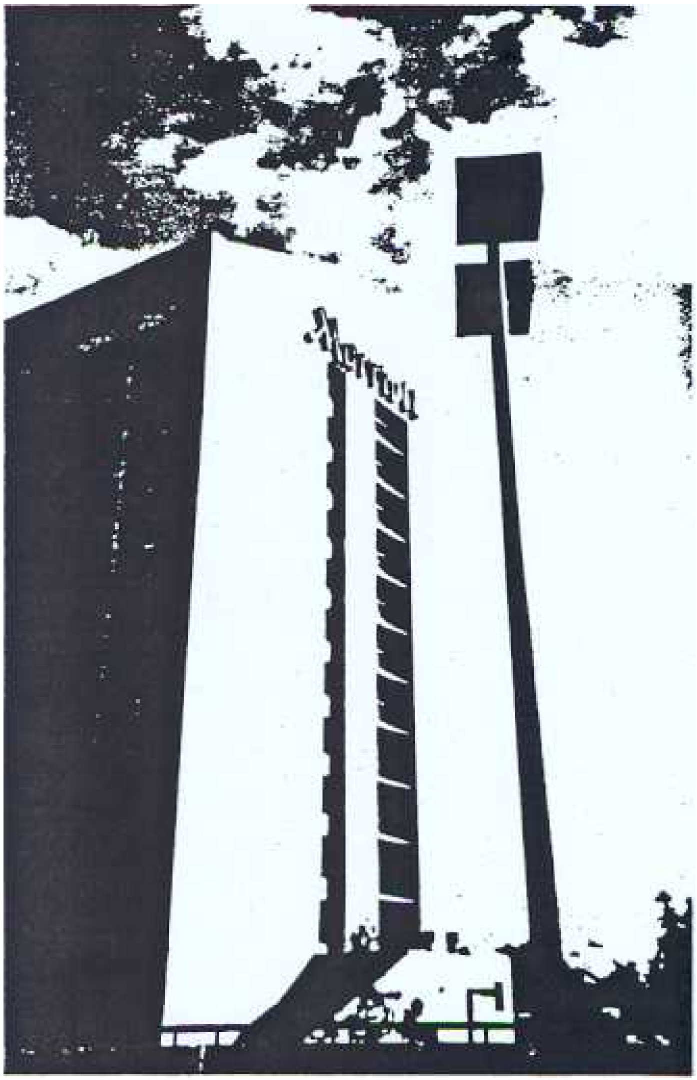
NOTES:

1) ALL GUY DIMENSIONS ASSUME LEVEL GROUND.
2) ALLOWABLE LOAD AT APEX OF TALLEST TOWER IS 300 LBS. LATERAL THRUST. (EQUIVALENT AREA IS 6 SQ.FT.) DESIGN ASSUMES USE OF ONE 7/8" LINE AND ONE 1/2" LINE.
3) GUYS SHOULD BE TENSIONED TO APPROXIMATELY 10% OF THEIR ULTIMATE STRENGTH.
4) ALL TOWERS ARE DESIGNED ACCORDING TO E.I.A. SPECIFICATIONS.

DRAWN AED		TITLE
CHECKED CK	WIND LOAD - EIA ZONE "C" 0-150' - 50 PSF	GUYING DETAILS FOR MODEL 25 TOWER
APPROVED RAF		
DATE 7-2-64	ROHN MANUFACTURING	DRAWING NO.
SCALE NONE		C 640605

E.12 METEROLOGICAL TOWERS

E.12.2 FIBERGLASS POLE



HISTORY

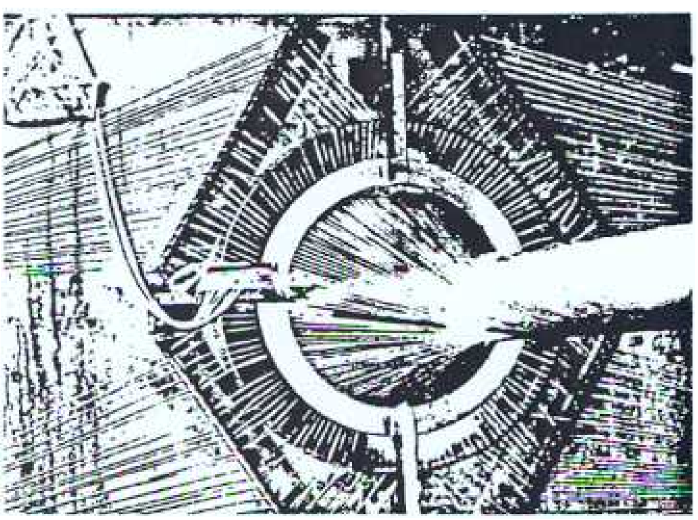
Wood rots. Concrete cracks and crumbles. Steel rusts and can be an unyielding menace. Aluminum oxidizes and corrodes.

Twenty years ago, recognizing the Shakespeare Company as the leader in fiberglass innovation, a major utility company approached Shakespeare in search of a composite light pole that would survive the hostile rigors of coastal salt air environments. The resulting successful research and development program not only answered the immediate need, but was destined to completely revolutionize the entire lighting standard industry.

Now, after two decades, literally thousands upon thousands of Shakespeare fiberglass poles enhance the landscape from coast to coast in every conceivable application. The reasons are simple. Fiberglass answers the inherent problems of all other pole materials. It is impervious to the elements, will retain its lustrous beauty for generations, is competitively priced and even affords substantial saving on initial installation costs due to light weight.

The possibilities are endless growing as progressive archite tural firms, consulting enginee and utilities nationwide contin to specify fiberglass for:

Shopping Centers
Hospitals
Roadways
Chemical Plants
Airports
Residential
Municipalities
Coastal Environments
Waste/Water Treatment Pl
Parking Lots
Auto Dealerships
Industrial Parks
Sports Complexes
Restaurants
Condominiums
Amusement Parks
Resorts ■



What are the primary advantages?

Light in Weight
Advantage-Labor, time, and equipment savings in installation.

Maintenance Free
Advantage-No rust, corrosion, or decay means no repainting.

Colorfast
Advantage-The color is impregnated throughout the wall of the pole.

Price and Availability
Advantage-Price and delivery competitive with other materials. Special orders are no problem.

Deflection Capability
Advantage-Engineered to withstand winds of 130 MPH with minimum deflection.

Non-Conductive
Advantage-Reduces hazard accidental electrocution due shorted wiring.

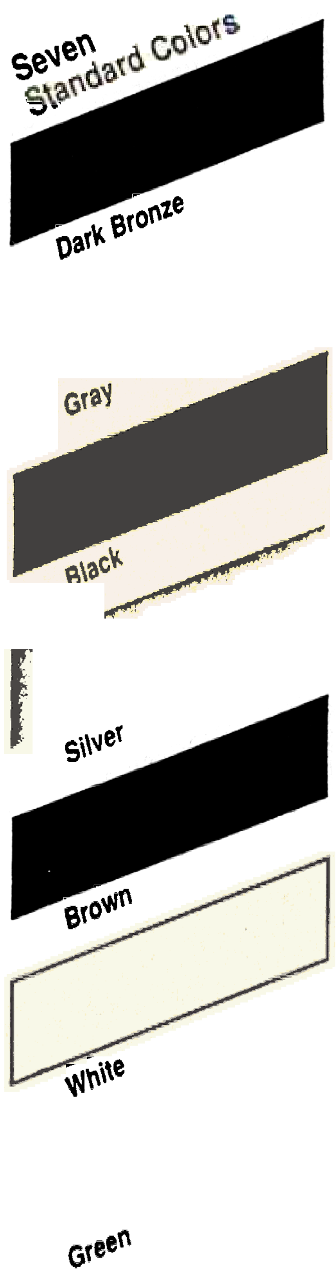
Non-Corrosive
Advantage-No above or bel ground line deterioration in soil or salt air climates.

Rigid in Cold Climates
Advantage-Actually strong sub-zero temperatures.

Longevity
Advantage-Over time, Shakespeare Fiberglass Co Light Poles will outlast wo aluminum, steel, and concr under the same climatic cir stances.

Results
Greater versatility, beauty owner satisfaction coupled much lower unit costs over lifetime of the pole. ■

SPECIFICATIONS



Sample Fiberglass Light Pole Specification

1. Fiberglass lighting poles shall be Shakespeare Company design.

2. Wind loading shall be calculated for 100 mph wind plus a 30% gust factor with AASHTO standard specification for structural supports for highway signs, luminaries, and traffic signals.

3. Effective projected area (EPA) is the actual area adjusted with the appropriate drag coefficient (shape factor) to result in an equivalent area having a drag coefficient equal to one (1.0).

Materials

1. The pole shall be constructed by the filament winding process from thermosetting polyester resin and containing a minimum of 65% "E" type fiberglass by weight. The ultra-violet resistant resin shall contain no clay fillers. The filament winding process shall be continuously applied with uniform tension and the winding will be placed on the pole helically at low angles to provide axial strength. Additional windings shall be placed on the pole in a circular manner to provide compressive strength.

2. The surface of the pole will be (smooth or natural) finish and uniform the entire length of the pole.

3. The laminate (resin) shall be pigmented the same color as the final coating. The pole color shall be uniform throughout the entire wall thickness of the pole. A highly weather resistant pigmented polyurethane coating shall be applied to the pole. The coating thickness shall have minimum dry film thickness of 1 1/2 mils.

4. The pole shall be flame resistant in accordance with ASTM D635.

5. Where applicable, the pole shall be delivered predrilled to accommodate the specified lighting fixture (s) or mast arms (s).

6. Tenons, where applicable, shall be epoxy bonded to the fiberglass shaft and shall be steel hot dipped galvanized to ASTM A153 or shall be 6061-T6 or A356-T6 aluminum.

7. The handhole shall be 2 1/2" x 5" with an oval A319 cast aluminum cover secured with a vandal resistant stainless steel 1/4" socket head screw.

8. Anchor base poles shall be delivered with heavy duty A356-T6 aluminum base casting, which shall be epoxy bonded to the outside of the fiberglass shaft.

9. Anchor bolts shall conform to ASTM A307 with threaded end, hex nuts, and flat washers (two per bolt) each galvanized to ASTM A153. A bolt hole template shall be furnished with the anchor bolts.

Packaging

1. Each pole shall be individually spiral wrapped with cushioned paper and overwrapped with plastic shrink film for protection during shipping and storage. The wrapping shall incorporate a zip string running the entire length for ease in removing the wrapping. ■

Consistent Quality in Every Step

At every stage of manufacture, the Shakespeare Fiberglass Light Pole is carefully inspected for structural integrity and visual appearance. Laboratory tests are continually performed for surface durability, weather resistance, and internal continuity. Additionally, a rigorous quality control program including random deflection testing insures maximum performance under wind loading.

The finished poles are individually spiral wrapped with cushioned paper and overwrapped with plastic shrink film for protection during shipping, handling and on-site delivery. ■

3-Year Limited Light Pole Warranty

Shakespeare warrants this product to be free of defects in materials and workmanship for a period of three (3) years from the date of purchase when used under normal conditions. Correction of any defect by either repair or replacement at the option of Shakespeare, constitutes fulfillment of the Seller's obligation under this warranty and constitutes the Purchaser's sole remedy.

Shakespeare makes no other express or implied warranty of fitness or merchantability or any other express or implied warranty. Shakespeare's obligation to repair or replace does not include any obligation to reimburse the purchaser for expenses of transportation, installation, removal, or other expenses which may be incurred. In no case shall Shakespeare be liable for consequential, special or indirect damages resulting from breach of this warranty. ■

ROUND TAPERED

Beautifully lightweight and durable...the standard of excellence.

Using the unique Shakespeare process, thousands of resin impregnated fiberglass filaments are wound spirally and helically on a spinning mandrel. These special windings insure the extra strength necessary for generations of dependable service.

The color is impregnated throughout the pole wall by pigmented polyester resin utilized during construction. A specially formulated heavy polyurethane coating with ultraviolet inhibitors finishes and beautifies the pole while adding increased protection against the environment.

Tapered for appearance as well as for function, the Shakespeare Fiberglass Light Pole is lightweight, easily handled and installed, yet tough enough to withstand high wind, corrosive elements, extreme temperatures, and incidental impact.■

Features

▮ Available in lengths from 8' to 47'

▮ Natural or smooth finish

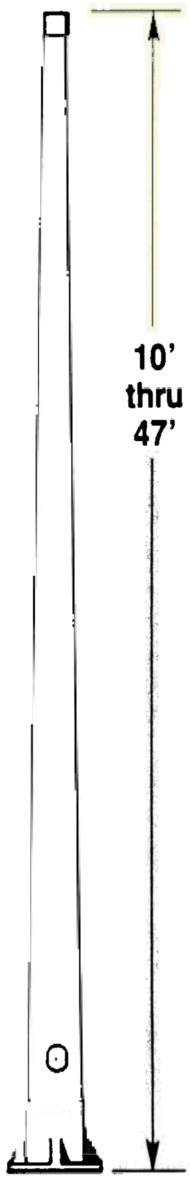
▮ Seven Colors — each integrated into the resin throughout the pole wall

▮ Finished with highly UV and weather-resistant pigmented polyurethane coating

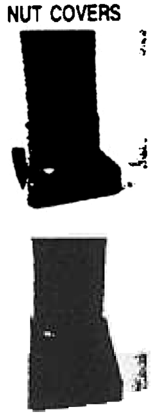
▮ Tenon and mast arm construction

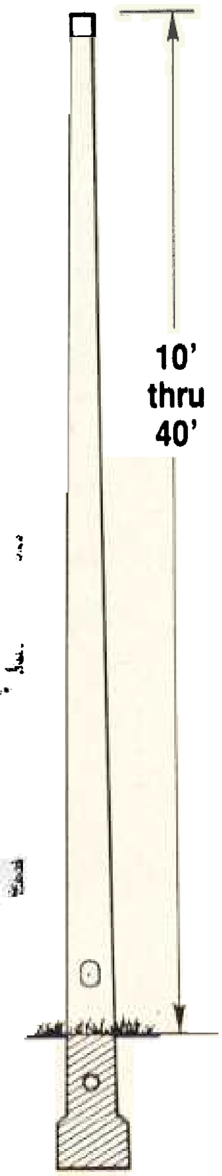
A: Poles are delivered predrilled for bolt-on side mount fixture (s). Shakespeare only needs to know manufacturer and model number — we will take care of the rest. The fixtures attach exactly as they do to metal poles.
B: For roadway lighting and applications requiring mast arms — Shakespeare manufactures a full line of mast arms in lengths of 4 to 15 feet. Poles are predrilled at the factory for ease of installation.

C: All tenons are 6061-T6 aluminum or hot dipped galvanized steel and are available in all standard sizes. Post top fixtures, flood lights, or bullhorns mount with ease.
D: 2 1/2" x 5" handholes are standard. 2 1/2" round or 4" x 6" available (most models). Handhole covers are coated to match the pole color.■



ROUND TAPERED
ANCHOR BASE





ROUND TAPERED
DIRECT BURIAL

Anchor Base Pole Features

▮ A356-T6 Aluminum base casting is epoxy bonded to the fiberglass shaft and polyurethane coated to match pole color

▮ Fiberglass shrouds or nut covers optional

▮ Hot dipped galvanized steel anchor bolts complete with nuts (2) and washers (2) are standard (5/8" x 24", 1" x 34" or 1 1/4" x 42" depending on pole specified)

Direct Burial Pole Features

▮ Substantially reduces installation cost and improves ground line appearance (utility companies have been doing it for decades)

▮ Shakespeare fiberglass doesn't rust, corrode, rot, or decay in the ground... which means:

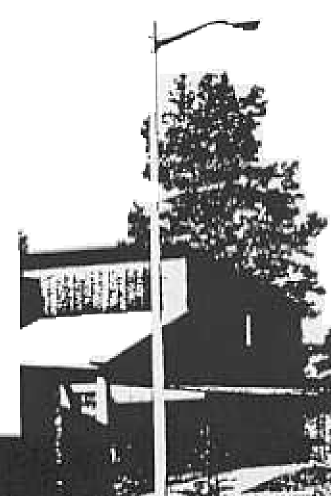
1. Less installation labor

2. No concrete foundations or anchor bolts

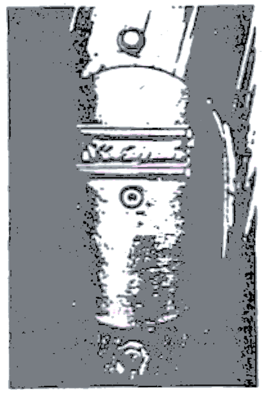
3. No special below-ground pole treatments

▮ Flared base increases stability and resists rotating

▮ Conductor entrance standard 2' below the ground line (rubber grommeted to protect conductor against damage).



ACCESSORIES AND OPTIONS



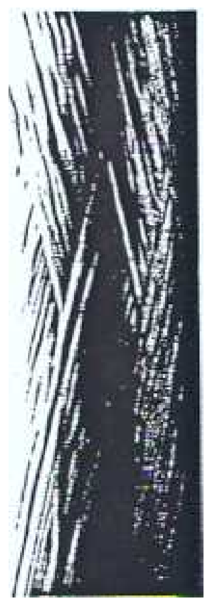
Handhole Covers
are cast aluminum. 2 1/2" x 5" handholes are standard. 2 1/2" round and 4"x 6" are available (most models). 4" x 12" are either standard or available depending on pole size. Handhole covers are coated to match the pole color. ■

Anchor Base Mounts
are heavy A356-T6 cast aluminum and are permanently bonded to the pole for a strong, secure installation. Anchor base template available with order. ■

Mast Arms
in lengths of 4' to 15' and Simplex-type arm fittings are available. ■

Flared Bases
(direct burial) resists rotation and pull-out while impervious fiberglass construction eliminates corrosion. ■

Tenons
are galvanized steel or aluminum and provide secure, snug fits for standard luminaries and tenon-type brackets. Size 2 3/8", 3", or 4". Cast aluminum pole caps are standard for side mount installations where tenons are not required. ■

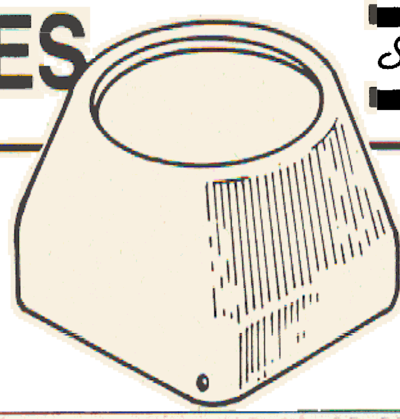


Textured (Natural) Finish

Smooth Finish

ACCESSORIES

Shakespeare® **AVAILABLE OPTIONS**

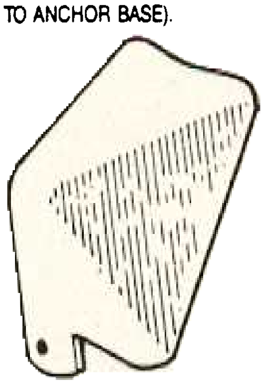


ANCHOR BASE SHROUDS

MATERIAL: FIBERGLASS REINFORCED POLYESTER
DESIGN: ONE PIECE
CATALOG ORDER NUMBERS:

ANCHOR BASE BHC	PART NUMBER	-NUMBER DESIGNATES COLOR OF SHROUD							FOR CATALOG NUMBER
		BLACK	GRAY	BROWN	GREEN	DARK BRONZE	SILVER	WHITE	
7½-8½"	OPSH-1017	-1	-2	-3	-4	-5	-6	-7	AS10-14, AO10
8-9"	OPSH-1821	-1	-2	-3	-4	-5	-6	-7	AS15-20, AO12-16
9-10"	OPSH-2225	-1	-2	-3	-4	-5	-6	-7	AS21-25, AO18-25
11-12"	OPSH-2735	-1	-2	-3	-4	-5	-6	-7	ALL AS AND AH 27-35
11-12"	OPSH-2025	-1	-2	-3	-4	-5	-6	-7	AH20-25
13½-14½"	OPSH-2425	-1	-2	-3	-4	-5	-6	-7	AA25, AB25
14-15"	OPSH-2930	-1	-2	-3	-4	-5	-6	-7	AB30-AD30
14½-15½"	OPSH-3435	-1	-2	-3	-4	-5	-6	-7	AB35-AD35
15-16"	OPSH-4047	-1	-2	-3	-4	-5	-6	-7	AA40-AD47
8"	OPSH-AQ	-1	-2	-3	-4	-5	-6	-7	ALL AQ POLES

EACH CATALOG NUMBER REFERS TO A COMPLETE SET OF ONE SHROUD WITH TWO TAMPER RESISTANT STAINLESS STEEL SCREWS (FOR ATTACHEMENT OF SHROUD TO ANCHOR BASE).



BOLT COVERS

MATERIAL: CAST ALUMINUM

CATALOG ORDER NUMBER:
OPNC-2735 FITS ALL 27-35 FOOT ANCHOR BASE POLES
OPNC-2025 FITS AH20-AH25 ANCHOR BASE POLES
OPNC-4045 FITS AA40-AD45 SERIES POLES

CATALOG NUMBER REFERS TO A COMPLETE SET OF FOUR COVERS WITH ONE STAINLESS STEEL SCREW (FOR ATTACHMENT OF COVER TO ANCHOR BASE) PER COVER.

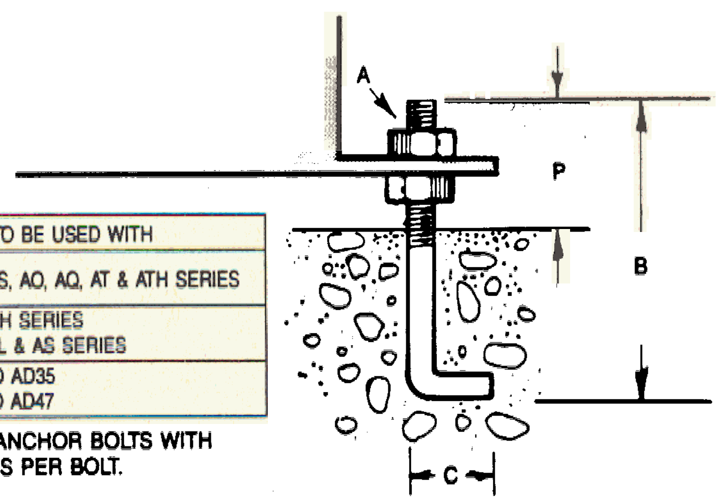
ANCHOR BOLTS

MATERIAL: LOW CARBON STEEL PER ASTM A-307
FINISH: HOT DIP GALVANIZED PER ASTM A-153

CATALOG ORDER NUMBERS:

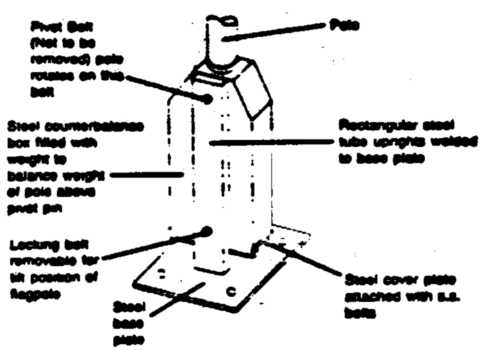
	A	B	C	P	BOLTS TO BE USED WITH
OPAB-1025	⅝-11 UNC	21"	3"	3"	10-25' AS, AO, AQ, AT & ATH SERIES
OPAB-2035	1-8 UNC	30"	4"	4"	20-35' AH SERIES 27-35' AL & AS SERIES
OPAB-2547	1¼-7 UNC	36"	6"	4" 5"	AA25 TO AD35 AA40 TO AD47

EACH CATALOG NUMBER REFERS TO A COMPLETE SET OF FOUR ANCHOR BOLTS WITH TWO GALVANIZED HEX NUTS AND TWO GALVANIZED FLAT WASHERS PER BOLT.

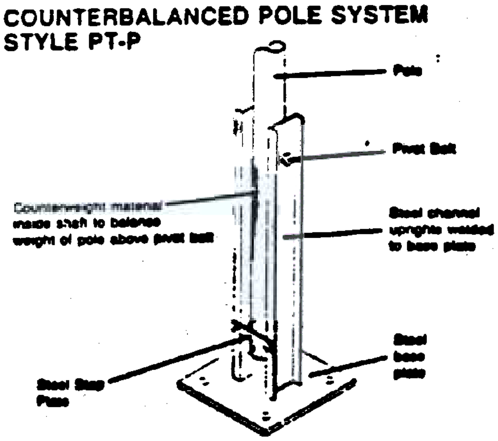


COUNTERBALANCED TILTING ALUMINUM FLAGPOLES

COUNTERBALANCED BOX SYSTEM STYLE PT-B



COUNTERBALANCED POLE SYSTEM STYLE PT-P



Counterbalanced tilting aluminum flagpoles are cone tapered - supplied with standard fittings and have an anchor bolt mounting system. This design provides the owner with a counterbalanced pole that can be lowered by two people. This reduces maintenance costs of servicing ropes and accessories. These poles are generally groundset but are suitable for roof top installations in the smaller sizes. Poles are readily available in heights up to 60 feet. A yardarm option is available.

COUNTERBALANCED SYSTEM:

Pole Exposed Height	Diameter		Base Plate Size	Anchor Bolt	Shipping Weights	
	Butt "A"	Top			Pole	Tilting Unit
25	5	3¼	20" x 20" x ½"	¾" x 24"	80	450
30	6	3½	20" x 20" x ½"	1" x 36"	117	520
35	7	3½	24" x 24" x ½"	1" x 36"	153	610
40	8	3½	24" x 24" x ¾"	1" x 36"	210	635
45	8	3½	30" x 30" x ¾"	1" x 36"	235	720
50	10	4	30" x 30" x ¾"	1¼" x 48"	318	1200
60	10	4	36" x 36" x 1"	1¼" x 48"	460	2000

Shakespeare

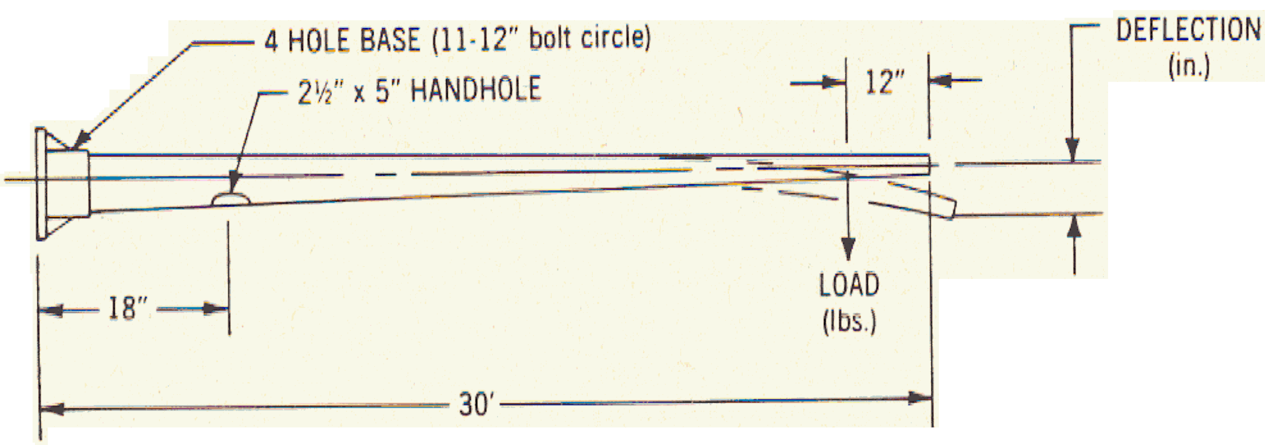
TECH DATA

LATERAL LOAD DEFLECTION TEST REPORT

The following test results were accumulated to determine load bearing and deflection characteristics.

MODEL TESTED: AS30-02N2BB01 FIBERGLASS LIGHT POLE WITH HAND HOLE

Results of test:



LOAD IN LBS.	Sample #1 DEFLECTION IN INCHES	Sample #2 DEFLECTION IN INCHES
0	0	0
50	4-3/4	4-5/8
100	10-3/8	10-3/8
150	15-1/4	14-5/8
200	21-1/8	19-3/8
250	25-3/4	24-3/8
300	31	30-3/4

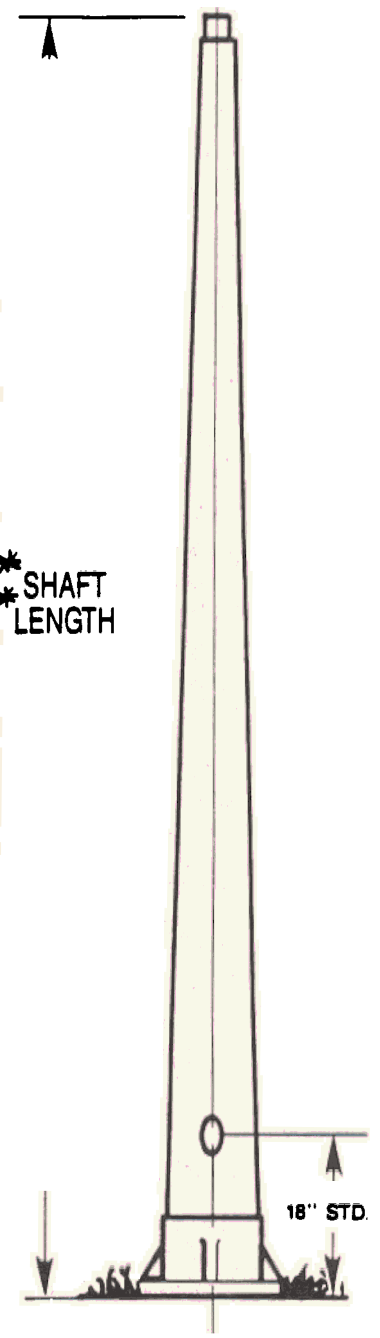
Pole weight:
123 lbs. ea.

TD6-87

ROUND TAPERED POST TOP DIRECT BURIAL FIBERGLASS LIGHT POLES

Series AA, AB, AC, AD, AH, AL and AS

NOMINAL MOUNTING HEIGHT (FT)	SHAFT LENGTH (FT)	WEIGHT (LBS)	POLE DIAMETER		STANDARD HANDHOLE LOCATION FROM BASE (IN)	RECOMMENDED TOTAL LOADING					BOLT HOLE CIRCLE	CATALOG NUMBER
			SHAFT TOP (IN)	SHAFT BASE (IN)		WEIGHT (LBS)	80 MPH EPA* (SQ FT)	90 MPH EPA* (SQ FT)	100 MPH EPA* (SQ FT)	120 MPH EPA* SQ FT)		
STANDARD POLE CONSTRUCTION (AS)												
10**	10	25	2.9	4.6	18	150	16.3	12.5	9.9	6.7	8"	AS10**
12**	12	29	2.9	4.9	18	150	13.6	10.3	8.1	5.3	8"	AS12**
	14	32	2.9			150	9.8		5.6	3.6	8"	AS14**
16**	16	34	2.9	5.5	18	100	6.8	4.9	3.7	2.2	8½"	AS16**
18**	18	39	2.9	5.8	18	100	6.7	4.9	3.8	2.4	8½"	AS18**
20**	20	50	2.9	6.1	18	100	5.7	4.0	3.1	1.8	8½"	AS20**
20	20	70	4.6	7.3	18	200	14.4	11.1	8.9	[illegible]	11½"	AH20
25**	25	59	2.9	6.8	18	100	4.0	2.9	2.1	.9	9½"	
25					18	200	9.6	7.3	5.7	3.4	11½"	
25												
30	30	90	4.4	8.3	18	100	3.7	2.6	1.9	08	11½"	AL30
* 30	30	122	4.6	8.4	18	100	11.2	8.5	6.7	4.5	11½"	AS30 *
* 30	30	161	4.8	8.5	18	200	15.6	12.0	9.5	6.0	11½"	AH30 *
30	30	200	6.4	10.4	18	300	19.7	15.2	11.7	7.1	14½"	AB30
30	30	232	6.6	10.5	18	300	28.7	22.4	17.4	11.0	14½"	AC30
30												
35												
	35	186	4.8	8.5	18	200	8.5					
	35	231	6.4	11.1	18	300	14.3	10.8	7.8	4.0	15"	AB35
	35	283	6.6	11.2	18	300	21.8	16.6	12.5	7.2	15"	AC35
	35	325	6.9	11.3	18	300	29.0	22.1	17.0	10.3	15"	AD35
40	40	190	6.2	11.7	18	300	6.4	4.3	2.4	—	15½"	AA40
				11.8	18	300	12.2	8.8	6.0	2.5	15½"	AB40
40	40	304	6.6	11.9	18	300	19.2	14.1	10.4	5.4	15½"	AC40
40	40	368	6.9	12.0	18	300	25.8	19.3	14.3	8.3	15½"	AD40
45	45	211	6.2	11.7	18	300	3.9	2.2	.6	—	15½"	AA45
45	45	293	6.4	11.8	18	300	9.1	6.2	3.8	.6	15½"	AB45
45	45	341	6.6	11.9	18	300	15.2	10.9	7.6	3.2	15½"	AC45
45	45	430	6.9	12.0	18	300	21.2	15.4	11.2	5.7	15½"	AD45



**Do Not Use For Side Mount Applications — Use BO Series
**DO NOT USE WITH TENON MOUNTED ARMS OR FOR MULTIPLE FIXTURE APPLICATIONS — USE BO SERIES

HANDHOLE: Standard 2½" x 5"
Optional 2½" Round, or 4" x 6" or 4" x 12" on Some Models
TENONS: 2⅜", 3", or 4" on Some Models

All poles are polyurethane coated and individually wrapped. Anchor bolts standard.
Bolt covers and base shrouds optional . . . see accessories.

*EPA ratings for capped pole are same as for tenon pole.
*EPA recommendations are calculated per AASHTO Standards and include a 30% gust factor.

See Catalog Sheet GI-4 for base dimensions.

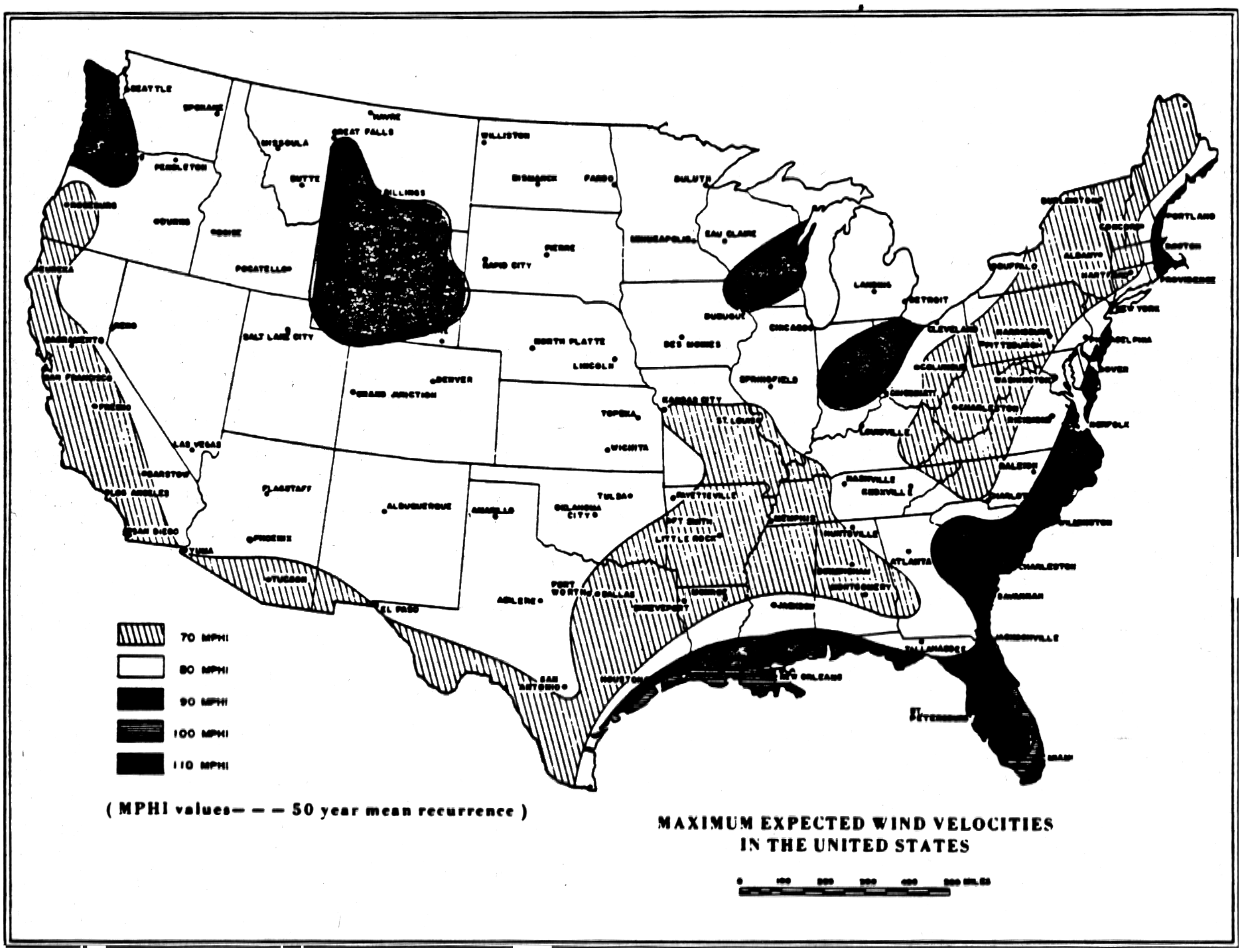
MAXIMUM EXPECTED WIND VELOCITIES

50 YEAR MEAN RECURRENCE (MPH)

The basis for selecting light poles from the catalog is the weight and effective projected area (EPA) data shown in the pole tabulations under the headings "Recommended Total Loading" or for the poles with mast arms "Recommended Maximum Size of Luminaire".

The wind velocities recorded on the map illustrated below are isotach values, not gust values. The design velocities include a gust factor of 1.3 which result in a pole designed for winds considerably greater than the isotach value.

Wind loading for Shakespeare light poles are calculated in accordance with the AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires & Traffic Signals.



ISOTACHS OF EXTREME MILE AT 30 FEET ABOVE GROUND	ISOTACH VALUES	GUST VELOCITIES	ISOTACH VALUES	GUST VELOCITIES	ISOTACH VALUES	GUST VELOCITIES
	60	78	80	104	100	130
	67	87	85	111	110	143
	75	98	90	117	120	156
			95	124		

For additional information or Representative nearest you, call:

Toll Free (800) 845-7750

(803) 276-5504 (In South Carolina)

FAX: (803) 276-8940

Shakespeare

SINCE 1897

ELECTRONICS AND FIBERGLASS DIVISION

P.O. Box 733, Newberry, SC 29108

- Verify the NGWLMS Site Report information and update as required. Report sensor calibration information on the NGWLMS Sensor Test Worksheet.