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Final Engineering Report
and
Engineer's Certification

Section II - Groundwater Extraction and Conveyance System

Former Deknatel Facility
Queens Village, New York

Prepared for

Pfizer

August 1995

Prepared by

Remedial Engineering, P.C.

FINAL ENGINEERING REPORT AND ENGINEER'S CERTIFICATION

SECTION II
GROUND-WATER EXTRACTION AND CONVEYANCE SYSTEM

Former Deknatel Facility
Queens Village, New York

August 1995

Prepared for:

Pfizer Inc
235 East 42nd Street
New York, New York 10017-5755

Prepared by:

REMEDIAL ENGINEERING, P.C.
1377 Motor Parkway
Islandia, New York 11788

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1.0 INTRODUCTION

This Engineer's Certification Report has been completed on behalf of Pfizer Inc (Pfizer) for the ground-water extraction system installed at the former Deknatel, Inc. facility at 96-20 222nd Street in Queens Village, New York (Site). Pfizer presently owns the Site through one of its wholly owned subsidiaries. The Site was previously owned and operated by Deknatel, Inc., a business formerly owned by Pfizer. The Site location is shown in Figure 1. The purpose of the construction and operation of the ground-water extraction system is to prevent further migration of hexavalent chromium from the Site, and to provide for the protection of human health and the environment in accordance with the requirements of the Order on Consent for the Site issued by the New York State Department of Environmental Conservation (NYSDEC) on April 5, 1994. This report describes the construction and installation of the ground-water extraction system at the Site including:

- all components comprising the system (recovery well, pump, piping, flow meter, etc.);
- quality assurance and quality control during system installation;
- system start-up activities;
- system operations and maintenance (O&M); and
- data evaluation and reporting of system performance.

As required by the Order on Consent, this document has been certified by a New York State licensed professional engineer stating that the remediation system was implemented and construction activities were completed in general accordance with the intent of the NYSDEC-approved Remedial Design.

2.0 GROUND-WATER EXTRACTION AND CONVEYANCE SYSTEM

The ground-water extraction system was designed, located and installed to extract ground-water from the area of the Site where the highest concentrations of hexavalent chromium have been detected during previous investigations at the Site (i.e., in the area of Monitoring Wells MW-5 and MW-7), and to prevent the further migration of inorganic contaminants offsite.

The system was installed in accordance with the plans and specifications presented in the Remedial Design Report for the Ground-Water Extraction System prepared by Remedial Engineering, P.C. (Remedial Engineering) dated May 24, 1994. System installation was performed by Fenley & Nicol, Inc. (Fenley & Nicol) of Deer Park, New York and the system installation was inspected by representatives of Remedial Engineering and Lehrer McGovern Bovis, Pfizer's construction manager for the work.

Construction of the ground-water extraction system began during the week of December 6, 1993, and was completed when the system was connected to the New York City sanitary sewer system on May 27, 1994. The extracted ground water is currently discharged to the city sewer system at a flow rate of approximately 30 gallons per minute (gpm) and conveyed for treatment to one of the City's Public Owned Treatment Works (POTW).

The as-built plan of the ground-water extraction system is provided in Figure 2. The extraction well is located in the southwest corner of the Site and the extracted ground water flows around the perimeter of the Site through a 2-inch diameter force main. The force main is buried with between 4 and 4½ feet depth of cover as required by the technical specifications.

The force main enters a concrete vault located in the northwest corner of the Site. Existing within the vault is a flow meter and a sampling port. These components are described in greater detail below and a plan view and two section views of the vault arrangement are presented in Figure 3. Also located in the northwest corner of the Site is the control panel for the system. Both the concrete vault and the control panel are located within a secure chain link fenced area.

The force main exits the concrete vault along the northern boundary of the property and continues to the eastern boundary of the Site where a 4-inch cleanout is located. After a 90° bend, the force main continues along the eastern boundary of the Site and ties into the New York City sanitary sewer through the former Deknatel facility sanitary sewer connection located on 222nd Street.

Discussed in greater detail below are the individual components comprising the ground-water extraction system.

2.1 System Components and Installation

The major components of the system consist of a 6-inch diameter extraction well, a 4-inch diameter ground-water extraction pump, high and low water level sensors, ¾-inch diameter polyvinyl chloride (PVC) electrical conduit, 2-inch diameter PVC force main, a flow meter and totalizer, a control panel with a remote telemetry system and a sample port. Detailed information regarding these components are provided in the Final Operation and Maintenance Plan for the Ground-Water Extraction and Conveyance System (O&M Plan) which is presented in Attachment A of this report.

2.1.1 Site Preparation

Prior to constructing the ground-water extraction system, the area was cleared of vegetation and various debris. The steel chain link fence bordering the western side of the property was removed and a 10-foot high temporary plywood construction fence was erected.

Project signs were also posted at the Site. The signs indicated the name, address and emergency contact phone numbers for the owner (Pfizer) and the construction manager for the work (Lehrer McGovern Bovis). Construction personnel provided Site security during working hours while a security guard was provided during non-working hours.

2.1.2 Trenching and Piping

As described above, the 2-inch PVC force main is located on the Site perimeter along the western, northern and eastern boundaries of the Site. The force main was placed within a trench that ranged from one to two feet in width and was excavated to approximately 4½ feet below grade by Fenley & Nicol. As defined in the plans and specifications, type C bedding material or natural soils meeting the specifications were placed in the bottom one-half foot of the trench and compacted prior to the placement of the force main and above it, the extraction well electrical conduit. The remainder of the trench was backfilled to grade with the previously excavated soil.

During the excavation of the trench for the force main and electrical conduit, two areas of green stained soil were discovered on the western portion of the property. The first location was approximately 50 feet to the south of the northwestern corner of the Site in the vicinity of formerly existing Monitoring Wells MW-1 and MW-3 approximately five feet below land surface. The second location was approximately 38 feet to the north of the southwestern corner of the Site in the vicinity of formerly existing Monitoring Wells MW-5 and MW-6 approximately two feet below land surface.

All of the stained soil (less than one 55-gallon drum) was removed from the trench, stockpiled on plastic and covered. Roux Associates performed post-excavation sampling of the two excavated areas once no visible staining was observed remaining within the trench. The analytical results from the post-excavation sampling of the two trench areas indicated that the concentrations of total chromium and hexavalent chromium remaining in the trench were consistent with Site background levels. The analytical results also indicated that the remaining metals associated with the former stained areas are not likely to migrate through the soil, nor is it likely that the ground water in these portions of the Site has been, or was in the past, impacted due to the presence of these metals. Provided in Appendix A are summaries of the activities performed and the analytical results from the two post-excavation sampling events.

2.1.3 Extraction Well Installation

The 6-inch diameter ground-water extraction well (designated PW-1) was installed by Fenley & Nicol from March 21 through March 22, 1994. A Canterra CT-450 hollow-stem auger drill rig was used to complete the drilling of the 14-inch diameter borehole and installation of the extraction well.

Following the completion of the borehole to 82 feet below land surface, 30 feet of 70-slot, 6-inch diameter black steel screen and 51.5 feet of 6-inch diameter black steel casing was installed within the borehole. Development of the extraction well was completed with a submersible pump until the suspended solids content of the extracted ground water was less than 5 milligrams per liter (mg/L) throughout a two-hour period of pumping at a pumping rate of 30 gpm.

The as-built extraction well construction detail is provided in Figure 4. Also provided in Appendix B is the geologic log of the extraction well.

2.1.4 Ground-Water Extraction Pump

The ground-water extraction pump installed in the extraction well is an EPG Companies, Inc. (EPG) Model No. TSP8-5. This 4¼-inch diameter pump is capable of pumping 40 gpm of extracted ground water at 95 feet of total dynamic head and has a rated capacity range of 20 to 55 gpm. The pump is made of 304 stainless steel with teflon seals and bearings. The pump has a 1.5 Hp 208 volt 3 phase motor manufactured by Franklin Electric. The bottom of the pump is set approximately 78 feet below grade.

2.1.5 High and Low Level Sensors

High and low level sensors have been installed within the ground-water extraction well in order to start and stop the ground-water extraction pump at pre-established levels. The high level sensor is set at a well depth to maintain desired drawdown, while the low level sensor is set above the pump intake to keep the pump and motor submerged at all times and maintain total fluids pumping. The pump will start and continue to run when the ground-water level rises to the point where both sensors are submerged. The pump will shut off when the ground-water level drops below the low level sensor. The low level sensor is set approximately 68 feet below grade. These capacitance type sensors are manufactured by EPG.

2.1.6 Flow Meter and Totalizer

The ground-water extraction system includes a 1-inch bronze positive displacement flow meter, model C-700 BP and a hermetically sealed direct reading register, which are both manufactured by Kent Meters, Inc. The meter is a volumetric type meter, capable of measuring flows between 3/4 and 50 gpm at an accuracy of 100 percent ± 1½ percent at its rated flow. The meter is approved for use by the New York City Department of Environmental Protection (NYCDEP) to monitor flows discharged to the New York City sewers. The meter reads locally through the use of a mechanical totalizer within the manhole, and remotely through the use of a flow rate totalizer at the control panel, as described in Section 2.1.7. The flow rate totalizer is an electronic powered vacuum fluorescent display on a panel mounted key pad.

2.1.7 Control Panel

The ground-water extraction system is provided with a single control panel which houses the main electrical disconnect switch, the ground-water extraction pump Hand-Off-Auto (HOA) switch, a pump running indication light, and a flow rate totalizer panel mounted key pad. The control panel is made of 304 stainless steel and is a NEMA 4 rated enclosure. The control panel is enclosed within a secured chain link fenced area located as shown in Figure 2.

2.1.8 Remote Telemetry System

The remote telemetry system, EPGs Telemax 3 sensor modem is a remote access programmable system which consists of the Sensor Modem Programmer software, a Nota Bene Technology, Inc. (NBT) Sensor Modem and a programmable logic controller (PLC). The PLC is programmed by the manufacturer to identify instantaneous flow rate, total flow, pump status (on/off), time when pump last cycled off and how often the pump has cycled. The remote telemetry system can be accessed by telephone (1-718-479-7008) while operating the vendor supplied Sensor Modem Programmer software.

2.1.9 Sample Port

The extraction system has a sample port located on the discharge line, contained within the concrete vault. The sample port is situated such that it is within arms reach and can be accessed without entering the vault. This eliminates the need to enter the vault in order to perform routine sampling. The sample port consists of a 2-inch self draining valve manufactured by Mueller, and a ½-inch teflon tubing and sample cock to regulate sample flow from the main discharge line. The sample port is utilized for monthly effluent sampling activities.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL OF GROUND-WATER EXTRACTION SYSTEM INSTALLATION

Quality assurance (QA) and quality control (QC) checks were performed during system construction to verify that the ground-water extraction system was installed in accordance with the NYSDEC-approved design documents. The QA/QC procedures were developed and implemented in accordance with applicable professional and technical standards and requirements.

As required by the technical specifications, shop drawings were reviewed to verify consistency of the materials provided for the work with those specified and approved shop drawings were utilized to verify consistency of these materials and the requirements for installation with the work completed in the field. All installations conducted in the field were inspected and/or tested to verify that the system was installed and operated properly. Provided below are the general requirements specified by the QA/QC program for the design and the various inspections and tests that were performed.

The general inspection procedures performed at the Site were as follows:

- all inspections were documented on forms, checklists, or in other written form; and identified the area of inspection, acceptance criteria, and results of the inspection;
- all inspection records were signed by the inspector;
- the frequency of inspections performed were identified;
- certifications for materials were obtained by the selected contractor;
- the selected contractor created a system to identify, control and verify correction of deficiencies; and
- the results of the inspections were documented in a field log book maintained on the Site.

Provided below are the various inspections that were performed, and the testing methods used during the construction of the ground-water extraction system.

- The extraction well was installed as indicated in the technical specifications and as shown in Figure 4 and as shown in the as-built boring log in Appendix B. The installation of associated piping, controls and the submersible pump also followed the guidelines in the technical specifications. The installation was inspected in the field by a representative of Pfizer.

- In order to verify that trenches and excavations were adequately compacted, density tests were performed and supervised during construction. Leakage testing was also performed on the system.

- Once the ground-water extraction system was tested for leakage, the system was backfilled and compacted.

- Trench compaction testing was performed to verify that the soil met the compaction criteria of 95 percent of proctor density.

- Start-up testing of the ground-water extraction system consisted of operating and supervising the system operation for one 8-hour day.

- The Site was visually inspected after the completion of construction of the ground-water extraction system. As required by the specifications, disturbed areas of the Site were restored following construction except in areas where future construction was planned.

- As-built drawings have been prepared to document final installations of all work completed at the Site and are submitted with this document.

- Post-construction collection of water levels and sampling (from monitoring wells and discharge force main to sewer) has been performed to estimate the influence of the pumping well on the water table and to verify that the discharge to the municipal sewer system is within guidelines.

4.0 SYSTEM START-UP ACTIVITIES

System start-up activities were conducted to verify the extraction system performance. System start-up activities included:

- pre-system start-up ground-water sampling;
- water-level measurements; and
- effluent sampling from the extraction well.

4.1 Pre-System Start-Up Activities

Prior to the start-up of the ground-water extraction system, Remedial Engineering collected background data that would be used as a baseline to compare additional data to once the system was started. The activities consisted of:

- a ground-water sampling round; and
- collection of water-level measurements.

4.1.1 Pre-System Start-Up Ground-Water Sampling

A pre-system start-up ground-water sampling round was completed on April 19, 1994. Ground-water samples were collected from Monitoring Wells MW-4, MW-5, MW-6, MW-8, MW-9, MW-12, MW-13, MW-14, and MW-15 and analyzed for copper, lead, total chromium and hexavalent chromium.

Ground-water samples were not collected from Monitoring Wells MW-1, MW-2, MW-3, MW-7, MW-10 and MW-11 as they were to be abandoned prior to the start of soil remediation at the Site.

The analytical results from this ground-water sampling round are provided in Appendix C.

4.1.2 Pre-System Start-Up Water-Level Measurements

One round of water levels were collected from both on-site and off-site monitoring wells immediately prior to the extraction system startup on June 14, 1994. Figure 5 illustrates the water-level measurements that were collected prior to the operation of the ground-water extraction system and the inferred direction of ground-water flow.

4.2 Post-System Start-Up Activities

Following the start-up of the ground-water extraction system, additional activities were completed as part of system startup including:

- water-level measurements; and
- effluent sampling from the extraction well.

4.2.1 Water-Level Measurements

Immediately following the startup of the ground-water extraction system on June 14, 1994, one round of water-level measurements were collected from on-site and off-site monitoring wells. Two additional rounds of water levels were collected following one day (June 15, 1994) of system operations. Three additional rounds of water-level measurements were collected on a weekly basis for the remainder of the start-up period. These water levels were collected on June 22, June 28, and July 7, 1994, and the data is presented in Appendix C.

Figure 6 provides the direction of ground-water flow and the inferred capture zone of the extraction well based upon the June 22, 1994 post pumping water-level data. The extraction well was installed in the southwestern portion of the Site to prevent further migration of inorganic contaminants offsite. The inferred capture zone, at a pumping rate of 30 gallons per minute, extends to a point adjacent to MW-12 in the area of highest hexavalent chromium concentrations.

4.2.2 Effluent Sampling from the Extraction Well

Two rounds of effluent sampling from the extraction well were completed on June 15 and June 28, 1994, as part of system start-up activities. The effluent sampling is a requirement by the NYCDEP Industrial Waste Control Section in order to allow discharge to the sewer system. The samples were analyzed by Recra Environmental, Inc. (a New York State Certified Laboratory) for the following parameters:

- pH;
- total petroleum hydrocarbons;
- oil and grease;

- amenable cyanide; and
- heavy metals, consisting of cadmium, chromium, copper, hexavalent chromium, lead, mercury, nickel and zinc.

The analytical results from the two rounds of effluent sampling during system startup indicated that all parameters of interest were below the NYCDEP Discharge Limits for sewer use.

All ground-water data and effluent sampling analytical results received to date have been submitted to NYSDEC with quarterly progress reports issued previously by Foster Wheeler Environmental Corporation (FWENC). Future analytical data will continue to be submitted in accordance with the O&M Plan.

5.0 OPERATIONS AND MAINTENANCE

During continuing soil remedial activities, routine operations and maintenance visits and inspections have been completed at the Site to verify that the ground-water extraction system is operating properly and to perform routine maintenance on the system. The following section describes the schedule for data submissions and routine O&M activities. Table 1 provides a schedule of the routine inspection, maintenance and reporting activities that have been performed as part of the O&M of the ground-water extraction system during the first year of system operation. Table 2 provides the schedule of routine inspection, maintenance and reporting activities that will be performed during subsequent years of system operation.

5.1 Routine Operations and Maintenance Visits

Routine O&M visits have been conducted according to the following schedule with status of inspections in parenthesis:

- weekly inspection and maintenance during the first month of system operation (completed);
- bi-weekly inspection during the second month of system operation (completed); and
- monthly inspection for the remainder of the operation of the system.

The specific activities that have been and will continue to be completed as part of the routine O&M visits are outlined in the O&M Plan for the ground-water extraction system. In addition, the O&M Plan describes other activities including quarterly water-level measurements and semi-annual ground-water sampling.

6.0 DATA EVALUATION AND REPORTING OF SYSTEM PERFORMANCE

System O&M requirements include data evaluation and reporting to provide information to establish that the ground-water extraction system is operating properly and in accordance with requirements. A description of the data reporting required as part of system O&M is provided below.

6.1 Data Reporting

The analytical results from the sampling of the ground-water extraction system effluent are submitted for review to the NYCDEP Program Development Section in a letter report. To date, these analytical results have also been submitted to the NYSDEC in quarterly progress reports. If any effluent analytical results exceed the discharge limits stipulated in the discharge permit, the operator shall immediately shut the system down and notify the NYCDEP, in accordance with the discharge permit. A written report evaluating the cause of the exceedance will be prepared, in a timely manner, for submission to the NYCDEP Program Development Section prior to continuing operations. In addition, the discharge permit issued by the NYCDEP will be renewed every 12 months while the ground-water extraction system is operating.

After completion of a round of quarterly water-level measurements and receipt of each round of analytical results from ground-water sampling, a data package is submitted to the NYSDEC. The quarterly reports will include, at a minimum, the results from water-level monitoring, effluent sampling and semi-annual ground-water sampling activities. These reports will include a narrative section summarizing the monitoring results and ground-water flow and quality conditions.

7.0 ENGINEERS CERTIFICATION

Remedial Engineering, P.C. has completed this engineering report describing implementation of the remedy for ground water at the Pfizer former Deknatel Facility (Site) located at 96-20 222nd Street in Queens Village, New York. This engineering certification is being submitted to the NYSDEC in accordance with the Order on Consent (Site No. 2-41-007) issued on April 5, 1994 by NYSDEC.

Remedial Engineering, P.C. hereby certifies that the Remedial Design for the ground-water extraction system was implemented and construction activities were completed in accordance with the intent of the NYSDEC-approved Remedial Design Documents dated May 1994, and as described in this document.

Respectfully Submitted,

REMEDIAL ENGINEERING, P.C.

STATE OF NEW YORK
PETER JOSEPH GERBASI
No. 070446
LICENSED PROFESSIONAL ENGINEER

Peter J. Gerbasi, P.E.
Principal Engineer/
Project Manager

Table 1. Schedule for Routine Inspection, Maintenance and Reporting Activities for the Ground-Water Extraction System (Year 1), Former Deknatel Facility, Queens Village, New York.

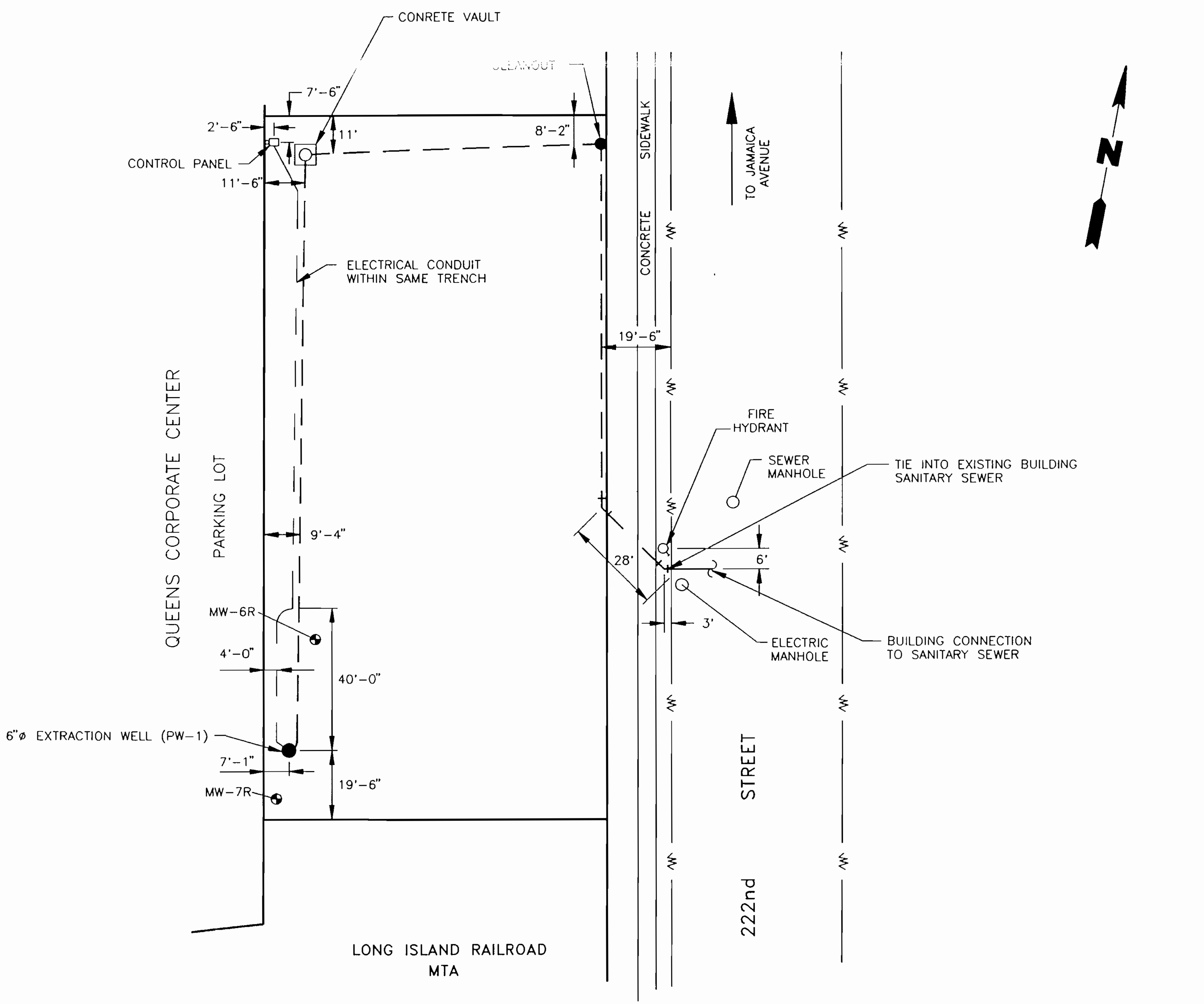
DESCRIPTION	SYSTEM START-UP				MONTHLY OPERATION AND MAINTENANCE											
	Week 1	Week 2	Week 3	Week 4	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
traction Pump, Flow Meter, Control Panel and lemetric Connection Inspection	W	W	W	W	W	BW	M	M	M	M	M	M	M	M	M	M
stem Check via Telemetric System	TW	TW	TW	TW	TW	W	W	W	W	W	W	W	W	W	W	W
ater-Level Measurements	W	W	W	W			Q			Q			Q			Q
fluent Sampling	W		W		M	M	M	M	M	M	M	M	M	M	M	M
ound-Water Sampling							S						S			
arterly Report Submission							Q			Q			Q			Q
ta Submission to the NYCDEP	BW		BW		M	M	M	M	M	M	M	M	M	M	M	M

TW - Inspection and maintenance activities conducted twice a week.
W - Inspection and maintenance activities conducted once a week.
BW - Inspection and maintenance activities conducted once every two weeks.
M - Inspection and maintenance activities conducted once a month.
Q - Inspection and maintenance activities conducted quarterly.
S - Ground-water sampling conducted semi-annually.

Table 2. Schedule for Routine Inspection, Maintenance and Reporting Activities for the Ground-Water Extraction System (Subsequent Years), Former Deknatel Facility, Queens Village, New York.

DESCRIPTION	MONTHLY OPERATION AND MAINTENANCE											
	January	February	March	April	May	June	July	August	September	October	November	December
Extraction Pump, Flow Meter, Control Panel and Telemetric Connection Inspection	M	M	M	M	M	M	M	M	M	M	M	M
System Check via Telemetric System	W	W	W	W	W	W	W	W	W	W	W	W
Water-Level Measurements			Q			Q			Q			Q
Effluent Sampling*	M	M	M	M	M	M	M	M	M	M	M	M
Ground-Water Sampling			S						S			
Quarterly Report Submission			Q			Q			Q			Q
Data Submission to the NYCDEP*	M	M	M	M	M	M	M	M	M	M	M	M

W - Inspection and maintenance activities conducted once a week.
M - Inspection and maintenance activities conducted once a month.
Q - Inspection and maintenance activities conducted quarterly.
S - Ground-water sampling conducted semi-annually.
* - The frequency of effluent sampling and data submission as required by the NYCDEP is subject to change.



LEGEND

PW-1 ●	PUMPING WELL LOCATION AND DESIGNATION
MW-7R	MONITORING WELL LOCATION AND DESIGNATION
	PROPERTY LINE
	EDGE OF STREET
	2"ø PVC FORCE MAIN
	3/4"ø PVC ELECTRICAL CONDUIT

NOTE

1. AS-BUILT SURVEY PERFORMED BY LEHRER McGOVERN BOVIS ON APRIL 4, 1994

0 30' 60'

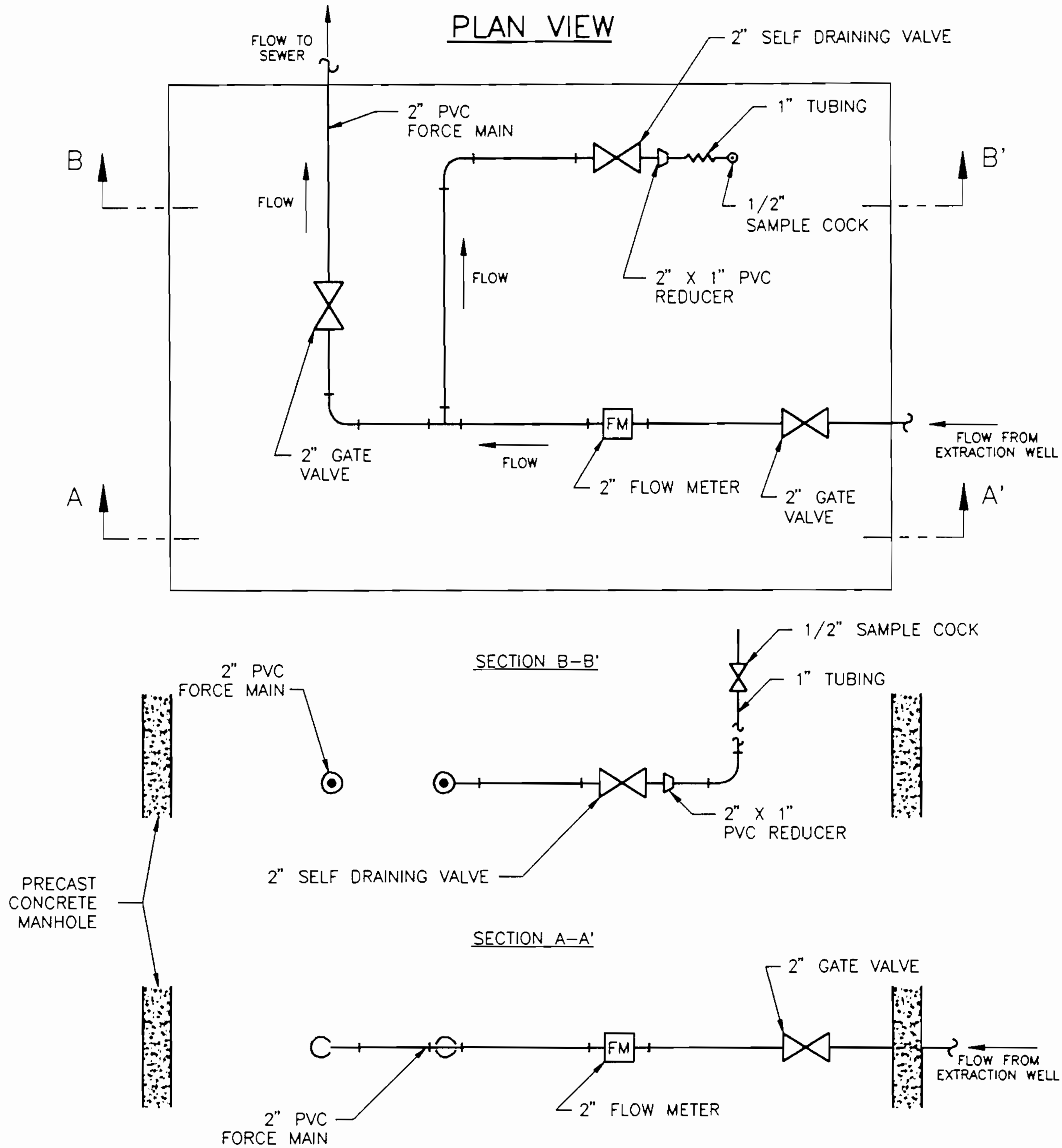
Title:

AS BUILT PLAN OF GROUND-WATER EXTRACTION SYSTEM AND SEWER DISCHARGE LOCATIONS

FORMER DEKNATEL FACILITY
96-20 222ND STREET
QUEENS VILLAGE, NEW YORK

Prepared For: PFIZER INC

REMEDIAL ENGINEERING, P.C. ENVIRONMENTAL ENGINEERS	Compiled By: J.M.	Date: 7/95	FIGURE
	Prepared By: G.M.	Scale: 1"=30'	2
	Project Mgr: P.J.G.	Revision: –	
	File No: 04773001	Project: 04773YRE	

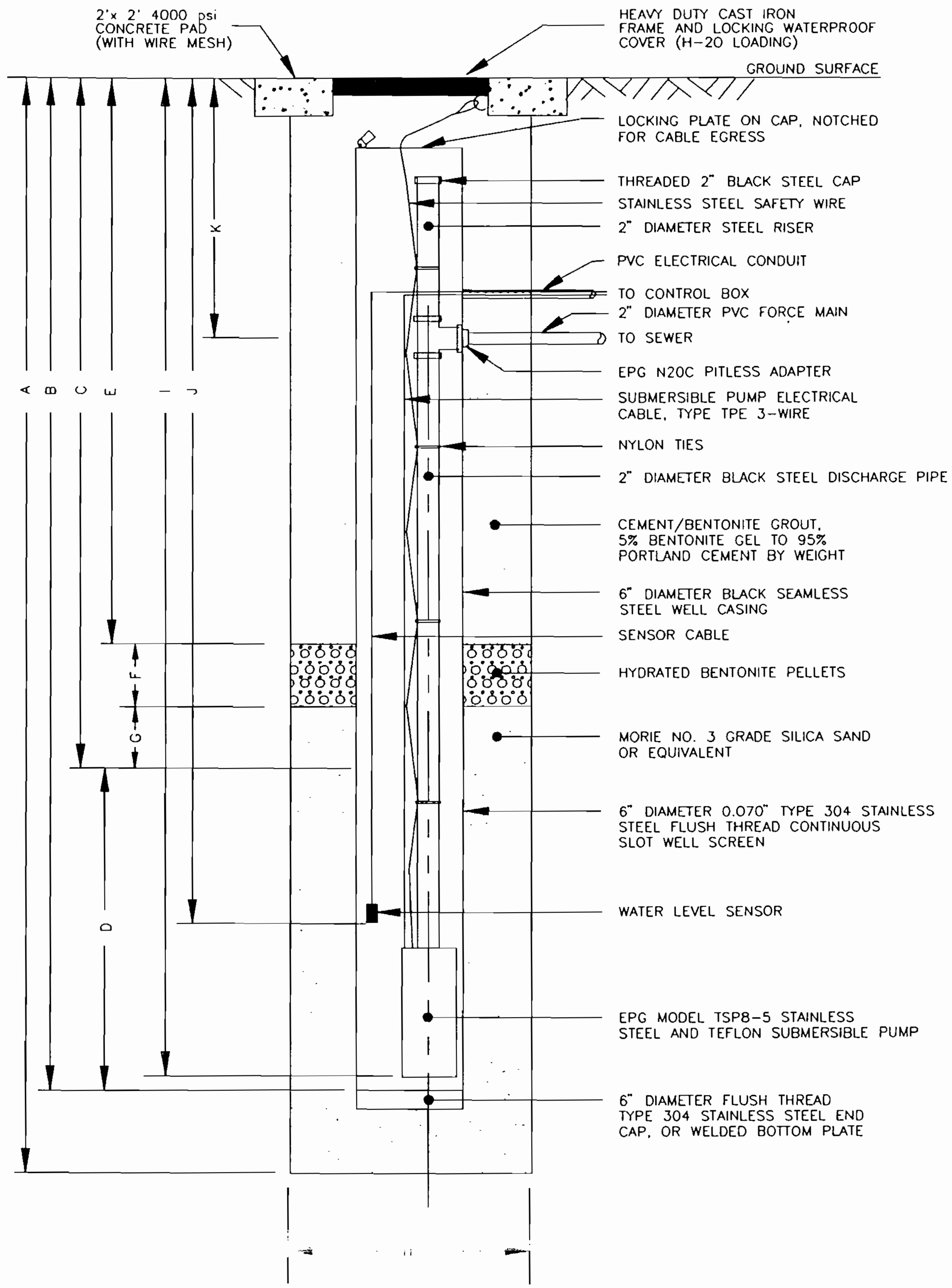


FLOW METER VAULT AND SAMPLING PORT PLAN AND SECTIONS

Prepared For:

PFIZER INC

REMEDIAL ENGINEERING, P.C. ENVIRONMENTAL ENGINEERS	Compiled By: J.M.	Date: 4/95	FIGURE
	Prepared By: J.R.	Scale: 1.2" = 1.0'	3
	Project Mgr: P.J.G.	Revision: –	
	File No: 04773003	Project: 4773YRE	



NOT TO SCALE

EXTRACTION WELL DIMENSIONS

FEATURE	DIMENSION	EXTRACTION WELL
TOTAL BORING DEPTH	A	82 FT
TOTAL WELL CASING DEPTH	B	81.5 FT
DEPTH TO TOP OF SCREEN	C	51.5 FT
LENGTH OF WELL SCREEN	D	30 FT
DEPTH TO TOP OF BENTONITE SEAL	E	44.4 FT
THICKNESS OF BENTONITE SEAL	F	2 FT
THICKNESS OF SAND PACK ABOVE SCREEN	G	5.1 FT
DIAMETER OF BORE HOLE	H	14 IN
DEPTH TO BOTTOM OF WELL PUMP	I	78 FT
DEPTH TO BOTTOM OF WATER LEVEL SENSOR	J	68 FT
DEPTH TO PITLESS ADAPTER	K	4 FT

NO.	DESCRIPTION	DRWN.BY	APPRV.BY
1	AS-BUILT AFTER INSTALLATION		

REVISIONS

DESIGNED BY: A.H.H.	PROJECT NO.: 04773YRE
DRAWN BY: V.W.S.	DRAWING NO.: 04773006
CHECKED BY: P.W.	SCALE: AS NOTED
APPROVED BY:	DATE: 5-4-95
LIC. NO.:	

ALTERATION OF THIS DOCUMENT EXCEPT BY A LICENSED PROFESSIONAL IS PROHIBITED.

TITLE:

AS-BUILT EXTRACTION WELL CONSTRUCTION DETAIL

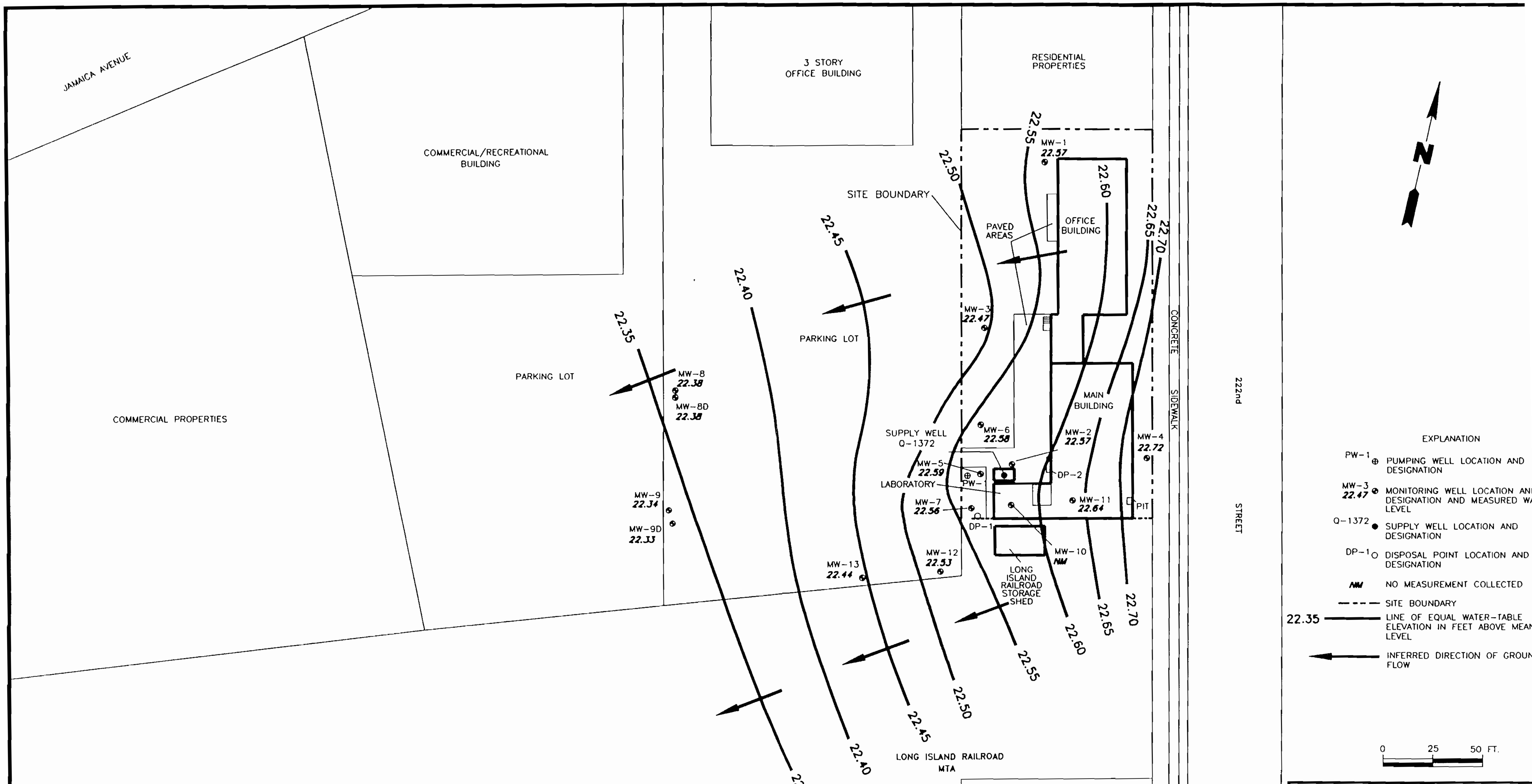
FORMER DEKNATEL FACILITY
96-20 222ND STREET
QUEENS VILLAGE, NEW YORK

PREPARED FOR:

PFIZER INC

ENVIRONMENTAL ENGINEERS
ISLANDIA, N.Y. (516) 232-2600

FIG



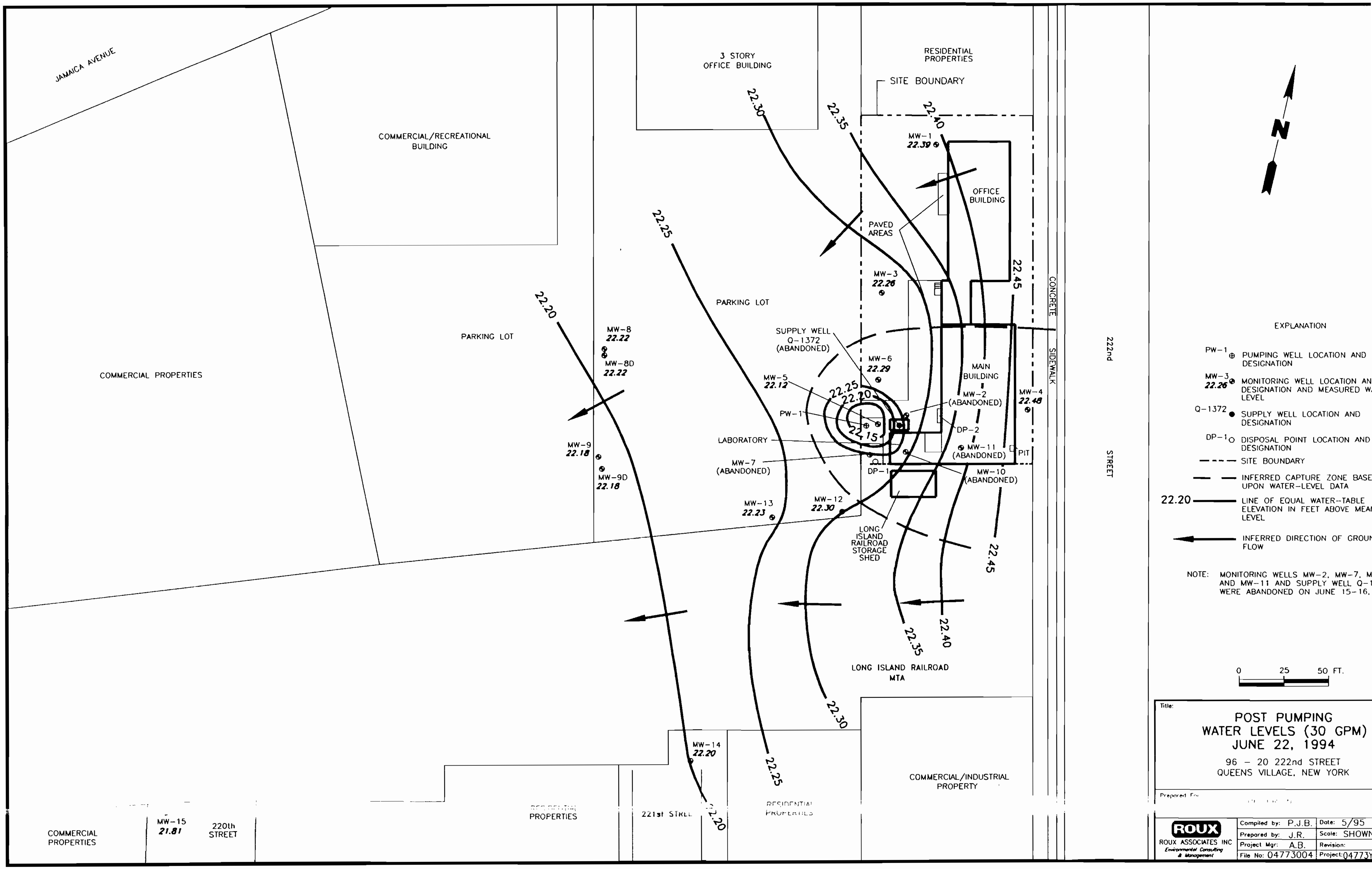
Title:

PRE-PUMPING WATER LEVELS JUNE 14, 1994

96 - 20 222nd STREET
QUEENS VILLAGE, NEW YORK

PFIZER INC

ROUX ASSOCIATES INC Environmental Consulting & Management	Compiled by: P.J.G.	Date: 5/95
	Prepared by: J.R.	Scale: SHOWN
	Project Mgr: A.B.	Revision:
	File No: 04773005	Project: 04773Y



JAMAICA AVENUE
COMMERCIAL/RECREATIONAL BUILDING
3 STORY OFFICE BUILDING
RESIDENTIAL PROPERTIES
SITE BOUNDARY
COMMERCIAL PROPERTIES
PARKING LOT
PARKING LOT
OFFICE BUILDING
PAVED AREAS
MAIN BUILDING
LABORATORY
SUPPLY WELL Q-1372 (ABANDONED)
MW-1 22.39
MW-2 (ABANDONED)
MW-3 22.26
MW-4 22.48
MW-5 22.12
MW-6 22.29
MW-7 (ABANDONED)
MW-8 22.22
MW-8D 22.22
MW-9 22.18
MW-9D 22.18
MW-10 (ABANDONED)
MW-11 (ABANDONED)
MW-12 22.30
MW-13 22.23
MW-14 22.20
MW-15 21.81
PW-1
DP-1
DP-2
PIT
LONG ISLAND RAILROAD STORAGE SHED
LONG ISLAND RAILROAD MTA
COMMERCIAL/INDUSTRIAL PROPERTY
RESIDENTIAL PROPERTIES
COMMERCIAL PROPERTIES
220th STREET
221st STREET
CONCRETE SIDEWALK
222nd STREET
22.15
22.20
22.25
22.30
22.35
22.40
22.45
N
EXPLANATION
PW-1 PUMPING WELL LOCATION AND DESIGNATION
MW-3 22.26 MONITORING WELL LOCATION AND DESIGNATION AND MEASURED WATER LEVEL
Q-1372 SUPPLY WELL LOCATION AND DESIGNATION
DP-1 DISPOSAL POINT LOCATION AND DESIGNATION
SITE BOUNDARY
INFERRED CAPTURE ZONE BASED UPON WATER-LEVEL DATA
22.20 LINE OF EQUAL WATER-TABLE ELEVATION IN FEET ABOVE MEAN SEA LEVEL
INFERRED DIRECTION OF GROUND-WATER FLOW
NOTE: MONITORING WELLS MW-2, MW-7, MW-10 AND MW-11 AND SUPPLY WELL Q-1372 WERE ABANDONED ON JUNE 15-16,
0 25 50 FT.
Title:
POST PUMPING WATER LEVELS (30 GPM) JUNE 22, 1994
96 - 20 222nd STREET QUEENS VILLAGE, NEW YORK
ROUX
ROUX ASSOCIATES INC Environmental Consulting & Management
Compiled by: P.J.B.
Prepared by: J.R.
Project Mgr: A.B.
File No: 04773004
Date: 5/95
Scale: SHOWN
Revision:
Project: 0477

APPENDIX A-1

Summary of Excavation and Sampling Results of
Stained Soil from the Ground-Water Extraction System
Trench in the Vicinity of Formerly Existing
Monitoring Wells MW-1 and MW-3

On March 25, 1994, Roux Associates, Inc. (Roux Associates) was informed by Mr. Steve Kemp of Pfizer Inc and Mr. Eli Jazra of Lehrer, McGovern, Bovis that green stained soil was discovered during the trenching of the ground-water extraction system for the Deknatel facility located in Queens Village, New York. The stained soil was located approximately 50 feet to the south of the northwestern corner of the Site boundary and approximately five feet below land surface.

Upon discovering the stained soil, all other intrusive operations occurring at the Site were terminated and the area of concern was investigated by representatives of Fenley & Nicol Co., Inc. (Fenley & Nicol). The area of stained soil was approximately one foot in diameter. Soil was removed by Fenley & Nicol in and around the area of the stained soil to observe if there was any migration in a radial direction. This excavated soil was stockpiled on plastic sheeting and the trench was inspected by Fenley & Nicol for possible staining or discoloring. No discoloration beyond the original area was noted during the inspection of the soil.

The remaining stained soil in the trench was excavated by Fenley & Nicol until no visible discoloration was present. The excavation extended approximately six to eight inches in depth below the original bottom of the trench. This additional excavated soil was stockpiled and combined with the soil previously removed from the area of concern and covered with plastic. At the completion of the excavation, Fenley & Nicol collected a sample of the stained soil.

A representative of Roux Associates arrived onsite March 28, 1994, to conduct waste characterization and post-excavation sampling activities. The stockpiled soil was first investigated and sampled. The amount of stockpiled soil was equivalent to approximately one bucket-load (i.e., less than one 55-gallon drum). A seven-point grid sampling scheme was established for the pile in which soil was composited from each of the seven sampling locations and placed in a 16-ounce pre-cleaned laboratory glass jar. The sample contains brown to orange-brown and stained, dark bluish-green sand mixed with coarse gravel.

The post-excavation sample was collected from the area of concern within the trench. Prior to sample collection, the representative of Roux Associates confirmed that there was no visible staining present in the soil. Two four-ounce pre-cleaned laboratory glass jars were filled (from the same sampling location) as requested by the analytical laboratory (Recra Environmental, Inc.) to complete the analysis for total chromium and hexavalent chromium. The post-excavation samples were shipped under chain-of-custody on March 29, 1994, with the laboratory receiving the samples on March 30, 1994.

This stained soil was discovered in an area which no known manufacturing or past property operations have occurred. Thus, this portion of the Site has not been the focus of past investigations. The nearest intrusive activities that have occurred in the vicinity of the stained soil area were the drilling and installation of two monitoring wells (MW-1 and MW-3). MW-1 is located approximately 50 feet to the northeast and MW-3 is located approximately 52 feet to the south of the stained soil area.

The analytical results for soil samples collected during the installation of Site background well MW-1 and subsequent ground-water sampling rounds indicated the following:

- soil samples ranged in concentrations from a minimum of 4.8 parts per million (ppm) to 17 ppm for total chromium, which are concentrations significantly less than the total chromium levels located in the proposed areas of soil excavation at the Site; and

- ground-water samples contained no detectable concentrations of total chromium or hexavalent chromium on January 20, 1993 and April 13, 1993.

Soil samples were not analyzed during the installation of MW-3 because this monitoring well was installed as part of an underground storage tank investigation and the concern at this location was to monitor ground water. However, split-spoon samples were collected at five-foot intervals and inspected for staining and odors. No odors were present in the split-spoons collected from MW-3 and the only staining that was present was the predominant iron staining that is found Site-wide approximately 40 feet below land surface.

Ground-water samples collected from MW-3 on January 20, 1993 and April 13, 1993, indicated that there were no detectable concentrations of total chromium or hexavalent chromium.

The analytical results from the post-excavation sampling of the trench area indicate the following:

- hexavalent chromium was detected at 0.26 ppm; and
- total chromium was detected at 19.7 ppm.

These concentrations are significantly less than the hexavalent chromium and total chromium levels located in the proposed areas of soil excavation at the Site and the hexavalent chromium levels are below Site background concentrations.

The above-referenced analytical results support the conclusion that this stained soil area is consistent with Site background levels and that the remaining metals associated with the former stained area are not likely to migrate through the soil, nor is it likely that the ground water has been, or was in the past, impacted in this portion of the Site due to the presence of these metals.

NYSDEC-ASP

1
INORGANIC ANALYSES DATA SHEET

NYSDEC SAMPLE NO.

POSTEX

Lab Name: RECRA_ENVIRONMENTAL_INC._ Contract: NY94-339__
Lab Code: RECNY_ Case No.: 4996_ SAS No.: _______ SDG No.: 1526__
Matrix (soil/water): SOIL_ Lab Sample ID: 7631
Level (low/med): LOW__ Date Received: 03/30/94
% Solids: _86.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum_				NR
7440-36-0	Antimony_				NR
7440-38-2	Arsenic__				NR
7440-39-3	Barium___				NR
7440-41-7	Beryllium				NR
7440-43-9	Cadmium__				NR
7440-70-2	Calcium__				NR
7440-47-3	Chromium_	19.7		*	A_
7440-48-4	Cobalt___				NR
7440-50-8	Copper___				NR
7439-89-6	Iron_____				NR
7439-92-1	Lead_____				NR
7439-95-4	Magnesium				NR
7439-96-5	Manganese				NR
7439-97-6	Mercury__				NR
7440-02-0	Nickel___				NR
7440-09-7	Potassium				NR
7782-49-2	Selenium_				NR
7440-22-4	Silver___				NR
7440-23-5	Sodium___				NR
7440-28-0	Thallium_				NR
7440-62-2	Vanadium_				NR
7440-66-6	Zinc_____				NR
	HexChrom_	0.26		N	A_

Color Before: BROWN____ Clarity Before: ______ Texture: COARSE
Color After: COLORLESS Clarity After: CLEAR_ Artifacts: _______

Comments:
LAB_SAMPLE_ID:__A4118501_&_A4152601
CLIENT_SAMPLE_ID:_POST_EXC_SAMPLE#1

APPENDIX A-2

Summary of Excavation and Sampling Results of
Stained Soil from the Ground-Water Extraction System
Trench in the Vicinity of Formerly Existing
Monitoring Wells MW-5 and MW-6

On April 1, 1994, Roux Associates, Inc. (Roux Associates) was informed by Mr. Steve Kemp of Pfizer Inc and Mr. Eli Jazra of Lehrer, McGovern, Bovis that green stained soil was discovered during the trenching of the ground-water extraction system for the Deknatel facility located in Queens Village, New York. The stained soil was located approximately 14 feet to the north of MW-5, eight feet to the east of the property boundary, and approximately two feet below land surface.

Upon discovering the stained soil, all other intrusive operations occurring at the Site were terminated until the area of concern was investigated by a representative of Roux Associates. The area of stained soil was approximately four feet in diameter and two inches in thickness. The stained soil was excavated by Roux Associates using a shovel until no visible discoloration was present. The excavation extended approximately two to three inches in depth until all stained soil was removed from the trench. This soil was stockpiled on plastic along with soils previously removed by Fenley & Nicol from the area of concern within the trench. After completing the excavation, the soil pile was covered with plastic and post-excavation samples were collected from the trench.

Prior to post-excavation sample collection, the representative of Roux Associates confirmed that there was no visible staining present in the remaining soil. Two four-ounce pre-cleaned laboratory glass jars were filled with soil collected one foot beneath the excavated stained soil area from both the eastern side and the western side of the trench. The post-excavation samples were shipped under chain-of-custody on April 1, 1994, to Recra Environmental, Inc. for the completion of the analyses for total chromium and hexavalent chromium.

The nearest intrusive activities that have occurred in the vicinity of the stained soil area were the drilling and installation of two monitoring wells (MW-5 and MW-6). MW-5 is located approximately 14 feet to the south and MW-6 is located approximately 13 feet to the north of the stained soil area.

The analytical results for soil samples collected during the installation of these monitoring wells (MW-5 and MW-6) indicated the following:

- MW-5 soil samples ranged in concentrations from a minimum of 6.4 parts per million (ppm) to 15.3 ppm for total chromium and all hexavalent chromium concentrations were below the detection limit; and

- MW-6 soil samples ranged in concentrations from a minimum of 6.2 ppm to 46.8 ppm for total chromium and all hexavalent chromium concentrations were below the detection limit.

These hexavalent chromium concentrations are less than the hexavalent chromium levels proposed within areas of soil excavation at the Site.

The analytical results from the post-excavation sampling of the trench area indicate the following:

- hexavalent chromium was detected at 0.21 ppm on the eastern side of the trench and not detected on the western side of the trench; and

- total chromium was detected at 22.1 ppm on the eastern side of the trench and 20.5 ppm on the western side of the trench.

These concentrations are also less than the hexavalent chromium and total chromium levels located in the proposed areas of soil excavation at the Site and the hexavalent chromium levels are below Site background concentrations.

The above-referenced analytical results support the conclusion that this stained soil area is consistent with Site background levels and that the remaining metals associated with the former stained area are not likely to migrate through the soil, nor is it likely that the ground water has been, or was in the past, impacted in this portion of the Site due to the presence of these metals.

NYSDEC - ASP

1
INORGANIC ANALYSES DATA SHEET

SAMPLE NO.

SAMP2

Lab Name: RECRA_ENVIRONMENTAL_INC._ Contract: NY94-389__

Lab Code: RECNY_ Case No.: 4996__ SAS No.: ______ SDG No.: ROUX1_

Matrix (soil/water): SOIL_ Lab Sample ID: 7769

Level (low/med): LOW__ Date Received: 04/02/94

% Solids: _79.8

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum_				NR
7440-36-0	Antimony_				NR
7440-38-2	Arsenic__				NR
7440-39-3	Barium__				NR
7440-41-7	Beryllium				NR
7440-43-9	Cadmium__				NR
7440-70-2	Calcium__				NR
7440-47-3	Chromium_	22.1			A_
7440-48-4	Cobalt__				NR
7440-50-8	Copper__				NR
7439-89-6	Iron____				NR
7439-92-1	Lead____				NR
7439-95-4	Magnesium				NR
7439-96-5	Manganese				NR
7439-97-6	Mercury__				NR
7440-02-0	Nickel__				NR
7440-09-7	Potassium				NR
7782-49-2	Selenium_				NR
7440-22-4	Silver__				NR
7440-23-5	Sodium__				NR
7440-28-0	Thallium_				NR
7440-62-2	Vanadium_				NR
	HexChrom_	0.21		N	A_

Color Before: BROWN____ Clarity Before: ______ Texture: COARSE

Color After: COLORLESS Clarity After: CLEAR_ Artifacts: ______

Comments:
LAB_SAMPLE_ID:__A4124501
CLIENT_SAMPLE_ID:__POST_EXCAV_SAMPLE_#2

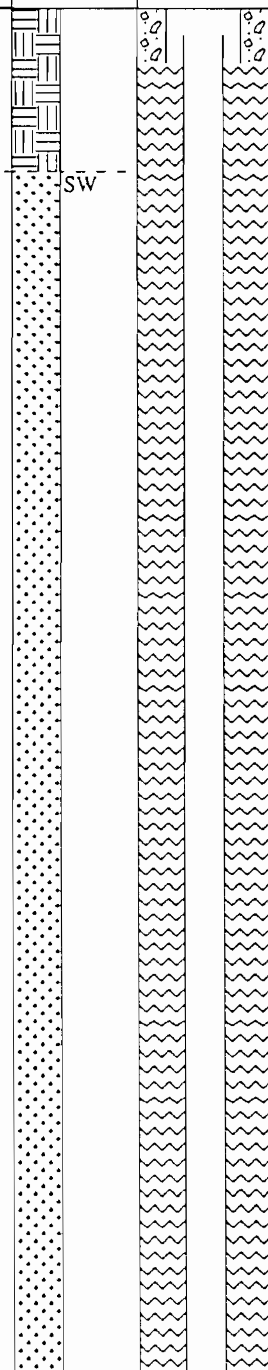
APPENDIX B

Extraction Well As-Built Boring Log

ROUX

Project: PFIZER-DEKNATEL QUEENS VILLAGE, NEW YORK		Log of Well No. PW-1			
Date Started: 3/21/94	Completed: 3/22/94	Measuring Point Elevation: NM		Total Depth: 82.0 ft	
Logged By: J. Makowski	Checked By: P. Gerbasi	Water Level During Drilling: 52.0		Stabilized: 52.0	
Drilling Co: Fenley & Nicol Co. Inc.	Driller: Skip	Casing: 6-Inch Black Steel		Drill Bit Diameter: 14.0 in.	
Drilling Method: Hollow-Stem Auger		Perforation: 70-Slot		from 51.5 ft.	to 81.5 ft.
Drilling Equipment: Canterra CT 450		Pack: #3 Sand		from 46.4 ft.	to 82.0 ft.
Sampler: No Sampler Used		Seal: Benonite Pellets		from 44.4 ft.	to 46.4 ft.
		Cement/Bentonite Grout		from 1.0 ft.	to 44.4 ft.

Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology	Monitoring Well Construction	Sample	Blow Counts	OVM (ppm)	REMARKS
0–3	Cuttings 0 to 3 feet: Gray to black SILTY CLAY and Debris (fill); dry						
3–5		SW					Pitless adapter located approx. 4.0' below land surface.
5–10	Cuttings 5 to 10 feet: Dark yellow to tan SAND, trace Gravel ; dry						
10–15	Cuttings 10 to 15 feet: Dark yellow to tan SAND, trace Gravel; dry						
15–20	Cuttings 15 to 20 feet: Dark yellow to tan SAND, trace Gravel; dry						
20–25	Cuttings 20 to 25 feet: Dark yellow to tan SAND, trace Gravel; dry						



Continued Next Page

Project: PFIZER-DEKNATEL
QUEENS VILLAGE, NEW YORK

Log of Well No. PW-1

Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology	Monitoring Well Construction	Sample	Blow Counts	OVM (ppm)	REMARKS
	Cuttings 25 to 30 feet: Dark yellow to tan SAND, trace Gravel; dry						
30							
	Cuttings 30 to 35 feet: Dark yellow to tan SAND, trace Gravel; dry						
35							
	Cuttings 35 to 40 feet: Dark yellow to tan SAND, trace Gravel; dry						
40							
	Cuttings 40 to 44 feet: Dark yellow to tan SAND, trace Gravel; dry						
45							
	Cuttings 44 to 50 feet: Dark yellow to tan SAND and Gravel; dry						
50							
	Cuttings 50 to 55 feet: Dark yellow to tan SAND and Gravel; dry to moist						Water detected approx. 52.0' below land surface during drilling.

Continued Next Page

ROUX

Project: PFIZER-DEKNATEL
QUEENS VILLAGE, NEW YORK

Log of Well No. PW-1

Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology	Monitoring Well Construction	Sample	Blow Counts	OVM (ppm)	REMARKS
55							
	Cuttings 55 to 60 feet: Dark yellow to tan SAND and Gravel; wet						
60							
	Cuttings 60 to 65 feet: Dark yellow to tan SAND and Gravel; wet						
65							
	Cuttings 65 to 70 feet: Dark yellow to tan SAND and Gravel; wet						Bottom of water level sensor approx. 68.0' below land surface.
70							
	Cuttings 70 to 75 feet: Dark yellow to tan SAND and Gravel; wet						
75							
	Cuttings 75 to 80 feet: Dark yellow to tan SAND and Gravel; wet						Bottom of well pump approx. 78.0' below land surface.
80							End of borehole at 82.0' below land surface.
	Cuttings 80 to 82 feet: Dark yellow to tan SAND and Gravel; wet						

APPENDIX C

System Start-Up Data

Table C-1. Summary of Pre-System Start-Up Analytical Results for Ground-Water Samples Collected by Roux Associates, Inc., 96-20 222nd Street, Queens Village, New York.

Sample Designation:	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-8D	Ground-Water
Sample Date:	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	Standards
Copper	--	--	--	5.0 U	79.0	10.0 B	--	13.0 B	--	200
Lead	--	--	--	2.0 B	4.0	4.0	--	7.0	--	25
Total Chromium	--	--	--	10.0 U	1760	43.0	--	17.0	--	50
Hexavalent Chromium	--	--	--	10.0 U	1300	27.0	--	10.0 U	--	50

Sample Designation:	MW-9	MW-9D	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15	MW-15R	Ground-Water
Sample Date:	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	4/19/94	Standards
Copper	5.0 U	--	--	--	813	228	25.0	8.0 B	10.0 B	200
Lead	4.0	--	--	--	14.0	5.0	6.0	4.0	6.0	25
Total Chromium	10.0	--	--	--	449	772	11.0	26.0	29.0	50
Hexavalent Chromium	10.0 U	--	--	--	388	701	10.0 U	17.0	12.0	50

NOTE: Analytical results and standards reported in micrograms per liter.
R - Replicate sample
U - Analyte not detected
B - Value greater than or equal to the Instrument Detection Limit but less than the Contract Required Detection Limit.
-- - Monitoring wells are not part of the long-term monitoring program, therefore no samples were collected.

Table C-2. Summary of System Start-Up Ground-Water Elevation Data Collected by Roux Associates, Inc., from June 14, 1994 through July 7, 1994, 96-20 222nd Street, Queens Village, New York.

		June 14, 1994 (Extraction Well Off)			June 14, 1994 (Extraction Well On)			June 15, 1994 (Extraction Well On)			June 15, 1994 (Extraction Well On)		
Well Designation	Measuring Point Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)
MW-1	75.56	1344	52.99	22.57	1600	53.03	22.53	1209	53.12	22.44	1548	53.12	22.44
MW-2	75.23	1405	52.66	22.57	1620	52.88	22.35		Abandonded			Abandonded	
MW-3	75.39	1351	52.92	22.47	1603	52.97	22.42	1213	53.07	22.32	1551	53.07	22.32
MW-4	74.99	1414	52.27	22.72	1632	52.37	22.62	1230	52.44	22.55	1606	52.44	22.55
MW-5	73.94	1358	51.35	22.59	1611	51.76	22.18	1222	51.78	22.16	1559	51.77	22.17
MW-6	75.52	1355	52.94	22.58	1606	53.11	22.41	1218	53.17	22.35	1554	53.18	22.34
MW-7	75.94	1402	53.38	22.56	1615	53.65	22.29		Abandonded			Abandonded	
MW-8	75.47	1245	53.09	22.38	1532	53.09	22.38	1132	53.21	22.26	1514	53.21	22.26
MW-8D	75.72	1243	53.34	22.38	1530	53.34	22.38	1129	53.46	22.26	1511	53.46	22.26
MW-9	75.58	1240	53.24	22.34	1528	53.24	22.34	1126	53.37	22.21	1507	53.36	22.22
MW-9D	75.57	1237	53.24	22.33	1526	53.24	22.33	1124	53.36	22.21	1505	53.36	22.21
MW-10	76.78	--	--	--	--	--	--		Abandonded			Abandonded	
MW-11	76.80	1408	54.16	22.64	1628	54.31	22.49		Abandonded			Abandonded	
MW-12	75.70	1302	53.17	22.53	1538	53.27	22.43	1146	53.38	22.32	1519	53.38	22.32
MW-13	75.39	1257	52.95	22.44	1535	53.00	22.39	1139	53.11	22.28	1517	53.11	22.28
MW-14	73.77	1328	51.46	22.31	1547	51.46	22.31	1235	51.58	22.19	1524	51.56	22.21
MW-15	75.25	1331	53.35	21.90	1553	53.35	21.90	1159	53.46	21.79	1537	53.45	21.80

ft - feet
msl - mean sea level
mp - measuring point
-- - Not measured due to access constraints to monitoring well

Table C-2. Summary of System Start-Up Ground-Water Elevation Data Collected by Roux Associates, Inc., from June 14, 1994 through July 7, 1994, 96-20 222nd Street, Queens Village, New York.

		June 22, 1994 (Extraction Well On)			June 28, 1994 (Extraction Well On)			July 7, 1994 (Extraction Well On)		
Well Designation	Measuring Point Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)	Time	Depth to Water (ft below mp)	Water-Level Elevation (ft above msl)
MW-1	75.56	0923	53.17	22.39	0824	53.27	22.29	1338	53.37	22.19
MW-2	75.23		Abandonded			Abandonded			Abandonded	
MW-3	75.39	0928	53.13	22.26	0827	53.24	22.15	1341	53.33	22.06
MW-4	74.99	0948	52.51	22.48	0845	52.59	22.40	1352	52.70	22.29
MW-5	73.94	0939	51.82	22.12	0835	51.92	22.02	1348	52.02	21.92
MW-6	75.52	0933	53.23	22.29	0832	53.32	22.20	1344	53.41	22.11
MW-7	75.94		Abandonded			Abandonded			Abandonded	
MW-8	75.47	0841	53.25	22.22	0855	53.37	22.10	1425	53.46	22.01
MW-8D	75.72	0838	53.50	22.22	0853	53.60	22.12	1428	53.70	22.02
MW-9	75.58	0835	53.40	22.18	0856	53.50	22.08	1432	53.60	21.98
MW-9D	75.57	0832	53.39	22.18	0859	53.49	22.08	1435	53.59	21.98
MW-10	76.78		Abandonded			Abandonded			Abandonded	
MW-11	76.80		Abandonded			Abandonded			Abandonded	
MW-12	75.70	0853	53.40	22.30	0903	53.52	22.18	1437	53.62	22.08
MW-13	75.39	0848	53.16	22.23	0906	53.26	22.13	1439	53.36	22.03
MW-14	73.77	0902	51.57	22.20	--	--	--	1407	51.82	21.95
MW-15	75.25	0909	53.44	21.81	0937	53.52	21.73	1417	53.62	21.63

ft - feet
msl - mean sea level
mp - measuring point
-- - Not measured due to access constraints to monitoring well

ATTACHMENT A

Final Operation and Maintenance Plan for the
Ground-Water Extraction and Conveyance System

FINAL OPERATION AND MAINTENANCE PLAN FOR THE GROUND-WATER EXTRACTION AND CONVEYANCE SYSTEM

Former Deknatel Facility
Queens Village, New York

August 1995

Prepared for:

Pfizer Inc
235 East 42nd Street
New York, New York 10017-5755

Prepared by:

REMEDIAL ENGINEERING, P.C.
1377 Motor Parkway
Islandia, New York 11788

CONTENTS

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

This Operation and Maintenance (O&M) Plan has been completed on behalf of Pfizer Inc (Pfizer) for the ground-water extraction system installed at the former Deknatel, Inc. facility at 96-20 222nd Street in Queens Village, New York (Site). Pfizer presently owns the Site through one of its wholly owned subsidiaries. The Site was previously owned and operated by Deknatel, Inc., a business formerly owned by Pfizer. The Site location is shown in Figure 1. The purpose of the ground-water extraction system is to prevent further migration of hexavalent chromium from the Site, and to provide for the protection of human health and the environment in accordance with the requirements of the Order on Consent for the Site issued by the New York State Department of Environmental Conservation (NYSDEC).

This O&M Plan was prepared pursuant to the Order on Consent. The objectives of the O&M Plan are to describe general procedures which will be followed to:

- prevent extraction system downtime caused by equipment failures;
- allow for safe and effective operation of the extraction system;
- evaluate the effectiveness of the extraction system; and
- document the required communication between Pfizer, contractors and regulatory agencies.

This O&M Plan is a reference for operating and maintaining the 30-gallon per minute (gpm) ground-water extraction and conveyance system in conformance with the intent of the design, applicable regulations, and permit requirements.

Detailed information on the installed equipment in the ground-water extraction and conveyance system can be found for each major component in the technical support documentation located in Appendices A through F. This O&M Plan is not intended to be a substitute for the manuals prepared by the manufacturers of the equipment used in this system. However, it is intended to be a supplement to the attached equipment specific documentation.

This O&M Plan presents the O&M activities which have occurred from system start-up to date, as well as those O&M activities that will occur throughout the operation of the extraction system. This manual and the procedures presented herein should be updated consistently so that when O&M activities are changed, modifications to this O&M Plan are documented through the preparation of manual revisions or addenda.

2.0 SYSTEM OPERATION AND MAINTENANCE

This O&M Plan describes the general procedures to be followed to operate and maintain the ground-water extraction system. Section 2.0 provides the following information:

- a brief description of the ground-water extraction system components;
- general information on system start-up requirements; and
- overall system O&M procedures.

The following information has been prepared to inform the operator of the specific equipment installed in this system. From the information provided, the operator should gain detailed knowledge of the system components' capabilities, operating ranges and maintenance requirements.

2.1 Ground-Water Extraction and Conveyance System

The major components of the system consist of a ground-water extraction pump, high and low water level sensors, a flow meter and totalizer, and a control panel which contains a telemetry system. The as-built plan of the system is shown in Figure 2.

2.1.1 Ground-Water Extraction Pump

The ground-water extraction pump is an EPG Companies, Inc. (EPG) Model No. TSP8-5. This pump is capable of pumping 40 gpm of extracted ground water at 95 feet of total dynamic head and has a capacity range of 20 to 55 gpm. The pump is made of 304 stainless steel with teflon seals and bearings. The pump has a 1.5 Hp 208 volt 3 phase motor manufactured by Franklin Electric. Periodic preventative maintenance on the pump should be performed on an annual basis. Additional detailed information about the pump and motor are provided in Appendix A, and Appendix B, respectively.

2.1.2 High and Low Level Sensors

The high and low level sensors have been installed within the ground-water extraction well in order to start and stop the ground-water extraction pump at pre-established levels. The high level sensor is set at a well depth to maintain desired drawdown, while the low level sensor is set above the pump intake to keep the pump and motor submerged at all times and maintain total fluids pumping. The pump will start and continue to run when the ground-water level rises to the point where both sensors are submerged. The pump will shut off when the ground-water level drops below the low level sensor. These capacitance type sensors are manufactured by EPG.

2.1.3 Flow Meter and Totalizer

The ground-water extraction system includes a 1-inch bronze positive displacement meter, model C-700 BP and a hermetically sealed direct reading register, which are both manufactured by Kent Meters, Inc. The meter is a volumetric type meter, capable of measuring flows between 3/4 and 50 gpm at an accuracy of 100% ± 1½% at its rated flow, and is approved for use by the New York City Department of Environmental Protection (NYCDEP) to monitor flows discharged to the New York City sewers. The meter reads locally through the use of a mechanical totalizer within the manhole, and remotely through the use of a flow rate totalizer at the control panel, as described in Section 2.1.4. The flow rate totalizer is an electronic powered vacuum fluorescent display on a panel mounted key pad. The meter should be removed from the system and cleaned on an annual basis. Additional information on this equipment is provided in Appendix C.

2.1.4 Control Panel

The ground water extraction system is provided with a single control panel which houses the main electrical disconnect switch, the ground-water extraction pump Hand-Off-Auto (HOA) switch, a pump running indication light, and a flow rate totalizer panel mounted key pad. The control panel is made of 304 stainless steel and is a NEMA 4 rated enclosure. Electrical gear such as switches, relays, and other items should be checked and/or tested annually in order to verify their operation.

2.1.5 Remote Telemetry System

The remote telemetry system, EPGs Telemax 3 sensor modem is a remote access programmable system which consists of the Sensor Modem Programmer software, a Nota Bene Technology, Inc. (NBT) Sensor Modem and a programmable logic controller (PLC). The PLC is programmed by the manufacturer to identify instantaneous flow rate, total flow, pump status (on/off), time when pump last cycled off and how often the pump has cycled.

The remote telemetry system can be accessed by telephone (1-718-479-7008) while operating the vendor supplied Sensor Modem Programmer software. System specific documentation and other details of the remote telemetry system are provided in Appendix D.

2.1.6 Sample Port

The extraction system has a sample port located on the discharge line, contained within a manhole. The sample port is situated such that it is within arms reach and can be accessed without entering the manhole. This eliminates the need to enter the manhole in order to perform routine sampling. The sample port consists of a 2-inch self draining valve manufactured by Mueller, and a ½-inch teflon tubing and sample cock to regulate sample flow from the main discharge line.

Figure 3 shows the layout of the flow meter vault and sampling port plan and sections. The following outline describes the procedures to follow in order to collect effluent samples from the sampling port.

1. Remove the 24-inch diameter manhole cover.
2. Use a six-foot long valve key to turn the self-draining valve counter-clockwise to the "open" position.
3. Open the sampling cock valve and allow the extracted ground water to discharge for two minutes prior to sample collection. This allows the sample port piping and tubing to be purged of any standing water that has accumulated between sampling events.
4. Collect effluent samples by discharging the ground water from the sampling cock into the sample containers. Effluent samples are to be analyzed for the parameters indicated in Section 3.1.
5. After all samples are collected, close the sampling cock.
6. Use the valve key to turn the drain valve clockwise into the "closed" position.
7. Replace the manhole cover over the manhole.

2.2 System Start-Up and Shut Down

Proper O&M and safety should be the operators primary concern when operating and maintaining the ground-water extraction system. A thorough understanding of the operating requirements and procedures of the major components of the system is required prior to start-up of the system. Refer to the manufacturers' equipment technical support documentation in the appendices. Note, this system is designed to be operating continuously, and should only be shut down during system maintenance or an emergency.

2.2.1 System Startup

Once the operator is familiar with the operating requirements and procedures, the following steps should be initiated to start-up the system.

1. Inspect the control panel and verify the following:

    - the main electrical disconnect switch is in the off position;
    - the pump HOA switch is in the off position;
    - the pump running indication light is off; and
    - the totalizer display is not operating.

    (The above system should be off prior to start-up.)

2. Turn the main electrical disconnect switch to the on position.
3. Access the pump controls, and place the pump HOA switch to the auto position. (This allows the pump to operate continuously until stopped manually , or until the low water level control probe is exposed.)
4. Check to see if all control panel components in item 1 are in the appropriate positions and compare to normal operating values.
5. Record required data on Water Discharge Monitoring Log (see Section 2.3 System Operation and Monitoring).
6. Adjust ground-water flow, if necessary, to $\leq$ 30 gpm (see Section 2.3 System Operation and Monitoring).

2.2.2 System Shutdown

The following steps should be initiated to perform shutdown during system maintenance or an emergency.

System Maintenance Shutdown

Prior to performing system maintenance the following steps should be initiated.

1. Turn the pump HOA switch and the main electrical disconnect switch to the off positions.

2. Record shutdown time on the Water Discharge Monitoring Log (see Section 2.3 System Operation and Monitoring).

Emergency System Shutdown

On an emergency basis, the following steps should be initiated.

1. Turn the main electrical disconnect switch to the off position.

2. Perform Step 2 above.

2.3 System Operation and Monitoring

A Ground-Water Discharge Monitoring Log has been prepared to standardize the collection of operating data from the system. All of the information on this log shall be recorded during each Site visit or when the remote telemetry system is accessed so that trends can be observed, changes in operations can be made or maintenance can be performed before a problem develops. A copy of the Ground-Water Discharge Monitoring Log is presented in Appendix E.

The following equipment and components shall be inspected and/or adjusted during system operation and monitoring.

1. Inspect the control panel and verify the following:

    - the main electrical disconnect switch is in the on position;
    - the pump HOA switch is in the on position;
    - the pump running indication light is on; and
    - the totalizer display is operating properly.

2. Record data from a general inspection of the system and the control panel on the Ground-Water Discharge Monitoring Log to include but not be limited to:

   - date and time of inspection;
   - totalizer reading;
   - flow rate; and
   - comments related to operating conditions, equipment adjustments or replacement parts required.

   Note: The total flow between two time periods can be calculated by referring back to the previous totalizer reading.

3. Compare recorded flow data with normal operating value (≤30 gpm) and adjust flow rate, if necessary, by performing the following:

   - open manhole cover to the flow meter and access the downstream gate valve on the discharge line;
   - close or open gate valve, as necessary, to adjust flow rate to ≤30 gpm;
   - inspect new flow rate reading at control panel and continue to adjust gate valve as necessary; and
   - when flow rate has been adjusted properly, replace manhole cover over manhole.

2.4 System Maintenance

Maintenance shall be performed according to manufacturer's instructions and on an as-needed-basis in order to optimize operation of the system and to prolong equipment life. Scheduled maintenance events, including start-up and routine O&M visits, are outlined in Sections 3.1 and 3.2. In addition, the manufacturers' recommended maintenance procedures are provided in the Appendices.

The following will be performed as indicated during system maintenance.

1. Check all visible piping and the sample port to verify that it is properly shut off and that there are no observable leaks.

2. Inspect system components (i.e., the pump, motor, and flow meter), in accordance with manufacturers' requirements and as necessary.

3. Check the level sensors in the extraction well, as necessary, by performing the following:

    - check the level sensors for proper operation by sequentially removing each level sensor (high level first, low level last) to cause the pump to shut off;

    - after allowing the water level to rise in the extraction well, sequentially insert the level sensors (low level first, high level last) to cause the pump to turn on; and

    - if the pump does not cycle off and on correctly, clean, repair or replace the level sensors.

Sensors shall be cleaned with a brush using standard non-phosphate detergent and water.

2.5 Remote Telemetry System Operations

Operation of the remote telemetry system shall be performed according to the manufacturer's instructions (Appendix D). However, the following outline describes the step-by-step procedures to take in order to access the remote telemetry system from a computer. This assumes that the Sensor Modem Programmer is properly installed in the computer accessing the data and that a mouse is available.

1. Turn computer on and start Microsoft Windows.

2. Double click on the "Sensor Modem Programmer" icon in the Program Manager.

3. Double click on the "NBTCOMM" icon.

4. Click on the "On-line Terminal Mode" icon (switches system to on-line terminal mode).

5. Click on the "Telephone" icon (opening dialing directory).

6. Click on "Add" within dialing directory.

7. Type "1-718-479-7008" within second box and click on "OK".

8. Click on "1-718-479-7008" shown on screen.

9. Click on "Dial" (you will now hear the system being dialed up).

10. After "Connect 2400/None 7608" appears on screen, click on "Auto Logon" (log onto "Sensor Modem RTSYS Display").

11. The screen will now read "Enter Sensor Modem Password on Screen".

12. Type in the password that appears on screen ("Qwerty") and click on "OK".

13. You are now in Sensor Modem RTSYS Display and the data appears on the screen.

14. In order to update data, click on "refresh".

15. Important: To shut down system, click on "Auto Logoff" and wait for screen to logoff. Once this occurs, click on the "cut phone line" icon.

3.0 OPERATIONS AND MAINTENANCE SCHEDULES

Routine operations and maintenance visits and inspections shall be completed at the Site in order to verify that the ground-water extraction system is operating properly and to perform routine maintenance on the system. The following sections provide the schedules for start-up and routine O&M visits, and various field activities to be performed in order to verify that the system is working properly. Refer to Table 1 for a schedule of all start-up and first-year O&M activities that have been performed and Table 2 for a schedule of routine O&M visits to be performed on the ground-water extraction system in subsequent years through shutdown of the extraction system.

It should be noted that system startup occurred on June 14, 1994, and all startup and first-year O&M activities described in this section have been completed.

3.1 Start-Up Operations and Maintenance Visits

Start-up operations were conducted to verify that the installed equipment is sound and was installed correctly, and that the entire system operates properly. The system has been designed to operate at a flow of between 20 and 40 gallons per minute with the intended flow rate at startup of 30 gallons per minute. The following work was completed during the one month system start-up period:

- collection of one round of water-level measurements and one round of ground-water effluent samples prior to system start-up in order to document baseline water table and effluent conditions;

- collection of one round of ground-water effluent samples from the pumping well after one day and two weeks of operation, and submission of the samples to Recra Environmental, Inc. for analysis of pH, total petroleum hydrocarbons, oil and grease, heavy metals (cadmium, chromium, copper, lead, mercury, nickel and zinc), amenable cyanide and hexavalent chromium on a priority turnaround basis;

- performance of site inspections and collection of additional water-level measurements twice during week one and once a week during weeks two, three and four of system operation; and

- verification of proper operation of extraction pump, flow meter, control panel, valves and telemetric connections during all Site inspections.

3.2 Routine Operations and Maintenance Visits

Following the start-up period, routine O&M visits were conducted over the course of the first year. Site visits were conducted according to the following schedule:

- weekly inspection and maintenance during the first month;
- bi-weekly inspection during the second month; and
- monthly inspection for the remainder of the year.

After the first year of operation a program of monthly inspections will be continued.

The following work has been and will continue to be completed during O&M visits:

- effluent samples will be collected on a monthly basis or as otherwise required by NYCDEP;
- verification of proper operation of extraction pump, flow meter, valves, control panel, and telemetric connections has occurred and will continue to occur on the same monthly time schedule as the collection of effluent samples; and
- the status of the system was checked via the telemetry system twice per week during the first month of O&M, and will continue at a minimum of once per week for the remainder of the systems operation.

3.3 Effluent Sampling

In accordance with NYCDEP requirements, effluent samples from the pumping well PW-1 are collected and are submitted to an approved laboratory and analyzed for the parameters indicated in Section 3.1.

A letter report summarizing the analytical results from the effluent sampling of the ground-water extraction system is submitted to the NYCDEP in accordance with Section 4.0.

3.4 Quarterly Water-Level Measurements

Water-level measurements have been performed quarterly (i.e., during the third, sixth, ninth and twelfth months of each year's O&M). The water-level measurements are evaluated to determine aquifer response to pumping conditions. Water-level measurements are performed in all existing on-site and off-site monitoring wells, and the data is plotted to indicate the water levels and the inferred capture zone of the pumping well. Data is submitted to the NYSDEC in accordance with Section 4.0.

3.5 Semi-Annual Ground-Water Sampling

Two rounds of ground-water sampling will be performed each year the ground-water extraction system is in operation. The first ground-water sampling round will be completed during the third month of the operating year, and the second round will be completed during the ninth month of the operating year. The monitoring includes sampling of the monitoring wells (Wells MW-9, MW-12, MW-13, MW-14 and MW-15) and the pumping well (PW-1). After their installation in August 1995, Wells MW-6R and MW-7R will be included in the semi-annual sampling round. The ground-water samples are submitted to an approved laboratory and analyzed for total chromium, hexavalent chromium, copper and lead on a standard turnaround time basis. Field measurement of Eh, pH and temperature will also be measured at the time of sample collection. Sample results are submitted to the NYSDEC in accordance with Section 4.0.

3.6 Documentation of Operations and Maintenance and Sampling Visits

All Site visits are documented in a dedicated field notebook. The following data are recorded for each Site visit:

- date and time of arrival;
- personnel present onsite;
- weather conditions;
- operating status of the ground-water extraction system;
- flow information;
- O&M performed, if appropriate;

- system upgrades or alterations; and
- effluent and ground-water sampling procedures and protocols.

In addition to recording the above data in the field notebook, all data are recorded in a Ground-Water Discharge Monitoring Log. Appendix E provides a typical Ground-Water Discharge Monitoring Log.

4.0 DATA COLLECTION, EVALUATION, AND REPORTING, AND REMEDY COMPLETION

This section of the O&M Plan outlines data collection, evaluation and reporting procedures in order to:

- provide information to the NYSDEC;
- enable Pfizer to monitor ground-water remediation; and
- determine the duration of pumping based on an evaluation of the ground-water quality data with respect to NYS Class GA Standards, and assessment of the cost-effectiveness of continued pumping (Record of Decision, January 1994).

A description of each of the data collection, evaluation and reporting tasks is provided below. In addition, copies of the agency permits and authorizations obtained for the system are provided in Appendix F.

4.1 Data Collection and Evaluation

Water-level, effluent, and ground-water analytical data collected during the O&M of the ground-water extraction system, as set forth in Section 3.0, will be compiled in a database. The database will present the required data and allow the evaluation of overall ground-water extraction system performance.

Once a final monitoring well network has been established and all new wells required have been installed (at the completion of the soil remediation), water-table elevation maps will be prepared quarterly from the collected water-table data to evaluate hydraulic capture zones. Ground-water analytical data tables and maps will be developed biannually to evaluate the effectiveness of the system in reducing the amount of hexavalent chromium in the ground water, and will be reported to the NYSDEC as set forth in Section 4.2. The pumping well data will be reviewed as it is received from the laboratory to determine if continued discharge to the sewer system is acceptable to the NYCDEP Program Development Section.

4.2 Reporting

During the O&M period, quarterly reports will be submitted to the NYSDEC. The quarterly reports will include, at a minimum, the results from water-level monitoring, effluent sampling and semi-annual ground-water sampling activities. These reports will include a narrative section summarizing the monitoring results and ground-water flow and quality conditions.

The analytical results obtained from the sampling of the ground-water extraction system effluent shall be submitted for review to the NYCDEP Program Development Section in a letter report. If any effluent analytical results exceed the discharge limits set forth in the discharge permit (Appendix F), the system will be shut down. Pfizer, or, as authorized, the system operator, shall notify the NYCDEP, in accordance with the discharge permit. A written report evaluating the cause of the exceedance will be prepared, in a timely manner, for submission to the NYCDEP Program Development Section. In addition, the discharge permit will be renewed every 12 months while the ground-water extraction system is operating.

4.3 Remedy Completion

The period of time during which the ground-water extraction system will remain in operation will be dependent upon monitoring results. Pfizer may cease operation of the system at any time based upon an evaluation of the ground-water quality data with respect to NYS Class GA Standards and an assessment of the cost-effectiveness of continued pumping.

If, based upon such an evaluation, Pfizer determines that it will cease operation of the ground-water extraction system, Pfizer shall submit a Site status report to the NYSDEC, which will assess the overall effectiveness of the system in the context of the remedial action objectives for the Site. With the cessation of the system's operation, Pfizer will cease submitting to the NYSDEC the quarterly reports described in Section 4.2 and a post-operation monitoring program will be implemented consisting of two additional quarterly ground-water sampling rounds, the results of which will be submitted to the NYSDEC. If the data obtained confirm that the quality conditions achieved through pumping are maintained, then the Site will be deleted from the NYS registry of sites. If, however, the ground-water quality conditions are found to degrade during these two quarterly sampling rounds, Pfizer will submit a plan to the NYSDEC with respect to the ground-water quality conditions.

4.4 Contingency Plan

If Pfizer determines that the ground-water extraction system is ineffective, based upon an evaluation by Pfizer as set forth in Section 4.3, then Pfizer will re-assess what measures, if any, are necessary to protect human health or the environment, and will submit a Contingency Plan to the NYSDEC. The Contingency Plan may include the determination to discontinue the ground-water extraction system if additional operation does not have the potential to remove significant amounts of contaminants.

5.0 COMMUNICATIONS

Clear lines of communication have been established to enable the O&M staff to effectively distribute pertinent operational information to the proper parties in a timely manner. The anticipated flow of information between the parties involved in system O&M is summarized below.

System Operations and Maintenance Contractor

The system O&M contractor is the principal operator of the ground-water extraction system. As such, communication is primarily with the following parties: (Note: no communication shall be made with outside parties without the consent of Pfizer.)

- Pfizer is contacted regarding all aspects of ground-water extraction system operations (including emergency shutdowns of the system), and receives copies of all correspondence issued as part of the operation of this system;
- the NYSDEC is contacted regarding quarterly progress reports;
- the NYCDEP Program Development Section representative is contacted regarding analytical results from samples collected from the effluent sampling port; and
- maintenance contractors are contacted, as required.

In addition, the System O&M contractor is responsible for submitting the following reports to the following parties:

- a written report shall be submitted should the NYCDEP discharge limits be exceeded in the system effluent, which requires that the system be shut down;
- a report is submitted to the NYCDEP summarizing the analytical results from the effluent sampling of the ground-water extraction system; and
- quarterly progress reports are submitted to NYSDEC, including results of quarterly water levels and any sampling and analyses performed.

Pfizer

Pfizer is responsible for the overall management of the project. As such, Pfizer or the System Operations and Maintenance Contractor communicates with the following parties:

- the System O&M Contractor is contacted regarding the status of the ground-water extraction system operation;

- the NYCDEP is contacted regarding the status of the ground-water extraction system discharge; and
- the NYSDEC is contacted regarding all aspects of the operation maintenance and monitoring of the ground-water extraction system including remedy completion.

Pfizer is responsible for submitting this O&M Plan to the NYSDEC, in accordance with the Order on Consent.

Table 1. Schedule for Routine Inspection, Maintenance and Reporting Activities for the Ground-Water Extraction System (Year 1), Former Deknatel Facility, Queens Village, New York.

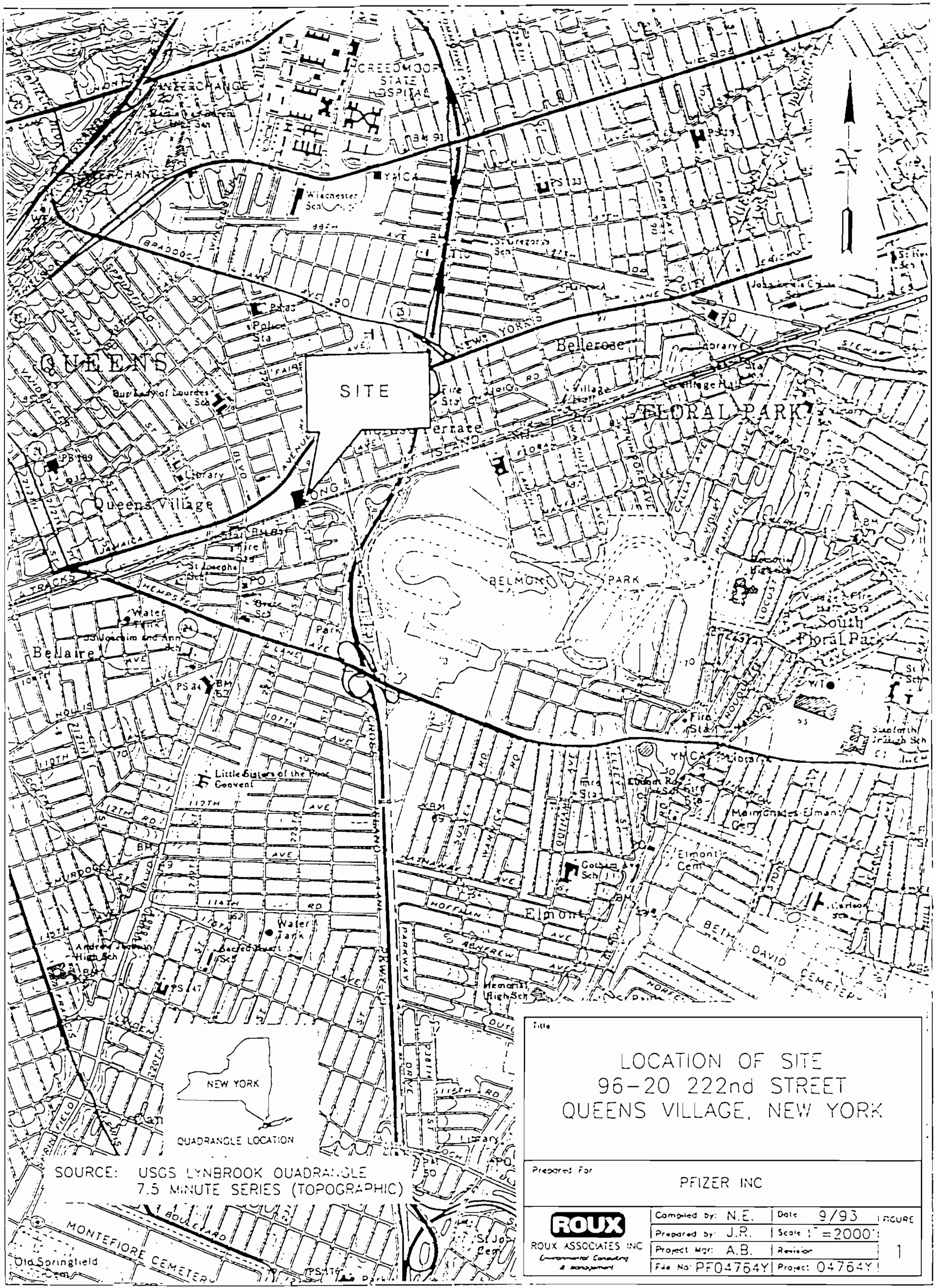
DESCRIPTION	SYSTEM START-UP				MONTHLY OPERATION AND MAINTENANCE											
	Week 1	Week 2	Week 3	Week 4	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
raction Pump, Flow Meter, Control Panel and lemetric Connection Inspection	W	W	W	W	W	BW	M	M	M	M	M	M	M	M	M	M
stem Check via Telemetric System	TW	TW	TW	TW	TW	W	W	W	W	W	W	W	W	W	W	W
ter-Level Measurements	W	W	W	W			Q			Q			Q			Q
luent Sampling	W		W		M	M	M	M	M	M	M	M	M	M	M	M
ound-Water Sampling							S						S			
arterly Report Submission							Q			Q			Q			Q
a Submission to the NYCDEP	BW		BW		M	M	M	M	M	M	M	M	M	M	M	M

TW - Inspection and maintenance activities conducted twice a week.
W - Inspection and maintenance activities conducted once a week.
BW - Inspection and maintenance activities conducted once every two weeks.
M - Inspection and maintenance activities conducted once a month.
Q - Inspection and maintenance activities conducted quarterly.
S - Ground-water sampling conducted semi-annually.

Table 2. Schedule for Routine Inspection, Maintenance and Reporting Activities for the Ground-Water Extraction System (Subsequent Years), Former Deknatel Facility, Queens Village, New York.

DESCRIPTION	MONTHLY OPERATION AND MAINTENANCE											
	January	February	March	April	May	June	July	August	September	October	November	December
Extraction Pump, Flow Meter, Control Panel and Telemetric Connection Inspection	M	M	M	M	M	M	M	M	M	M	M	M
System Check via Telemetric System	W	W	W	W	W	W	W	W	W	W	W	W
Water-Level Measurements			Q			Q			Q			Q
Effluent Sampling*	M	M	M	M	M	M	M	M	M	M	M	M
Ground-Water Sampling			S						S			
Quarterly Report Submission			Q			Q			Q			Q
Data Submission to the NYCDEP*	M	M	M	M	M	M	M	M	M	M	M	M

W - Inspection and maintenance activities conducted once a week.
M - Inspection and maintenance activities conducted once a month.
Q - Inspection and maintenance activities conducted quarterly.
S - Ground-water sampling conducted semi-annually.
* - The frequency of effluent sampling and data submission as required by the NYCDEP is subject to change.



Title

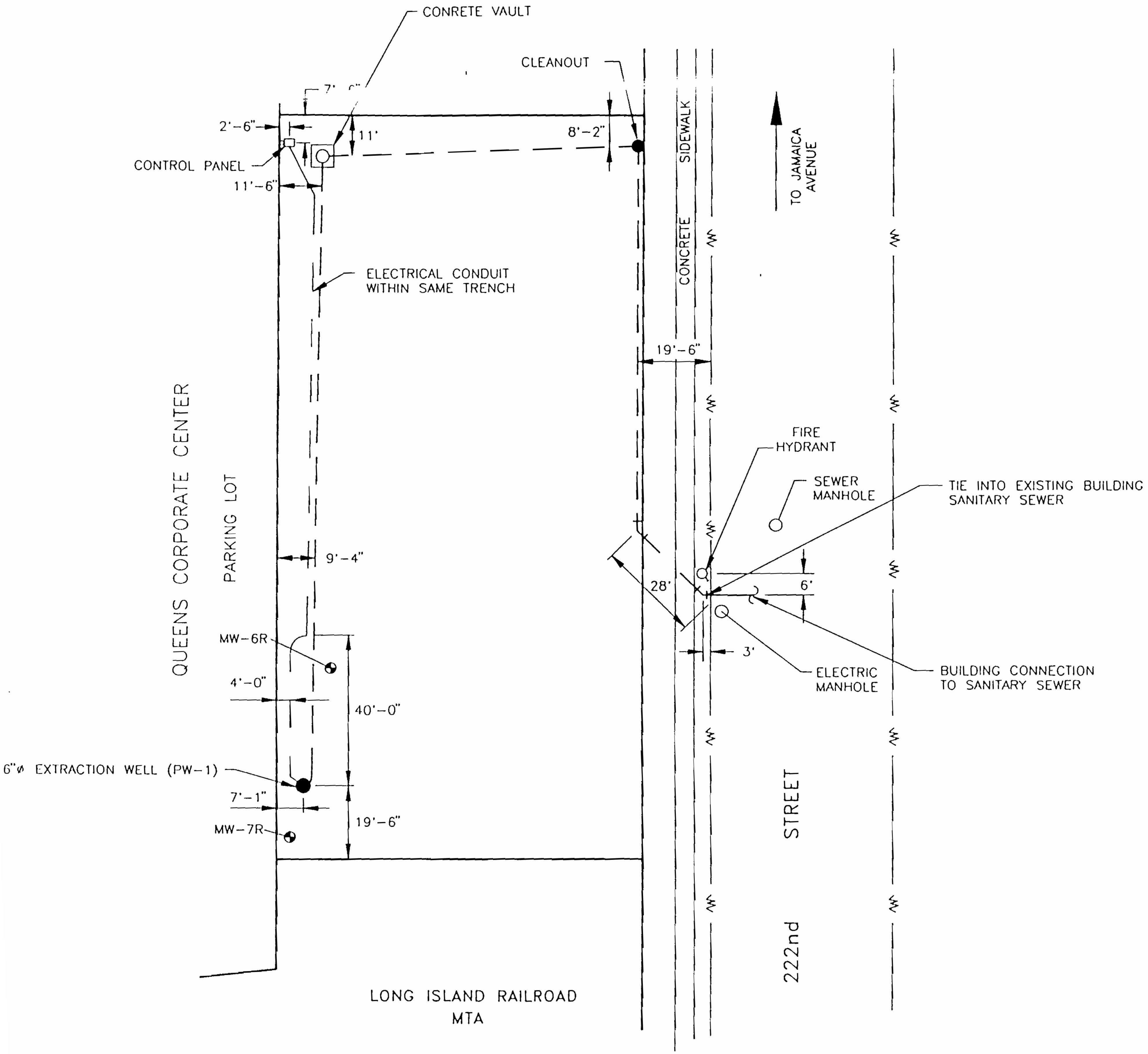
LOCATION OF SITE
96-20 222nd STREET
QUEENS VILLAGE, NEW YORK

Prepared For

PFIZER INC

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: N.E.	Date 9/93	FIGURE
Prepared by: J.R.	Scale 1" = 2000'	
Project Mgr: A.B.	Revision	1
File No: PF04764Y	Project: 04764Y	



LEGEND

PW-1 ●	PUMPING WELL LOCATION AND DESIGNATION
MW-7R ⊕	MONITORING WELL LOCATION AND DESIGNATION
———	PROPERTY LINE
— W —	EDGE OF STREET
— — —	2"ø PVC FORCE MAIN
—— ——	3/4"ø PVC ELECTRICAL CONDUIT

NOTE

1. AS-BUILT SURVEY PERFORMED BY LEHRER McGOVERN BOVIS ON APRIL 4, 1994

0 30' 60'

Title:

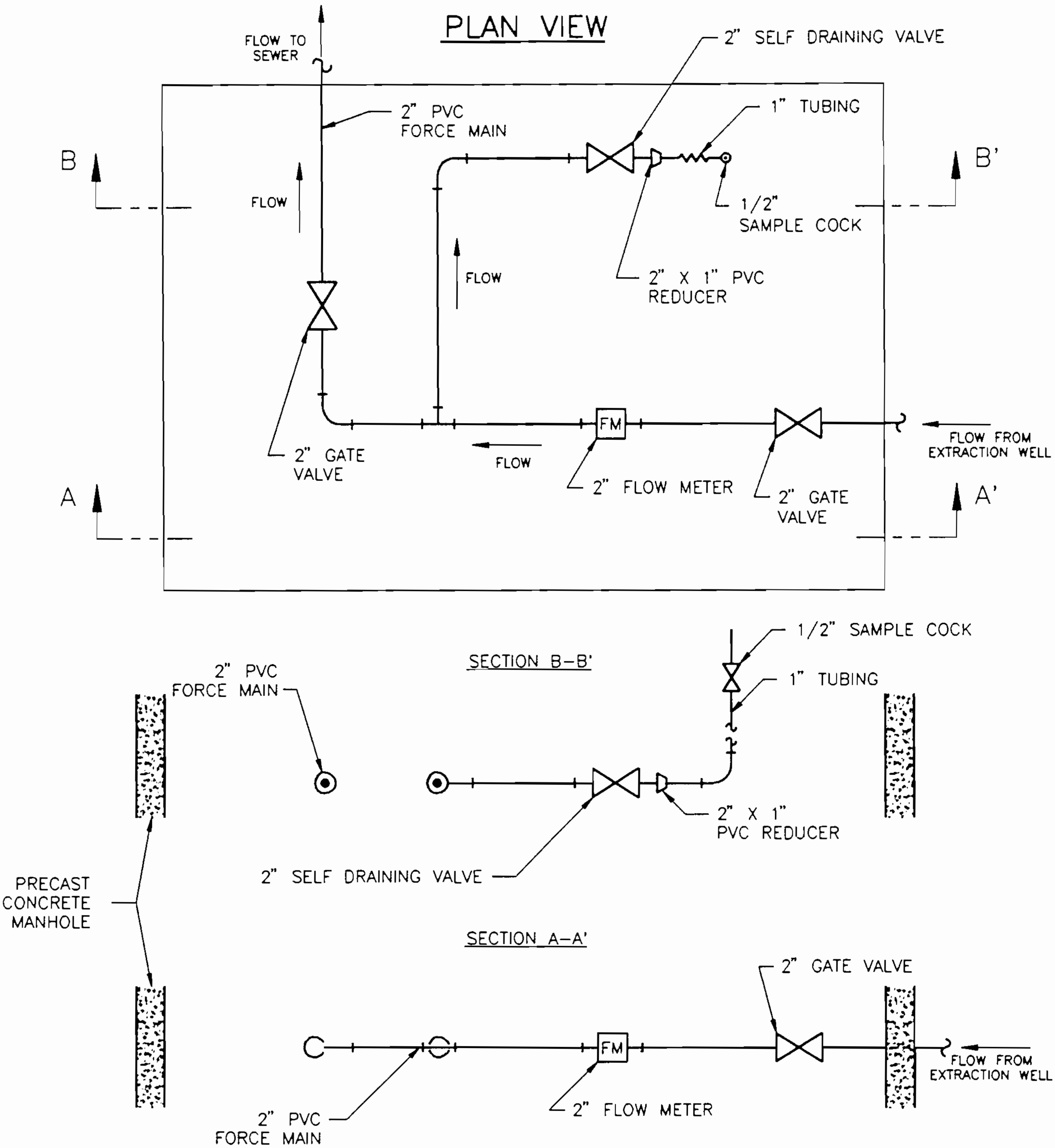
AS BUILT PLAN OF GROUND-WATER EXTRACTION SYSTEM AND SEWER DISCHARGE LOCATIONS

FORMER DEKNATEL FACILITY
96-20 222ND STREET
QUEENS VILLAGE, NEW YORK

Prepared For:

PFIZER INC

REMEDIAL ENGINEERING, P.C. ENVIRONMENTAL ENGINEERS	Compiled By: J.M.	Date: 7/95	FIGURE
	Prepared By: G.M.	Scale 1"=30'	2
	Project Mgr: P.J.G.	Revision: –	
	File No: 04773001	Project: 04773YRE	



FLOW METER VAULT AND SAMPLING PORT PLAN AND SECTIONS

Prepared For: PFIZER INC

REMEDIAL ENGINEERING, P.C. ENVIRONMENTAL ENGINEERS	Compiled By: J.M.	Date: 4/95	FIGURE
	Prepared By: J.R.	Scale: 1.2" = 1.0'	3
	Project Mgr: P.J.G.	Revision: –	
	File No: 04773003	Project: 4773YRE	

APPENDIX A

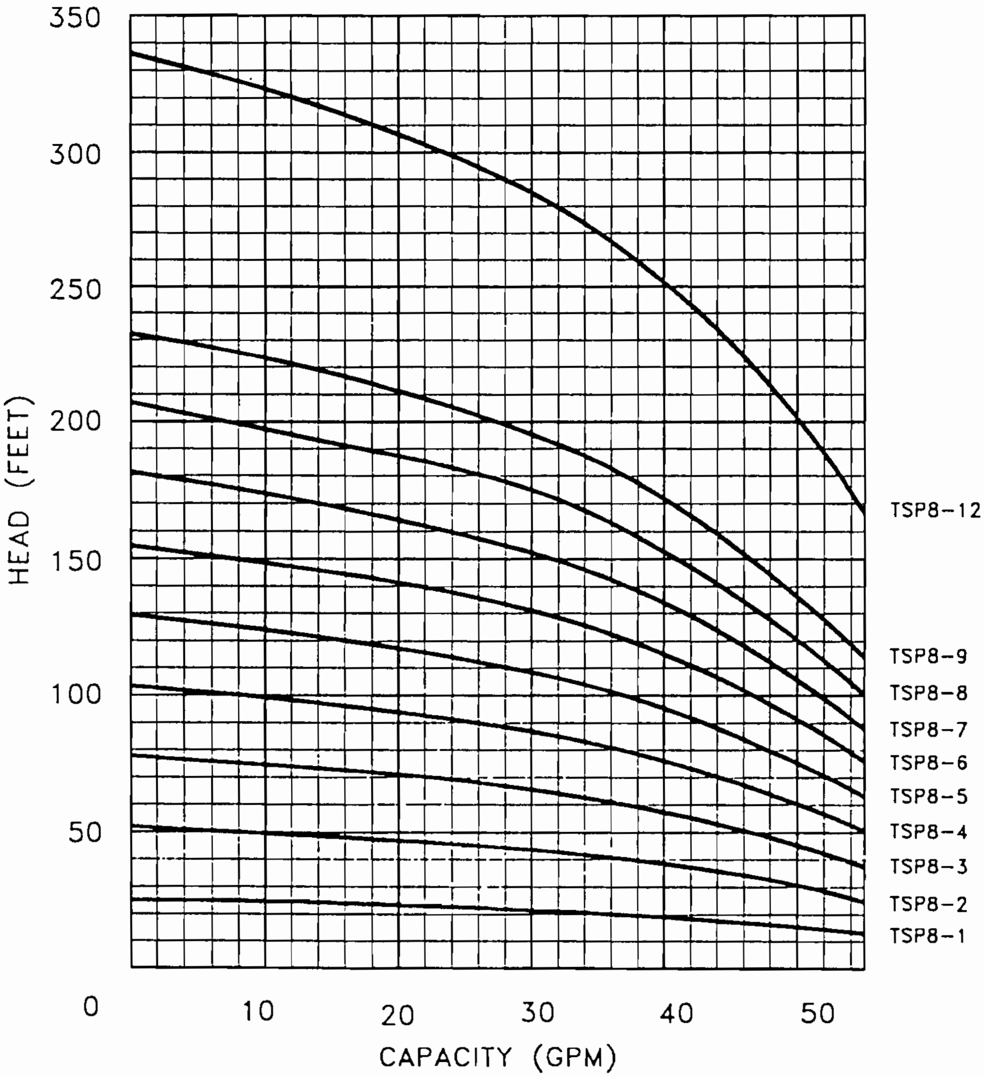
Pump Manufacturer's Literature

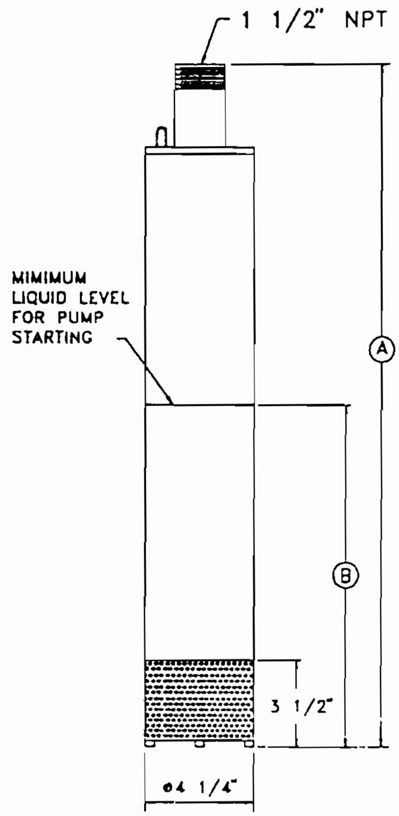
SurePump™ for Vertical Applications

If the following curves do not meet your needs please call us at (800)443-7426. Custom pumps in additional sizes, flow rates and head are available.

Graph	Model	Capacity
0590	TSP1	1 to 7 GPM
0591	TSP1.5	3 to 10 GPM
0592-1	TSP2	6 to 14 GPM
0592-2	TSP2	High Head
0593	TSP3	10 to 20 GPM
0594	TSP5	15 to 30 GPM
✓0595	TSP8	20 to 55 GPM
0596-1	TSP12	40 to 75 GPM
0596-2	TSP12	High Head
0597-1	TSP15	45 to 95 GPM
0597-2	TSP15	High Head
0598-1	TSP16	45 to 110 GPM
0598-2	TSP16	High Head
0599-1	TSP27	75 to 200 GPM
0599-2	TSP27	High Head
0600-1	TSP45	150 to 290 GPM
0600-2	TSP45	High Head

TSP8 SurePump™
VERTICAL





PUMP MODEL	SINGLE PHASE			THREE PHASE			SHIPPING WEIGHT (LBS)	
	MOTOR HP	A (in)	B (in)	MOTOR HP	A (in)	B (in)	1ø	3ø
TSP8-1	0.50	26.25	15.00	0.50	26.25	15.00	38.0	38.0
TSP8-2	0.75	29.25	16.25	0.75	29.25	16.25	41.6	41.6
TSP8-3	1.00	31.75	17.25	1.00	31.75	17.25	46.5	46.5
TSP8-4	1.00	33.50	17.25	1.00	33.50	17.25	48.0	48.0
TSP8-5	1.50	37.00	19.25	1.50	36.00	18.00	56.0	51.6
TSP8-6	1.50	38.75	19.25	1.50	37.50	18.00	57.5	53.1
TSP8-7	2.00	41.75	20.75	2.00	40.50	19.25	62.4	58.0
TSP8-8	2.00	43.50	20.75	2.00	42.50	19.25	64.4	60.0
TSP8-9	3.00	53.50	31.25	3.00	50.75	28.50	88.8	79.0
TSP8-12	5.00	64.50	37.25	5.00	58.50	31.25	112.0	94.3

ENGINEER'S SPECIFICATION
EPG SurePump™ with Sump Drainer
For Vertical Installation

Furnish and install 1 centrifugal submersible EPG SurePump(s) with Sump Drainer (U.S. patented), Model TSP 8 - 5 with 5 impeller stages. Each unit shall be suitable for vertical installation. Each unit shall come with a 1.5 HP, submersible electric motor for operation on 208 volts, 3 phase, 60 hertz service with 100 feet of power cable. Each SurePump with Sump Drainer shall have a 1.5 inch threaded discharge nozzle and be capable of delivering 40 GPM at 95 feet of TDH.

DESIGN

Each SurePump with Sump Drainer shall be capable of pumping contaminated groundwater for spill recovery, leachate, purge and sampling applications. A transmitter mount shall be welded to the Sump Drainer for liquid level control. The Sump Drainer shall permit the unit to "pump down" to within 4" inches of the wet well bottom without any loss of performance or damage to the pump. External "priming" or "pump down" systems shall not be required nor allowed. The Sump Drainer shall be equipped with a vent valve to assist with the evacuation of air from the Sump Drainer.

MATERIALS

Major components shall be made of 304 SS, seals and bearings are to be made of Teflon™. In addition, all fasteners shall be 304 SS.

CHECK VALVE

Each unit shall include a built-in check valve, with housing and disc of 304 SS and check valve seat of Teflon.

SHAFT

The shaft shall be of 304 stainless steel and rotate on Teflon bearings which are product lubricated.

DIFFUSER CHAMBER

The diffuser chambers for each impeller shall be of 304 stainless steel. Further, they shall be fitted with Teflon impeller seal rings.

IMPELLERS

The impeller(s) shall be closed and consist of 304 stainless steel.

OPTIONS

- Each SurePump will be equipped with an EPG guide-rail or non-guide rail Disconnect System for ease of installation and service.

- Each SurePump will be fitted with __0__ feet of Stainless Steel lifting cable of sufficient strength to raise and lower the pump unit.

- Each SurePump shall be equipped with the EPG LevelMaster™ Liquid Level Sensor system including a submersible level transmitter, chemically resistant leadwire, and digital readout programmable meter.

MOTOR

The motor shall be a submersible, hermetically sealed Franklin motor in either Pollution Recovery or 316 Stainless Steel construction. The motor shall be designed for continuous duty, capable of sustaining up to __100__ starts per day. The motor shall be connected to the pump via a motor adaptor and coupling in 304 stainless steel. Single phase motors shall have thermal protection in the motor windings to protect the windings from overload. The unit will restart automatically after the motor cools down. Three phase motors shall have thermal protection located in the control panel which is to be manually reset.

MOTOR LEADWIRE

The leadwire shall be no-splice with "chemically resistant" or Teflon insulation and be of the length specified above.

WARRANTY

The manufacturer warranties the units against defects in materials and workmanship for a period of twelve(12) months from date of installation, not to exceed 18 months from date of shipment.

LIMITED WARRANTY

This agreement shall be deemed to have been entered into in the State of Minnesota, and shall be construed in accordance with the laws of the State of Minnesota, including Minnesota's enactment of the Uniform Commercial Code. Buyer hereby stipulates and agrees that Hennepin County, Minnesota shall be the proper jurisdiction for adjudicating all claims and controversies arising from this agreement.

Products manufactured by EPG Companies Inc. are warranted for a period of 12 months from date of installation or eighteen(18) months from date of manufacture* to be free from defects of materials and workmanship. It is expressly agreed that the exclusive remedy under this warranty is limited solely to the repair or replacement, at the sole discretion of EPG, of the part that failed. EPG Companies will not be liable for any damage or wear due to abnormal conditions or improper installation.

To have a defective part repaired or replaced, you must return the defective product to EPG Companies. Please call (800)443-7426 or (612) 424-2613 to obtain a Return Goods Authorization (RGA) number. Send defective product (freight prepaid) with RGA #, description of installation, installation data and failure date to EPG Companies Inc., 9060 Zachary Lane North, Suite 115, Maple Grove, MN 55369.

EPG Companies will not be held liable for any incidental or consequential damages, losses or expenses incurred from installation, use or any other reason. THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF EITHER FITNESS FOR A PARTICULAR PURPOSE OR OF MERCHANTABILITY, WHICH EXTEND BEYOND THOSE SPECIFICALLY LISTED HERE.

If equipment is to be stored for a period greater than six months, proper storage precautions must be taken if the warranty is to be maintained. Please call EPG Companies for specific requirements regarding product storage.

The following is a partial list of items which will void the warranty:

- Opening the motor for any reason.
- Using undersized electrical wire.
- Making unauthorized circuit changes. Please call EPG Companies before making any changes.
- Operating a three phase submersible motor from single phase power through a phase converter unless 3-leg ambient-compensated quick trip overload protectors are used and complete details are sent in writing to EPG Companies.

* To qualify for the delayed installation warranty you must contact EPG Companies Inc., at (800)443-7426 or (612) 424-2613 within 60 days of purchase.

You Need To Know...

The 1Ø submersible motor used by EPG Companies with their SurePumps™ is a three wire capacitor start motor.

When power is applied to a capacitor-start motor, the capacitor in the start winding causes the field in the start winding to reach a peak at a time different from the field set up by the main winding. As a result, a two phase rotating magnetic field is created to produce starting torque.

When the motor reaches three quarter speed a voltage or current relay cuts out the starting winding with capacitor and the motor operates as an induction motor. The motor usually takes about one second to reach full operating speed. Even in larger horsepower motors , it rarely takes longer than three seconds to reach full speed.

The capacitor-start motor provides high starting torque (ranging from 225 to 400 per cent of full load torque) and draws lower starting current than a split phase (2 wire) motor. The capacitor-start motor is ideally suited for the variety of applications which the SurePump was designed.

These motors require three wires to be run from the start winding controller (Red - start winding, Yellow- common, Black- run winding) to operate and a fourth wire (Green- ground) to meet the requirements of the 1990 Electrical Code grounding requirements.

EPG Companies Inc.

Materials of Construction: **EPG SurePump™**

	STANDARD	SPECIAL ORDER
Check Valve Housing	304 Stainless Steel	316 Stainless Steel
Check Valve	304 Stainless Steel	316 Stainless Steel
Check Valve Seat	Teflon	Teflon
Diffuser Chamber	304 Stainless Steel	316 Stainless Steel
Impeller Seal Ring	Teflon	Teflon
Impeller	304 Stainless Steel	316 Stainless Steel
Motor Adaptor	304 Stainless Steel	316 Stainless Steel
Inlet Screen	304 Stainless Steel	316 Stainless Steel
Pump Shaft	304 Stainless Steel	316 Stainless Steel
Coupling	329/420/431 Stainless Steel	329/420/431 Stainless Steel
Fasteners	304 Stainless Steel	316 Stainless Steel
Bearings	Teflon	Teflon

Materials of Construction: **FRANKLIN POLLUTION RECOVERY MOTORS**

1/3 to 2 HORSEPOWER	STANDARD	STAINLESS STEEL
End Bell Castings	304 Stainless Steel over Iron	316 Stainless Steel
Stator Shell	201 Stainless Steel	316 Stainless Steel
Shaft Extention	303 Stainless Steel	17-4 Stainless Steel
Fasteners	316 Stainless Steel	316 Stainless Steel
Seal Cover	Acetal	316 Stainless Steel
Shaft Seal	Viton	Viton
Diaphragm	Viton	Viton
Diaphragm Plate	304 Stainless Steel	316 Stainless Steel
Diaphragm Spring	302 Stainless Steel	17-7 Stainless Steel
Diaphragm Cover	316 Stainless Steel	316 Stainless Steel
Slinger	Viton	Viton
Lead Sleeve	Nickel Plated Brass	316 Stainless Steel
Lead Jam Nut	304 Stainless Steel	316 Stainless Steel
Lead Potting	Epoxy	Epoxy
Lead Bushing	Viton	Viton

3 to 10 HORSEPOWER	NI-RESIST	316 STAINLESS STEEL
End Bell Castings	Ni-Resist Type 1-B	316 Stainless Steel
Stator Shell	316 Stainless Steel	316 Stainless Steel
Shaft Extention	17-4 Stainless Steel	316 Stainless Steel
Fasteners	316 Stainless Steel	17-4 Stainless Steel
Seal Cover	316 Stainless Steel	316 Stainless Steel
Shaft Seal	Viton, Carbon, Ceramic Face Seal	Viton, Carbon, Ceramic Face Seal
Diaphragm	Type 200 Hydrin	Type 200 Hydrin
Diaphragm Plate	304 Stainless Steel	304 Stainless Steel
Diaphragm Spring	302 Stainless Steel	302 Stainless Steel
Diaphragm Cover	316 Stainless Steel	316 Stainless Steel
Slinger	Nitrile Rubber	Nitrile Rubber
Lead Sleeve	316 Stainless Steel	316 Stainless Steel
Lead Potting	Epoxy	Epoxy
Lead Jam Nut	316 Stainless Steel	316 Stainless Steel
Filter	316 Stainless Steel Plug	316 Stainless Steel

Note: Prices Subject to Change Without Notice

APPENDIX B

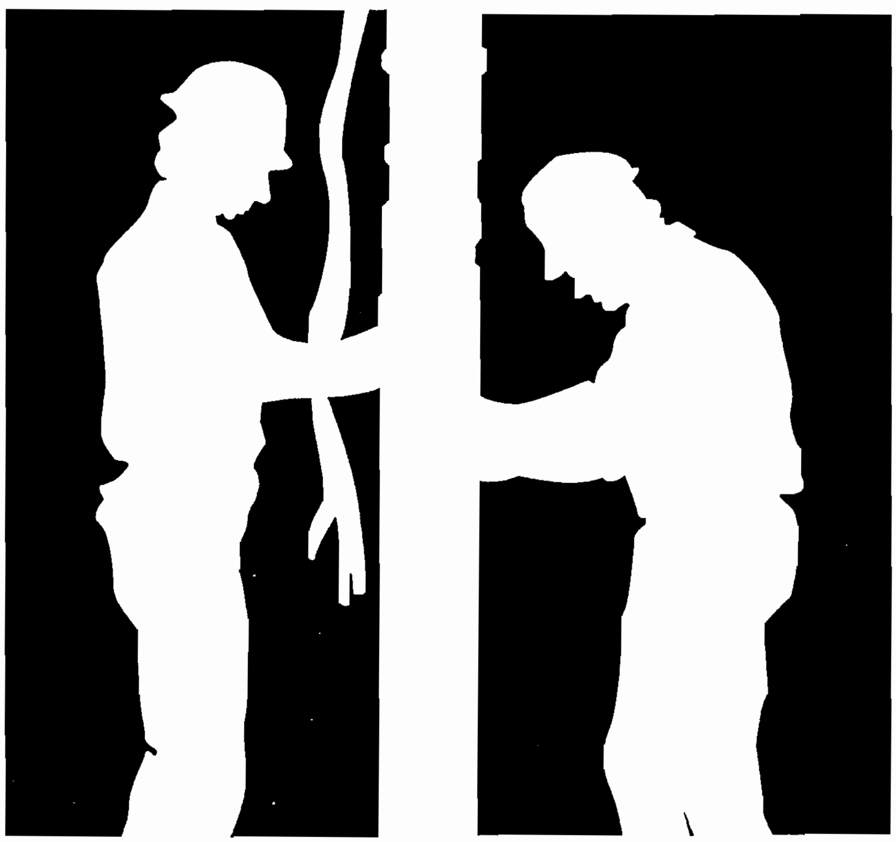
Motor Manufacturer's Literature

SERVICE DATA
PAGE: 263SD
DATE: September 1, 1992
SUPERSEDES: 10/1/88

Submersible Motors

Application ■ Installation ■ Maintenance Manual

Water Well Motors, Single and Three Phase 60HZ, 4", 6" and 8" Diameter



Franklin Electric
QUALITY IN THE WELL

ATTENTION!
IMPORTANT INFORMATION FOR INSTALLERS OF THIS EQUIPMENT!

THIS EQUIPMENT IS INTENDED FOR INSTALLATION BY TECHNICALLY QUALIFIED PERSONNEL. FAILURE TO INSTALL IT IN COMPLIANCE WITH NATIONAL AND LOCAL ELECTRICAL CODES, AND WITH FRANKLIN ELECTRIC RECOMMENDATIONS, MAY RESULT IN ELECTRICAL SHOCK OR FIRE HAZARD, UNSATISFACTORY PERFORMANCE, AND EQUIPMENT FAILURE. FRANKLIN INSTALLATION INFORMATION IS AVAILABLE FROM PUMP MANUFACTURERS AND DISTRIBUTORS, AND DIRECTLY FROM FRANKLIN ELECTRIC. CALL FRANKLIN TOLL FREE 800-348-2420 FOR INFORMATION.

WARNING

SERIOUS OR FATAL ELECTRICAL SHOCK MAY RESULT FROM FAILURE TO CONNECT THE MOTOR, CONTROL ENCLOSURES, METAL PLUMBING, AND ALL OTHER METAL NEAR THE MOTOR OR CABLE, TO THE POWER SUPPLY GROUND TERMINAL USING WIRE NO SMALLER THAN MOTOR CABLE WIRES. TO REDUCE RISK OF ELECTRICAL SHOCK, DISCONNECT POWER BEFORE WORKING ON OR AROUND THE WATER SYSTEM. DO NOT USE MOTOR IN SWIMMING AREAS.

ATTENTION!
INFORMATIONS IMPORTANTES POUR L'INSTALLATEUR DE CET EQUIPEMENT.

CET EQUIPEMENT DOIT ETRE INTALLE PAR UN TECHNICIEN QUALIFIE. SI L'INSTALLATION N'EST PAS CONFORME AUX LOIS NATIONALES OU LOCALES AINSI QU'AUX RECOMMANDATIONS DE FRANKLIN ELECTRIC, UN CHOC ELECTRIQUE, LE FEU, UNE PERFORMANCE NON ACCEPTABLE, VOIRE MEME LE NON-FONCTIONNEMENT PEUVENT SURVENIR. UN GUIDE D'INSTALLATION DE FRANKLIN ELECTRIC EST DISPONIBLE CHEZ LES MANUFACTURIERS DE POMPES, LES DISTRIBUTEURS, OU DIRECTEMENT CHEZ FRANKLIN. POUR DE PLUS AMPLES RENSEIGNEMENTS, APPELEZ SANS FRAIS LE 800-348-2420.

AVERTISSEMENT

UN CHOC ELECTRIQUE SERIEUX OU MEME MORTEL EST POSSIBLE, SI L'ON NEGLIGE DE CONNECTER LE MOTEUR, LA PLOMBERIE METALLIQUE, BOITES DE CONTROLE ET TOUT METAL PROCHE DU MOTEUR A UN CABLE ALLANT VERS UNE ALIMENTATION D'ENERGIE AVEC BORNE DE MISE A LA TERRE UTILISANT AU MOINS LE MEME CALIBRE QUE LES FILS DU MOTEUR. POUR REDUIRE LE RISQUE DE CHOC ELECTRIQUE, COUPER LE COURANT AVANT DE TRAVAILLER PRES OU SUR LE SYSTEM D.EAU. NE PAS UTILISER CE MOTEUR DANS UNE ZONE DE BAIGNADE.

ATENCION!
INFORMACION PARA EL INSTALADOR DE ESTE EQUIPO.

PARA LA INTALACION DE ESTE EQUIPO, SE REQUIERE DE PERSONAL TECNICO CALIFICADO. EL NO CUMPLIR CON LAS NORMAS ELECTRICAS NACIONALES Y LOCALES, ASI COMO CON LAS RECOMENDACIONES DE FRANKLIN ELECTRIC DURANTE SU INSTALACION, PUEDE OCASIONAR, UN CHOQUE ELECTRICO, PELIGRO DE UN INCENDIO, OPERACION DEFECTUOSA E INCLUSO LA DESCOMPOSTURA DEL EQUIPO. LOS MANUALES DE INTALACION Y PUESTA EN MARCHA DE LOS EQUIPOS, ESTAN DISPONIBLES CON LOS DISTRIBUIDORES, FARICATES DE BOMBAS O DIRECTAMENTE CON FRANKLIN ELECTRIC. PUEDE LLAMAR GRATUITAMENTE PARA MAYOR INFORMACION AL TELEFONO 800-348-2420.

ADVERTENCIA

PUEDE OCURRIR UN CHOQUE ELECTRICO, SERIO O FATAL DEBIDO A UNA ERRONEA CONECCION DEL: MOTOR, DE LOS TABLEROS ELECTRICOS, DE LA TUBERIA, DE CUALQUIER OTRA PARTE METALICA QUE ESTA CERCA DEL MOTOR O POR NO UTILIZAR UN CABLE PARA TIERRA DE CALIBRE IGUAL O MAYOR AL DE LA ALIMENTACION. PARA REDUCIR EL RIESGO DE CHOQUE ELECTRIC. DESCONECTAR LA ALIMENTACION ELECTRICA ANTES DE INICIAR A TRABAJAR EN EL SISTEMA HIDRAULICO. NO UTILIZAR ESTE MOTOR EN ALBERCAS O AREAS EN DONDE SE PARATIQUE NATACION.

Submersible Motors

Application ■ Installation ■ Maintenance Manual

The submersible motor is a reliable, efficient and trouble free means of powering a pump. Its needs for a long operation life are simple. They are:

1. A suitable operating environment
2. An adequate supply of electricity
3. An adequate flow of cooling water over the motor

All of the considerations of application, installation and maintenance of submersible motors relate to these three things. The purpose of this manual is to acquaint you with these needs, to help you assure that these needs are being met and to assist and direct you if service or maintenance is ever required.

Contents

Storage

Franklin Electric submersible motors are a water lubricated design. The filling solution consists of a mixture of deionized water and Propylene Glycol, a non-toxic antifreeze. The solution will prevent damage from freezing for temperatures down to -40°F (-40°C). Repeated freezing and thawing should be avoided to prevent possible loss of solution.

There may be an interchange of filling solution with well water during operation. Care must be taken with motors removed from wells during freezing conditions to prevent damage.

When the storage temperature does not exceed 100°F, (37°C.) storage time should be limited to two years. Where temperatures reach 130°F, (54°C.) storage time should be limited to one year.

Loss of a few drops of liquid will not damage the motor as an excess amount is provided, and the filter check valve will allow lost liquid to be replaced by filtered well water upon installation. If there is reason it believe there has been a considerable amount of leakage, consult the factory for checking procedures.

Frequency of Starts

The average number of starts per day over a period of months or years influences the life of a submersible pumping system. Excessive cycling affects the life of control components such as pressure switches, starters, relays and capacitors, plus splines and bearings. Rapid cycling can also cause motor overheating and winding failures.

The pump size, tank size and other controls should be selected to keep the starts per day as low as practical for longest life, based upon the maximum number of starts per 24 hour day, as shown in Table 1.

Motors should be allowed to run a minimum of one minute to dissipate heat build up from starting current.

Table 1 Number of Starts

	Maximum Starts Per 24 Hr. Day	
Motor Rating	Single Phase	Three Phase
Up to 3/4 HP	300	300
1 HP thru 5 HP	100	300
7 1/2 HP thru 30 HP	50	100
40 HP and over		100

Mounting Position

Motors are suitable for operation in mounting positions from vertical shaft up to horizontal. If 4 inch motors thru 2 HP are started more than 10 times per day, it is recommended the shaft be tilted up at 15° from horizontal to minimize coast-down wear of the upthrust washer.

Transformer Capacity Required For Submersible Motors

Single Phase or Three Phase

Distribution transformers must be adequately sized to satisfy the KVA requirements of the submersible motor. When transformers are too small to supply the load, there is a reduction in voltage to the motor.

Table 2 references the motor horsepower rating, single phase and three phase, total effective KVA required, and the smallest transformer required for open or closed three phase systems. Open systems require larger transformers since only two transformers are used.

Other loads would add directly to the KVA sizing requirements of the transformer bank.

Use of Engine Driven Generators

Single Phase or Three Phase

Table 3 lists recommended generator sizes, based on typical 80°C rise continuous duty generators, with 35% maximum voltage dip during starting, for specific Franklin three wire motors, single or three phase.

This chart is conservative and it is recommended the generator manufacturer be consulted whenever possible, especially on larger sizes.

There are two types of generators available, externally and internally regulated. Most are externally regulated. They use an external mounted voltage regulator that senses the output voltage. As the voltage dips at motor start up, the regulator increases the output voltage of the generator.

Internally regulated generators have an extra winding in the generator stator and are also called self excited. The extra winding senses the output current to automatically increase the output voltage.

Generators must be sized to deliver at least 65% of the rated voltage during motor starting to ensure adequate motor starting torque. Besides sizing, generator frequency is all important as the motor speed varies with the frequency (HZ). Due to pump affinity laws a pump running at 1 to 2 HZ below motor nameplate frequency design will not meet its performance curve. Conversely, a pump running at 1 to 2 HZ above may trip overloads.

Generator Operation. Always start the generator before the motor is started, and always stop the motor before the generator is shut down. The motor thrust bearing may be damaged when generators are allowed to coast down with the motor connected. This same condition occurs when generators are allowed to run out of fuel.

Follow generator manufacturer's recommendations for derating at higher elevations or using natural gas.

WARNING: To prevent accidental electrocution, automatic or manual transfer switches must be used any time a generator is used as standby or back up on power lines. Contact power company for use and approval.

Table 2 TRANSFORMER CAPACITY

Motor HP	Total Effective KVA Required	Smallest KVA Rating - Each Transformer: Open WYE or DELTA 2 Transformers	Smallest KVA Rating - Each Transformer: WYE or DELTA 3 Transformers
1.5	3	2	1
2	4	2	1.5
3	5	3	2
5	7.5	5	3
7.5	10	7.5	5
10	15	10	5
15	20	15	7.5
20	25	15	10
25	30	20	10
30	40	25	15
40	50	30	20
50	60	35	20
60	75	40	25
75	90	50	30
100	120	65	40
125	150	85	50
150	175	100	60
175	200	115	70
200	230	130	75

Table 3 ENGINE DRIVEN GENERATORS

Motor HP	Minimum Rating of Generator: Externally Regulated		Internally Regulated	
	KW	KVA	KW	KVA
1/3	1.5	1.9	1.2	1.5
1/2	2.0	2.5	1.5	1.9
3/4	3.0	3.8	2.0	2.5
1	4.0	5.0	2.5	3.13
11/2	5.0	6.25	3.0	3.8
2	7.5	9.4	4.0	5.0
3	10.0	12.5	5.0	6.25
5	15.0	18.75	7.5	9.4
71/2	20.0	25.0	10.0	12.5
10	30.0	37.5	15.0	18.75
15	40.0	50.0	20.0	25.0
20	60.0	75.0	25.0	31.0
25	75.0	94.0	30.0	37.5
30	100.0	125.0	40.0	50.0
40	100.0	125.0	50.0	62.5
50	150.0	188.0	60.0	75.0
60	175.0	220.0	75.0	94.0
75	250.0	313.0	100.0	125.0
100	300.0	375.0	150.0	188.0
125	375.0	469.0	175.0	219.0
150	450.0	563.0	200.0	250.0
175	525.0	656.0	250.0	313.0
200	600.0	750.0	275.0	344.0

NOTE: FOR BEST STARTING OF TWO-WIRE MOTORS MINIMUM GENERATOR RATINGS 50% HIGHER THAN SHOWN ARE RECOMMENDED.

Use of Check Valves

It is recommended that one or more check valves always be used in submersible pump installations. A line check valve, if the pump does not have a built-in check valve, should be installed in the discharge line within 25 feet of the pump and below the drawdown level of the water supply. For deeper settings, it is recommended that a line check valve be installed every 200 feet.

Swing type check valves should never be used with submersible pumps. When the pump stops, there is a sudden reversal of flow before the swing check closes, causing a sudden change in the velocity of the water. Spring loaded check valves should be used as they are designed to close quickly as the water flow stops and before it begins to move in the reverse direction. There is little or no velocity of flow when the spring loaded valve closes and no hydraulic shock or water hammer is produced by the closing of the valve.

Check valves are used to hold pressure in the system when the pump stops.They are also used to prevent backspin, waterhammer and upthrust. Any of these three or a combination of them can lead to immediate pump or motor failure, a shortended service life or operating problems in the system

A. **Backspin** - with no check valve or if the check valve fails, the water in the drop pipe and the water in the system can flow back down the discharge pipe when the motor stops. This can cause the pump to rotate in a reverse direction as the water flows back down the pipe. If the motor is started while this is happening, a heavy strain may be placed across the pump-motor assembly. It can also cause excessive thrust bearing wear because the motor is not turning fast enough to ensure an adequate film of water in the thrust bearing.

B. **Upthrust** - with no check valve, or with a leaking check valve, the unit starts each time under zero head conditions. With most pumps, this causes an uplifting or upthrust on the impellers-shaft assembly in the pump. This upward movement carries across the pump-motor coupling and creates an upthrust condition in the motor. Repeated upthrust at each start can cause premature wear and failure of either or both the pump and the motor.

C. **Water Hammer** - If the lowest check valve is more than 30 feet above the standing water level or the lower check valve leaks and the check valve above holds, a partial vacuum is created in the discharge piping. On the next pump start, water moving at very high velocity fills the void and strikes the closed check valve and the stationary water in the pipe above it, causing a hydraulic shock. This shock can split pipes, break joints and damage the pump and/or motor. Water hammer is an easily detected noise. When discovered, the system should be shut down and the pump installer contacted to correct the problem.

Wells-Large Diameter, Uncased Top feeding & Screened Sections

Franklin Electric submersible motors are designed to operate with a cooling flow of water over the motor.

If the pump installation does not ensure at least the minimum flow shown in table 5, a flow inducer sleeve as shown in fig. 1 must be used. Some conditions requiring a flow sleeve are:

- Well diameter is too large to meet Table 5 flow requirements
- Pump is in an open body of water.
- Pump is in a rock well or below the end of the well casing
- The well is "top-feeding"
- Pump is set in or below any part of screens or perforations.

Effects of Torque

During the starting of a submersible pump, the torque developed by the motor must be supported through the pump, delivery pipe or other supports. Most pumps rotate in the direction which causes unscrewing torque on right hand threaded pipe or pump stages. All threaded joints, pumps and other parts of the pump support system must be capable of withstanding the maximum torque repeatedly without loosening or breaking. Unscrewing joints will break the electrical cable and may cause loss of the pump-motor unit.

To safely withstand maximum unscrewing torques with a minimum safety factor of 1.5, tightening all threaded joints to at least 10lb. ft per motor horsepower is recommended. It may be necessary to tack or strap weld pipe joints on high horsepower pumps, especially at shallower settings.

Table 4 Torque Required (Examples)

Motor H.P. Rating	x 10 Lb. Ft.	Minimum Safe Torque-Load
1 HP & Less	1 x10	10 Lb. Ft.
20 HP	20 x10	200 Lb. Ft.
75 HP	75 x10	750 Lb. Ft.
200 HP	200 x10	2,000 Lb. Ft.

Water Temperature and Flow

Franklin Electric submersible motors are designed to operate with loading up to maximum service factor horsepower in water up to 86 degrees F (30°C) with a water flow past the motor of 0.25 ft/sec for 4" motors and 0.5 ft/sec for 6 & 8 inch motors. Table 5 shows minimum flow rates, in GPM, for various well diameters and motor sizes.

If the motors are operated in water over 86 degrees F (30°C), water flow past the motor and/or the motor horsepower must be increased to maintain safe motor operating temperatures as shown in HOT WATER APPLICATIONS on page 6.

Table 5 Required Cooling Flow

Minimum GPM required for motor cooling in water up to 86°F (30°C).

Inches Casing or Sleeve I.D.	4" Motor .25 ft/sec GPM	6" Motor .5 ft/sec GPM	8" Motor .5 ft/sec GPM
4	1.2	—	—
5	7	—	—
6	13	9	—
7	20	25	—
8	30	45	10
10	50	90	55
12	80	140	110
14	110	200	170
16	150	280	245

.25 ft/sec = 7.62 cm/sec
.50 ft/sec = 15.24 cm/sec
1 inch = 2.54 cm

Flow Inducer Sleeve

If the flow rate is less than specified or coming from above the pump, then a flow inducer sleeve must be added for motor cooling. A flow sleeve is always required in an open body of water. FIG 1. shows a typical flow inducer sleeve construction.

Example: A six-inch motor and pump that delivers 60 GPM will be installed in a 10" well. 90 GPM past the motor is required in a 10" I.D. well. An 8" or smaller sleeve must be added to the pump to provide a cooling flow of water past the motor.

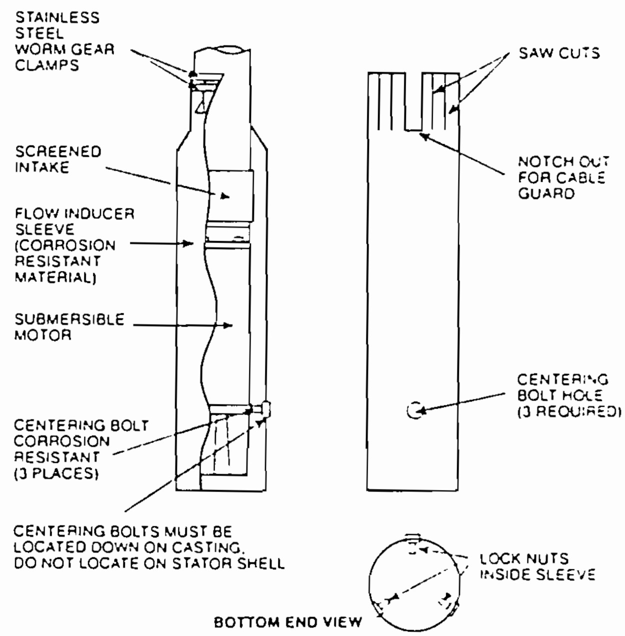


FIG 1

Head Loss From Flow Past Motor

The following lists the approximate feet of head loss from flow between an average length motor and smooth casing or flow inducer sleeve.

Table 6 Head Loss Past Motor

Motor (Nominal)		4"	4"	4"	6"	6"	6"	8"	8"
Casing I.D. Inches		4"	5"	6"	6"	7"	8"	8.1"	10"
GPM	25	1.9							
	50	6.3							
	100	21.0	0.3		1.7				
	150		0.6	0.2	3.7				
	200		1.1	0.4	6.3	0.5		6.8	
	250		1.8	0.7	9.6	0.8		10.4	
	300		2.5	1.0	13.6	1.2	0.2	14.6	
	400				23.7	2.0	0.4	24.6	
	500					3.1	0.7	37.3	0.6
	600					4.4	1.0	52.2	0.8
	800								1.5
	1000								2.4

1" = 25.4 millimeters

Hot Water Applications

When the pump-motor operates in water hotter than 86°F (30°C), the best motor cooling and most economical motor result when a flow rate of at least 3 ft/sec is provided.

When selecting the correct motor to drive a pump at elevated water temperatures, and 3 ft/sec the flow rate pump horsepower required and water temperature must be used with a heat factor multiplier to calculate the rated HP motor needed.

1. The flow past the motor must be a minimum of 3 ft/second. Using Chart A, determine pump GPM delivery required for different well or sleeve diameters and motor sizes. If necessary, add a flow sleeve to obtain at least 3 ft/sec flow rate.

Chart A — Minimum GPM Required to Obtain 3ft/sec Flow Rate

Inches Casing or Sleeve I.D.	4" Motor GPM	6" Motor GPM	8" Motor GPM
4	15	—	—
5	85	—	—
6	155	80	—
7	—	180	—
8	—	270	60
10	—	510	330
12	—	—	660
14	—	—	1020
16	—	—	1440

2. Determine pump horsepower required from the pump manufacturer's curve.

See Manufacturer's Pump Curve

FIG 2

3. Multiply the pump horsepower required by the heat factor multiplier from Chart B.

Chart B — Heat Factor Multiplier at 3 ft/sec Flow Rate

Maximum Water Temp	1/3 — 5 HP	7 1/2 — 30 HP	Over 30 HP
140°F (60°C)	1.25	1.62	2.00
131°F (55°C)	1.11	1.32	1.62
122°F (50°C)	1.0	1.14	1.32
113°F (45°C)	1.0	1.0	1.14
104°F (40°C)	1.0	1.0	1.0
95°F (35°C)	1.0	1.0	1.0

4. Select a rated HP motor on Chart C whose SFHP is at least the value calculated in Item 3.

Chart C — Service Factor Horsepower

HP	SFHP	HP	SFHP	HP	SFHP	HP	SFHP
1/3	.58	3	3.45	25	27.5	100	115.0
1/2	.8	5	5.75	30	34.5	125	143.75
3/4	1.12	7 1/2	8.65	40	46.0	150	172.50
1	1.40	10	11.5	50	57.5	175	201.25
1 1/2	1.95	15	17.25	60	69.0	200	230.00
2	2.50	20	23.0	75	86.25		

Hot Water Applications - Example

EXAMPLE: A 6" pump end requiring 39 HP input will pump 124°F water in an 8" well at a delivery rate of 140 GPM. From Chart A, a 6" flow sleeve will be required to increase the flow rate to at least 3ft/sec.

Using Chart B, the 1.62 heat factor multiplier is selected because the HP required is over 30 HP and water temperature above 122°F. Multiply 39 x 1.62 which equals 63.2. This is the minimum service factor horsepower motor which is usable at 39 HP in 124°F water. Using Chart C, select a motor with a service factor horsepower above 63.2. A 60 HP motor has a service factor horsepower of 69, so a 60 HP motor may safely be used.

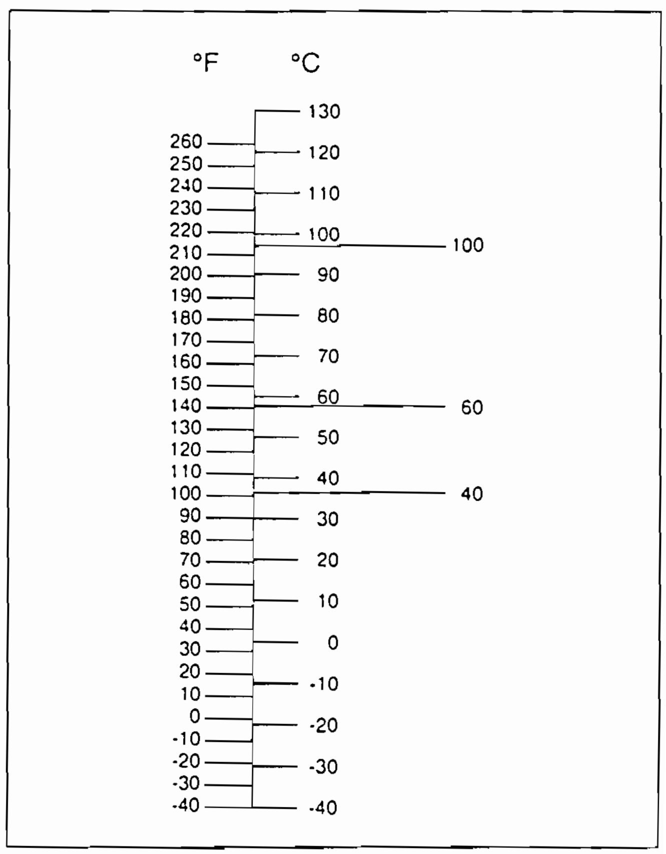


FIG 3 Temperature Conversion

Grounding Control Boxes and Panels

The National Electrical Code requires that the control box or panel grounding terminal always be connected to circuits which include a grounding conductor. If the circuit has no grounding conductor and no metal conduit from the box to supply panel, use a wire at least as large as line conductors and connect as required by the NEC, from the grounding terminal to the electrical supply ground.

WARNING: Failure to ground the control frame can result in a serious electrical shock hazard if a circuit fault occurs.

Grounding lightning arrestors

An above ground lightning arrestor must be grounded, metal to metal, all the way to the water strata for the lightning arrestor to be effective. GROUNDING THE ARRESTOR TO THE SUPPLY GROUND OR TO A DRIVEN GROUND ROD PROVIDES LITTLE OR NO PROTECTION FOR THE MOTOR.

In some areas, electrical codes require a ground wire from a submersible motor to the panel and supply ground. This provides maximum protection with aboveground arrestors. In locations where this ground wire is not required by code, there are three acceptable ways of grounding above ground lightning arrestors:

1. When metallic well casing extends within at most 20 feet of the motor, the arrestor should be grounded to the well casing with a no. 12 or larger wire. See Figure 4.

2. If the well casing is plastic or terminates more than 20 feet above the motor, and metal drop pipe is used, then the best available protection is provided by grounding the arrestor to the metal drop pipe. See Figure 5. If the pump is electrically insulated from the motor as it would be with a nonmetallic pump adaptor bracket, then a wire should connect the drop pipe to the motor studs. See Figure 6.

3. If the well casing is nonmetallic or terminates more than 20 feet above the motor and nonmetallic drop pipe is used, then protection is only provided when the arrestor is grounded to a No. 12 or larger bare copper wire run with the power cable to the motor and connected to a motor stud. This wire should also connect to the top of the well casing if metallic. See Figure 7.

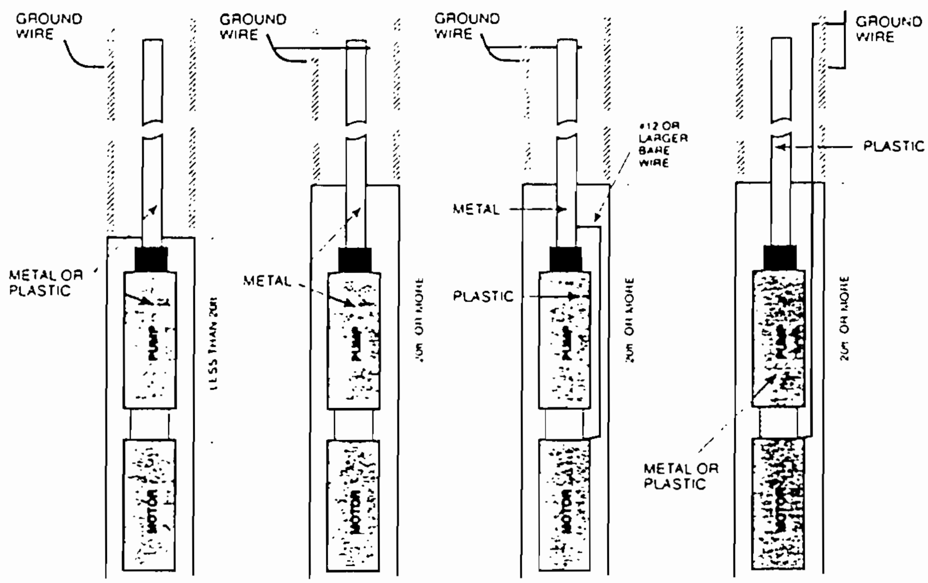


FIG 4 FIG 5 FIG 6 FIG 7

Control Box and Panel Environment

Franklin Electric control boxes meet U.L. requirements for Type 3R enclosures. They are suitable for indoor and outdoor applications within temperatures of +14°F. (-10°C) to 122°F. (50°C). Operating control boxes below +14° F can cause reduced starting torque and loss of overload protection when overloads are located in control boxes. During coldest weather, temperature may be kept above +14° F by having an enclosure around the control box and using heat tape or a small light bulb in the enclosure as a heat source.

Control boxes and panels should never be mounted in direct sunlight or high temperature locations as this will cause shortened capacitor life and unnecessary tripping of overload protectors. A ventilated enclosure painted white to reflect heat is recommended for outdoor high temperature locations.

The worst place to mount a control box is in a damp well pit, or other humid location, as this accelerates component failure from voltage breakdown and corrosion.

Control boxes with voltage relays are designed for vertical upright mounting only. Mounting in other positions will affect the operation of the relay.

3-Wire Control Boxes

Single phase three wire submersible motors require the use of above ground control boxes. Operation of motors without control boxes or with incorrect boxes can result in failure of motors and voids warranty.

Control boxes contain starting capacitors, starting relay, and in some sizes overload protector and running capacitors.

Ratings through 1 HP may use either a solid state, current or a potential (voltage) type starting relay, while larger ratings use potential relays.

CAUTION:
Be certain that control box HP and voltage match the motor.

Potential (Voltage) Relays —

Before the power is applied the starting relay contacts are closed. When the power is applied, both start and main motor windings are energized, and the motor starts. At this instant the voltage across the start winding is relatively low, not enough to open the contacts of the starting relay.

As the motor comes up to speed, the voltage across the start winding (and the starting relay coil) increases enough to pick up the starting relay and open its contacts. This opens the starting circuit and the motor continues to run on the main winding alone, or the main plus running capacitor circuit and the relay contacts remain open.

Current Relays —

Before power is applied the starting relay contacts are open. When power is applied the high main winding current through the relay coil immediately closes the contacts, energizing the start winding and starting the motor. As the motor comes up to running speed, current through the relay coil gradually drops and allows the contacts to open the start winding circuit, and the motor completes acceleration and runs on the main winding.

Solid State Relays

There are two simple elements in the solid state starting relay, a reed switch and a triac. The reed switch consists of two tiny rectangular blade-type contacts which bend under magnetic flux. It is hermetically sealed in glass and is located within a coil which conducts line current. When power is supplied to the control box, the high main winding current through the coil immediately closes the reed switch contacts. This turns on the triac, which supplies voltage to the start winding, thus starting the motor.

Once the motor is started, the operation of the solid state relay is a complex interaction between the triac, the reed switch and the motor windings. Basically, the solid state switch senses motor speed by means of the changing phase relationship between start winding current and line current. As the motor approaches running speed, the phase angle between the sine wave of the start current and the sine wave of the line current become nearly in-phase. At this point, the reed switch contacts open, turning off the triac. This removes voltage from the start winding and the motor continues to run on the main winding only. With the reed switch contacts open and the triac turned off, the solid state relay is ready for the next starting cycle.

2-Wire Motor Solid State Controls

BIAC Switch Operation

When power is applied to the two motor leads the bi-metal switch contacts are closed so the triac is conducting. This allows current to pass through the start winding, thus starting the motor. The Biac switch responds to voltage from a sensor coil located inside the motor. This sensor coil voltage is proportional to motor RPM. As RPM increases the increased voltage in the sensor coil generates heat in one of the two bi-metal strips, causing this bi-metal strip to bend away from the other bi-metal strip, thus opening the switch circuit. This removes the starting winding current and the motor continues to run on the main winding alone.

Approximately 1 to 3 seconds after power is removed from the motor, the bi-metal strip cools sufficiently to return to its upright position, reclose the contacts, and the motor is ready for the next start cycle. If, during operation, the motor speed drops for some reason, the lowered voltage in the sensor coil allows the bi-metal contacts to re-close, supplying start winding current to bring the motor back to operating speed.

Extreme Fast Cycling (Due to Water-Logged Tank)

The Biac starting switch will reset within one to three seconds after the motor is stopped. If an attempt is made to restart the motor before the starting switch has reset, the motor may not start; however, there will be current flow through the main winding until the overload protector interrupts the circuit. The time for the protector to reset is longer than the reset of the starting switch. Therefore, the start winding switch will have closed and the motor will operate. The repeated on-off cycle will continue until the overload again trips out.

When a severely water-logged condition does occur, the user will be alerted to the problem during the off time (overload reset time) since the pressure will drop drastically. When the water-logged tank condition is detected the condition should be corrected to prevent nuisance tripping of the overload protector.

Bound Pump (Sandlocked)

When the motor is not free to turn, as with a sandlocked pump, the Biac switch creates a "reverse impact torque" in the motor in either direction. When the sand is dislodged, the motor will start and operate in the correct direction.

Two or Three Wire Cable, 60 HZ
(Service Entrance to Motor - Maximum Length In Feet)

Table 7

Motor Rating		AWG Copper Wire Size												
Volts	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**3**	**2**	**1**	**0**	**00**	**000**	**0000**
115	1/3	130	210	340	540	840	1300	1610	1960	2390	2910	3540	4210	5060
	1/2	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/3	550	880	1390	2190	3400	5250	6520	7960	9690	11770			
	1/2	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870		
	1	250	400	630	990	1540	2380	2960	3610	4410	5360	6520		
	1.5	190	310	480	770	1200	1870	2320	2850	3500	4280	5240		
	2	150	250	390	620	970	1530	1910	2360	2930	3620	4480		
	3	120*	190	300	470	750	1190	1490	1850	2320	2890	3610		
	5	0	0	180	280	450	710	890	1110	1390	1740	2170	2680	
	7.5	0	0	120*	200	310	490	610	750	930	1140	1410	1720	
	10	0	0	0	160*	250	390	490	600	750	930	1160	1430	1760
	15.0	0	0	0	0	170*	270	340	430	530	660	820	1020	1260

1 Foot = .3048 Meter

Lengths without the asterisk * meet the U.S. National Electrical Code ampacity for either individual conductors or jacketed 75°C cable.

Lengths marked * meet the NEC ampacity only for individual conductor 75°C cable in free air or water, not in conduit.

Flat molded cable is considered to be jacketed cable.

This table is based on copper wire. If aluminum wire is to be used; it must be two sizes larger. Example: If the table calls for #12 copper wire, #10 aluminum wire would be required.

Single phase control boxes may be connected at any point of the total cable length.

CAUTION—Use of wire size smaller than listed will void warranty.

Two different cable sizes can be used.

The example below is for reference. Depending on the installation, any number of combinations may be used, as long as the total percentage length of the two cables used does not exceed 100%. This is to insure that adequate voltage will be supplied to the motor.

EXAMPLE: 3 HP, 230 Volt, 1 PH Motor

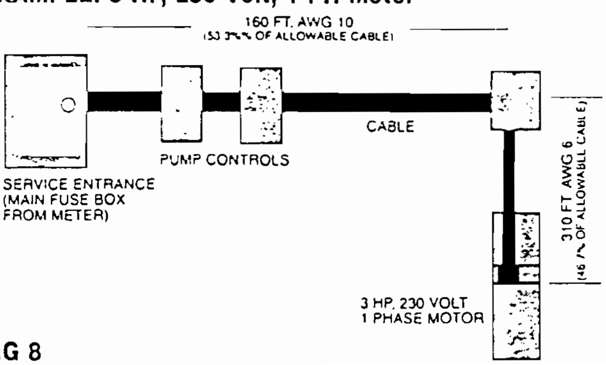


FIG 8

In a replacement installation, the well already has 160 feet of buried #10 cable between the service entrance and the well head. The question is: What size cable is required in the well with a 3 HP, 230 volt, 1 PH motor setting at 310 feet?

1. According to the table #10 cable is large enough for the 3 HP motor so the percent of the maximum allowable cable used by the 160-foot run is 160 ÷ 300 = 53.3%, since 300 feet is the total allowable.

2. With 53.3% of the total allowable cable already used between the service entrance and the well head, only 46.7% is left for the well. Therefore, the 310 feet needed in the well can only utilize 46.7% of the total feet allowed in the table.

3. From the table, 46.7% of the 470 feet for #8 cable equals only 220 feet, so a larger size is needed. For #6, 46.7% of 750 feet = 350 feet. As a result, #6 can be used for the 310 feet in the well.

Table 8 Single Phase Motor Specifications (60 Hertz)

Type	Motor Model Prefix					Rated Input		Maximum (S.F. Load)		(1) Line to Line	Efficiency %			Power Factor %			Locked Rotor	KVA	Circuit Breaker or Fuse AMPS	
		HP	Volts	HZ	S.F.	(2) Amps	Watts	(2) Amps	Watts	Res. M = Main S = Start	S.F.	F.L.	3/4	S.F.	F.L.	3/4	Amps	Code	Std.	Delay
4 Inch Two Wire	2445020	1/3	115	60	1.75	8.0	480	9.2	780	1.4-1.8	60.0	51.0	44.8	71.0	53.5	46.5	48.4	S	25	10
	2445030	1/3	230	60	1.75	4.0	480	4.6	780	6.0-7.4	60.0	51.0	44.8	71.0	53.5	46.5	24.2	S	15	5
	2445040	1/2	115	60	1.60	10.0	680	12.0	1050	1.0-1.3	61.5	55.0	48.8	72.5	57.5	49.7	64.8	R	30	15
	2445050	1/2	230	60	1.60	5.0	680	6.0	1050	4.2-5.2	61.5	55.0	48.8	72.5	57.5	49.7	32.4	R	15	7
	2445070	3/4	230	60	1.50	7.2	950	8.4	1500	3.0-3.6	63.5	59.0	53.2	74.0	61.5	53.2	40.7	N	25	10
	2445081	1	230	60	1.40	8.2	1200	9.8	1700	2.2-2.7	65.0	62.2	57.4	74.0	62.5	53.5	48.7	N	25	12
	2445091	1 1/2	230	60	1.30	10.6	1780	13.1	2400	1.5-1.9	65.0	62.8	59.4	79.7	74.2	66.1	56.8	L	35	15
4 Inch Three Wire	2145024	1/3	115	60	1.75	Y8.0 B8.0 R 0	480	Y9.2 B9.2 R0	780	1.4-1.8M 6.5-7.9S	60.0	51.0	44.8	71.0	53.5	46.5	34.8	N	25	10
	2145034	1/3	230	60	1.75	Y4.0 B4.0 R0	480	Y4.6 B4.6 R 0	780	6.0-7.4M 26.1-32.S	60.0	51.0	44.8	71.0	53.5	46.5	17.2	N	15	5
	2145044	1/2	115	60	1.60	Y10.0 B10.0 R0	680	Y12.0 B112.0 R0	1050	1.0-1.3M 4.1-5.1S	61.5	55.0	48.8	72.5	57.5	49.7	50.5	M	30	15
	2145054	1/2	230	60	1.60	Y5.0 B5.0 R0	680	Y6.0 B6.0 R0	1050	4.2-5.2M 16.7-20.5 S	61.5	55.0	48.8	72.5	57.5	49.7	23.0	M	15	7
	2145074	3/4	230	60	1.50	Y7.2 B7.2 R0	950	Y8.4 B8.4 R0	1500	3.0-3.6M 11.0-13.4S	63.5	59.0	53.2	74.0	61.5	53.2	34.2	M	25	10
	2145081	1	230	60	1.40	Y8.2 B8.2 R0	1200	Y9.8 B9.8 R0	1700	2.2-2.7M 10.1-12.3S	65.0	62.2	57.4	74.0	62.5	53.5	41.8	L	25	12
4 Inch 3 Wire W-Run Cap	2243001	1 1/2	230	60	1.30	Y10.0 B9.9 R1.3	1700	Y11.6 B11.0 R1.3	2150	1.5-2.3M 6.2-12.0S	67.9	66.0	62.0	81.4	74.4	66.1	52.8	J	30	15
	2243011	2	230	60	1.25	Y10.0 B9.3 R2.6	2100	Y13.2 B11.9 R 2.6	2750	1.6-2.3M 52-7.15S	70.0	71.0	68.8	93.1	90.5	86.7	51.0	G	30	15
	2243007	1 1/2	230	60	1.30	Y10.0 B9.9 R1.3	1700	Y11.6 B11.0 R1.3	2150	1.5-2.3M 6.2-12.0S	67.9	66.0	62.0	81.4	74.4	66.1	52.8	J	30	15
	2243017	2	230	60	1.25	Y10.0 B9.3 R2.6	2100	Y13.2 B12.0 R2.6	2800	1.6-2.3M 5.2-7.15S	70.0	71.0	68.8	93.1	90.5	86.7	51.0	G	30	15
	2243027	3	230	60	1.15	Y14.0 B12.2 R4.7	3150	Y17.0 B14.5 R4.5	3700	.9-1.5M 3.0-4.9S	70.9	71.8	69.6	98.0	97.5	96.0	71.0	F	45	20
	2243037	5	230	60	1.15	Y23.0 B19.1 R8.0	5200	Y27.5 B23.2 R7.8	6100	.68-1.0M 2.1-2.8S	71.1	71.9	70.0	97.5	96.4	94.0	118.0	F	70	30
6 Inch	2261109	5	230	60	1.15	Y23.0 B18.2 R8.0	5000	Y27.5 B23.2 R7.8	5700	.55-.68M 1.3-1.6S	75.8	75.0	72.2	98.0	98.3	98.5	99.0	E	70	30
	2261119	7 1/2	230	60	1.15	Y36.5 B34.4 R5.5	7300	Y42.0 B40.5 R5.4	8800	.36-.50M .92-1.2S	73.4	74.4	74.2	91.0	90.4	87.2	165.0	F	100	45
	2261129	10	230	60	1.15	Y45.0 B39.5 R9.3	9800	Y51.0 B47.5 R8.9	11300	.27-.33M .80-.99S	76.2	76.8	76.3	95.8	95.8	95.3	204.0	E	150	60
	2261139	15	230	60	1.15	Y62.0 B52.0 R17.5	13900	Y72.0 B62.5 R16.9	17500	.17-.22M .68-.93S	79.4	80.3	79.7	97.3	97.9	98.2	303.0	E	200	80

(2) Y = Yellow lead, line amps

Auxiliary Running Capacitors for Noisy Installations

The addition of auxiliary running capacitors as a method of reducing noise in submersible installations is not reliable in all cases, but in some installations does reduce the noise to an acceptable level. In some cases, there is space in the control box to add an additional running capacitor or capacitors. In others, there is not room and the additional capacitor(s) should be mounted in an auxiliary box and used in conjunction with the regular control box.

Added capacitors must be connected across "Red" and "Black" control box terminals, in parallel with any existing running capacitors. Given below are the values of additional running capacitors most likely to reduce noise in cases where it may be a problem. The tabulation also gives the running capacitors originally supplied in each rating control box and the S.F. amps normally in each lead with the added capacitor.

Table 9 Auxiliary Capacitor Sizing

Motor Rating		Normal Running Capacitor(s) Mfd.	Auxiliary Running Capacitors For Noise Reduction			S.F. Amps (with Run Cap)		
HP	Volts		Mfd.	Min. Volts	Franklin Part	Yellow	Black	Red
1/3	115	0	45(1)	370	One 155327109	6.3	5.3	2.9
1/2	115	0	60(1)	240	Two 155328108	8.4	7.0	4.0
1/3	230	0	10(1)	370	One 155328102	3.3	3.1	1.2
1/2	230	0	15(1)	370	One 155328101	4.2	3.5	2.0
3/4	230	0	20(1)	370	One 155328103	5.8	5.0	2.5
1	230	0	25(1)	370	One ea. 155328101 155328102	7.1	5.6	3.4
1.5	230	10	20	370	One 155328103	9.3	7.5	4.4
2	230	20	10	370	One 155328102	11.2	9.2	3.8
3	230	35	10	370	One 155328102	16.1	13.0	5.9
	230	60	None			27.5	23.2	7.8
7.5	230	45	45	370	One ea. 155327101 155328101	37	32	11.3
10	230	75	30	370	One 155327101	49	42	13
15	230	135	None			72	62.5	16.9

(1) Do not add running capacitors to standard production 1/3 through 1 HP control boxes which use current relays or solid state starting switches! Adding capacitors will cause switch failure. If the control box is converted to use a voltage relay, the specified running capacitance can be added.

Buck-Boost Transformers

When the available power supply voltage is not within the proper range for a standard or available motor, a buck-boost transformer is often used to adjust voltage to match the motor. While tables to give a wide range of voltage boost or buck are published by transformer manufacturers, the following table shows Franklin recommendations for the most common usage on submersible motors, boosting a 208 volt supply to use a standard 230 volt single phase submersible motor and control. The table, based on boosting the voltage 10%, shows the minimum rated transformer KVA needed to supply the 10% boost, and the common standard transformer KVA.

Table 10 Buck-Boost Transformer Sizing

Motor HP	1/3	1/2	3/4	1	1.5	2	3	5	7.5	10	15
Load KVA	1.02	1.36	1.84	2.21	2.65	3.04	3.91	6.33	9.66	11.7	16.6
MIN XFMR KVA	.11	.14	.19	.22	.27	.31	.40	.64	.97	1.2	1.7
STD XFMR KVA	.25	.25	.25	.25	.50	.50	.50	.75	1.0	1.5	2.0

Buck-Boost transformers are power transformers not control transformers. They may also be used to lower voltage when the available power supply voltage is too high.

Application Three Phase Motors

Table 11 Three Phase Cable, 60 Hz (Service Entrance to Motor) Maximum Length In Feet

Motor Rating		AWG Copper Wire Size																	
Volts	HP	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
230V	1/2	710	1140	1800	2840	4420													
60 Hz	3/4	510	810	1280	2030	3160													
Three Phase	1	430	690	1080	1710	2670	4140	5140											
Three Wire	1.5	310	500	790	1260	1960	3050	3780											
	2	240	390	610	970	1520	2360	2940	3610	4430	5420								
	3	180	290	470	740	1160	1810	2250	2760	3390	4130								
	5	110*	170	280	440	690	1080	1350	1660	2040	2490	3050	3670	4440	5030				
	7.5	0	0	200	310	490	770	960	1180	1450	1770	2170	2600	3150	3560				
	10	0	0	150*	230	370	570	720	880	1090	1330	1640	1970	2390	2720	3100	3480	3800	4420
	15	0	0	0	160*	250	390	490	600	740	910	1110	1340	1630	1850	2100	2350	2570	2980
	20	0	0	0	0	190*	300	380	460	570	700	860	1050	1270	1440	1650	1850	2020	2360
	25	0	0	0	0	0	240*	300	370	460	570	700	840	1030	1170	1330	1500	1640	1900
	30	0	0	0	0	0	200*	250*	310	380	470	580	700	850	970	1110	1250	1360	1590
230V	1/2	930	1490	2350	3700	5760	8910												
60 Hz	3/4	670	1080	1700	2580	4190	6490	8060	9860										
Three Phase	1	560	910	1430	2260	3520	5460	6780	8290										
Three Wire	1.5	420	670	1060	1670	2610	4050	5030	6160	7530	9170								
	2	320	510	810	1280	2010	3130	3890	4770	5860	7170	8780							
	3	240	390	620	990	1540	2400	2980	3660	4480	5470	6690	8020	9680					
	5	140*	230	370	590	920	1430	1790	2190	2690	3290	4030	4850	5870	6650	7560	8460	9220	
	7.5	0	160*	260	420	650	1020	1270	1560	1920	2340	2870	3440	4160	4710	5340	5970	6500	7510
	10	0	0	190*	310	490	760	950	1170	1440	1760	2160	2610	3160	3590	4100	4600	5020	5840
	15	0	0	0	210*	330	520	650	800	980	1200	1470	1780	2150	2440	2780	3110	3400	3940
	20	0	0	0	160*	250*	400	500	610	760	930	1140	1380	1680	1910	2180	2450	2680	3120
	25	0	0	0	0	200*	320	400	500	610	750	920	1120	1360	1540	1760	1980	2160	2520
	30	0	0	0	0	0	260*	330	410	510	620	760	930	1130	1280	1470	1650	1800	2110
460V	1/2	3770	6020	9460															
60Hz	3/4	2730	4350	6850															
Three Phase	1	2300	3670	5770	9070														
Three Wire	1.5	1700	2710	4270	6730														
	2	1300	2070	3270	5150	8050													
	3	1000	1600	2520	3970	6200													
	5	590	950	1500	2360	3700	5750												
	7.5	420	680	1070	1690	2640	4100	5100	6260	7680									
	10	310	500	790	1250	1960	3050	3800	4680	5750	7050								
	15	0	340*	540	850	1340	2090	2600	3200	3930	4810	5900	7110						
	20	0	0	410	650	1030	1610	2000	2470	3040	3730	4580	5530						
	25	0	0	330*	530	830	1300	1620	1990	2450	3010	3700	4470	5430					
	30	0	0	270*	430	680	1070	1330	1640	2030	2490	3060	3700	4500	5130	5860			
	40	0	0	0	320*	500*	790	980	1210	1490	1830	2250	2710	3290	3730	4250			
	50	0	0	0	0	410*	640	800	980	1210	1480	1810	2190	2650	3010	3420	3830	4180	4850
	60	0	0	0	0	0	540*	670*	830	1020	1250	1540	1850	2240	2540	2890	3240	3540	4100
	75	0	0	0	0	0	440*	550*	680*	840	1030	1260	1520	1850	2100	2400	2700	2950	3440
	100	0	0	0	0	0	0	0	500*	620*	760*	940	1130	1380	1560	1790	2010	2190	2550
	125	0	0	0	0	0	0	0	0	0	600*	740*	890*	1000	1220	1390	1560	1700	1960
	150	0	0	0	0	0	0	0	0	0	0	630*	760*	920*	1050	1190	1340	1460	1690
	175	0	0	0	0	0	0	0	0	0	0	0	670*	810*	930*	1060	1190	1300	1510
	200	0	0	0	0	0	0	0	0	0	0	0	590*	710*	810*	920	1030	1130	1310
575V	1/2	5900	9410																
60Hz	3/4	4270	6810																
Three Phase	1	3630	5800	9120															
Three Wire	1.5	2620	4180	6580															
	2	2030	3250	5110	8060														
	3	1580	2530	3980	6270														
	5	920	1480	2330	3680	5750													
	7.5	660	1060	1680	2650	4150													
	10	490	780	1240	1950	3060	4770	5940											
	15	330*	530	850	1340	2090	3260	4060											
	20	0	410*	650	1030	1610	2520	3140	3860	4760	5830								
	25	0	0	520	830	1300	2030	2530	3110	3840	4710								
	30	0	0	430*	680	1070	1670	2080	2560	3160	3880	4770	5780	7030	8000				
	40	0	0	0	500*	790	1240	1540	1900	2330	2860	3510	4230	5140	5830				
	50	0	0	0	410*	640*	1000	1250	1540	1890	2310	2840	3420	4140	4700	5340	5990	6530	7580
	60	0	0	0	0	540*	850	1060	1300	1600	1960	2400	2890	3500	3970	4520	5070	5530	6410
	75	0	0	0	0	0	690*	860	1060	1310	1600	1970	2380	2890	3290	3750	4220	4610	5370
	100	0	0	0	0	0	0	640*	790*	970	1190	1460	1770	2150	2440	2790	3140	3430	3990
	125	0	0	0	0	0	0	0	630*	770*	950*	1160	1400	1690	1920	2180	2440	2650	3070
	150	0	0	0	0	0	0	0	0	660*	800*	990*	1190	1440	1630	1860	2080	2270	2640
	175	0	0	0	0	0	0	0	0	0	700*	870*	1050*	1270	1450	1650	1860	2030	2360
	200	0	0	0	0	0	0	0	0	0	0	760*	920*	1110*	1260	1440	1620	1760	2050
460V-60Hz	150	0	0	0	0	0	0	420*	510*	630*	770	950	1140	1380	1570	1790	2000	2180	2530
Three Phase	175	0	0	0	0	0	0	0	450*	550*	680*	830	1000	1220	1390	1580	1780	1950	2270
Six Wire	200	0	0	0	0	0	0	0	0	480*	590*	730*	880	1070	1210	1380	1550	1690	1970
575V-60Hz	150	0	0	0	0	0	520	650	800	990	1210	1480	1780	2160	2450	2790	3120	3410	3950
Three Phase	175	0	0	0	0	0	0	570	700	860	1060	1300	1570	1910	2170	2480	2780	3040	3540
Six Wire	200	0	0	0	0	0	0	500	610	760	930	1140	1370	1670	1890	2160	2420	2640	3070

Lengths without the asterisk * meet the U.S. National Electrical Code ampacity for either individual conductors or

Flat molded cable is considered to be jacketed cable.

This is based on copper wire. If aluminum wire is to be used, it must be two sizes larger

Table 12 Three Phase Motor Specifications (60 Hertz)

Motor Model Prefix					Rated Input		Maximum (S.F. Load)		Line to Line	Efficiency %			Power Factor %			Locked Rotor	KVA	Circuit Breaker or Fuse AMPS	
	HP	Volts	HZ	S.F.	Amps	Watts	Amps	Watts	Res.	S.F.	F.L.	3/4	S.F.	F.L.	3/4	Amps	Code	Std.	Delay
4 Inch																			
2345014	1/2	200	60	1.6	2.8	635	3.7	900	6.64-7.3	66.4	59.4	53.3	76.6	64.1	56.5	17.3	N	10	5
2345114	1/2	230	60	1.6	2.3	635	2.9	900	9.5-10.4	66.4	59.4	53.3	76.6	64.1	56.5	15.0	N	8	4
2345213	1/2	460	60	1.6	1.2	635	1.6	900	38.4-41.6	66.4	59.4	53.3	76.6	64.1	56.5	7.5	N	4	2
2345024	3/4	200	60	1.5	3.7	920	4.7	1250	4.66-5.12	67.5	63.0	57.7	79.5	69.0	66.0	24.6	N	12	6
2345124	3/4	230	60	1.5	3.3	920	4.1	1250	7.24-7.84	67.5	63.0	57.7	79.5	69.0	66.0	21.4	N	11	5
2345223	3/4	460	60	1.5	1.6	920	2.0	1250	27.8-30.2	67.5	63.0	57.7	79.5	69.0	66.0	10.7	N	5	3
2345031	1	200	60	1.4	4.5	1140	5.7	1520	4.1-4.5	69.3	67.0	63.0	79.1	71.0	63.4	31.0	M	14	6
2345131	1	230	60	1.4	3.9	1140	4.8	1520	5.2-5.6	69.3	67.0	63.0	79.1	71.0	63.4	27.0	M	12	6
2345231	1	460	60	1.4	2.0	1140	2.4	1520	21.2-23.0	69.3	67.0	63.0	79.1	71.0	63.4	13.5	M	6	3
2345041	11/2	200	60	1.3	6.1	1570	7.3	2000	2.4-3.4	75.0	74.0	70.9	80.0	73.0	64.5	39	K	20	9
2345141	11/2	230	60	1.3	5.2	1570	6.3	2000	3.2-4.1	75.0	74.0	70.9	80.0	73.0	64.5	34	K	20	8
2345241	11/2	460	60	1.3	2.6	1570	3.1	2000	11.3-15.0	75.0	74.0	70.9	80.0	73.0	64.5	17	K	15	4
2345341	11/2	575	60	1.3	2.1	1570	2.5	2000	17.6-23.4	75.0	74.0	70.9	80.0	73.0	64.5	14	K	15	3
2343047	1/12	200	60	1.3	6.1	1570	7.4	2050	2.4-3.4	75.0	74.0	70.9	80.0	73.0	64.5	39	K	20	9
2343147	11/2	230	60	1.3	5.3	1570	6.4	2050	3.2-4.1	75.0	74.0	70.9	80.0	73.0	64.5	34	K	20	8
2343247	11/2	460	60	1.3	2.7	1570	3.2	2050	11.3-15.0	75.0	74.0	70.9	80.0	73.0	64.5	17	K	15	4
2343347	11/2	575	60	1.3	2.2	1570	2.6	2050	17.6-23.4	75.0	74.0	70.9	80.0	73.0	64.5	14	K	15	3
2343051	2	200	60	1.25	7.7	2050	9.3	2580	1.9-2.4	69.5	69.5	67.4	84.4	79.0	71.2	53	L	25	10
2343151	2	230	60	1.25	6.7	2050	8.1	2580	2.4-3.0	69.5	69.5	67.4	84.4	79.0	71.2	46	L	20	10
2343251	2	460	60	1.25	3.4	2050	4.1	2580	9.7-12.0	69.5	69.5	67.4	84.4	79.0	71.2	23	L	15	5
2343057	2	200	60	1.25	7.7	2150	9.3	2690	1.9-2.4	69.5	69.5	67.4	84.4	79.0	71.2	53	L	25	10
2343157	2	230	60	1.25	6.7	2150	8.1	2690	2.4-3.0	69.5	69.5	67.4	84.4	79.0	71.2	46	L	20	10
2343257	2	460	60	1.25	3.4	2150	4.1	2690	9.7-12.0	69.5	69.5	67.4	84.4	79.0	71.2	23	L	15	5
2343357	2	575	60	1.25	2.7	2150	3.2	2690	15.1-18.7	69.5	69.5	67.4	84.4	79.0	71.2	18	L	15	4
2343067	3	200	60	1.15	10.9	2980	12.5	3420	1.3-1.7	75.5	75.2	73.2	81.5	77.8	69.5	70	K	35	14
2343167	3	230	60	1.15	9.5	2980	10.9	3420	1.8-2.2	75.5	75.2	73.2	81.5	77.8	69.5	61	K	30	15
2343267	3	460	60	1.15	4.8	2980	5.5	3420	7.0-8.7	75.5	75.2	73.2	81.5	77.8	69.5	31	K	15	7
2343367	3	575	60	1.15	3.8	2980	4.4	3420	10.9-13.6	75.5	75.2	73.2	81.5	77.8	69.5	24	K	15	6
2343077	5	200	60	1.15	18.3	5050	20.5	5810	.70-.94	74.0	74.0	72.2	84.0	81.0	73.0	120	K	50	24
2343177	5	230	60	1.15	15.9	5050	17.8	5810	.93-1.2	74.0	74.0	72.2	84.0	81.0	73.0	104	K	45	20
2343277	5	460	60	1.15	8.0	5050	8.9	5810	3.6-4.4	74.0	74.0	72.2	84.0	81.0	73.0	52	K	25	10
2343377	5	575	60	1.15	6.4	5050	7.1	5810	5.6-6.9	74.0	74.0	72.2	84.0	81.0	73.0	42	K	20	8
2343087	7 1/2	200	60	1.15	26.5	7360	30.5	8450	.46-.57	76.2	76.0	74.0	83.2	80.0	72.2	188	K	80	35
2343187	7 1/2	230	60	1.15	23.0	7360	26.4	8450	.61-.75	76.2	76.0	74.0	83.2	80.0	72.2	164	K	70	30
2343287	7 1/2	460	60	1.15	11.5	7360	13.2	8450	2.4-3.4	76.2	76.0	74.0	83.2	80.0	72.2	82	K	35	15
2343387	7 1/2	575	60	1.15	9.2	7360	10.6	8450	3.5-5.1	76.2	76.0	74.0	83.2	80.0	72.2	65	K	30	12
2343297	10	460	60	1.15	17.0	10100	18.8	11700	1.8-2.3	75.2	74.5	72.0	79.2	75.5	67.1	116	K	50	20
2343397	10	575	60	1.15	13.6	10100	15.0	11700	2.8-3.5	75.2	74.5	72.0	79.2	75.5	67.1	93	K	40	20
6 Inch																			
2366506	5	200	60	1.15	17.5	4700	19.1	5400	.68-.84	79.5	79.1	77.2	82.0	79.5	73.8	98.9	H	50	24
2366006	5	230	60	1.15	15.0	4700	16.6	5400	.88-1.09	79.5	79.1	77.2	82.0	79.5	73.8	86	H	45	20
2366106	5	460	60	1.15	7.5	4700	8.3	5400	3.53-4.37	79.5	79.1	77.2	82.0	79.5	73.8	43	H	25	10
2366206	5	575	60	1.15	6.0	4700	6.4	5400	5.93-7.16	79.5	79.1	77.2	82.0	79.5	73.8	34.4	H	20	8
2366516	71/2	200	60	1.15	25.1	7000	28.3	8000	.39-.48	79.8	80.0	78.7	83.0	80.5	73.8	149.5	H	70	30
2366016	71/2	230	60	1.15	21.8	7000	24.6	8000	.57-.71	79.8	80.0	78.7	83.0	80.5	73.8	130	H	70	30
2366116	71/2	460	60	1.15	10.9	7000	12.3	8000	2.17-2.68	79.8	80.0	78.7	83.0	80.5	73.8	65.0	H	30	15
2366216	71/2	575	60	1.15	8.7	7000	9.8	8000	3.65-4.41	79.8	80.0	78.7	83.0	80.5	73.8	52	H	25	12

Table 13 Three Phase Motor Specifications (60 Hertz)

Motor Model	HP	Volts	HZ	S.F.	Rated Input Amps	Rated Input Watts	Maximum (S.F. Load) Amps	Maximum (S.F. Load) Watts	Line to Line Res.	Efficiency % S.F.	Efficiency % F.L.	Efficiency % 3/4	Power Factor % S.F.	Power Factor % F.L.	Power Factor % 3/4	Locked Rotor Amps	KVA Code	Circuit Breaker or Fuse AMPS Std.	Circuit Breaker or Fuse AMPS Delay
6 Inch Con't																			
2366526	10	200	60	1.15	32.7	9400	37.0	10800	.33-.42	79.2	79.4	78.0	85.5	83.2	77.2	198	H	100	40
2366026	10	230	60	1.15	28.4	9400	32.2	10800	.44-.55	79.2	79.4	78.0	85.5	83.2	77.2	172	H	80	35
2366126	10	460	60	1.15	14.2	9400	16.1	10800	1.76-2.17	79.2	79.4	78.0	85.5	83.2	77.2	86	H	40	20
2366226	10	575	60	1.15	11.4	9400	12.9	10800	2.87-3.47	79.2	79.4	78.0	85.5	83.2	77.2	69	H	35	15
2366536	15	200	60	1.15	47.8	13700	54.4	15800	.22-.27	81.0	81.5	80.2	84.9	82.8	76.5	306	H	150	70
2366036	15	230	60	1.15	41.6	13700	47.4	15800	.27-.33	81.0	81.5	80.2	84.9	82.8	76.5	266	H	125	60
2366136	15	460	60	1.15	20.8	13700	23.7	15800	1.07-1.32	81.0	81.5	80.2	84.9	82.8	76.5	133	H	60	30
2366236	15	575	60	1.15	16.6	13700	19.0	15800	1.70-2.10	81.0	81.5	80.2	84.9	82.8	76.5	106	H	50	25
2366546	20	200	60	1.15	61.9	18100	69.7	20900	.14-.17	82.0	82.3	81.6	86.8	84.8	79.5	416	J	200	80
2366046	20	230	60	1.15	53.8	18100	60.6	20900	.20-.25	82.0	82.3	81.6	86.8	84.8	79.5	362	J	175	70
2366146	20	460	60	1.15	26.9	18100	30.3	20900	.76-.94	82.0	82.3	81.6	86.8	84.8	79.5	181	J	80	35
2366246	20	575	60	1.15	21.5	18100	24.2	20900	1.22-1.52	82.0	82.3	81.6	86.8	84.8	79.5	145	J	70	35
2366556	25	200	60	1.15	77.1	22500	86.3	25700	.11-.14	82.8	83.0	82.0	87.0	85.0	79.2	552	J	225	100
2366056	25	230	60	1.15	67.0	22500	75.0	25700	.15-.19	82.8	83.0	82.0	87.0	85.0	79.2	480	J	200	90
2366156	25	460	60	1.15	33.5	22500	37.5	25700	.59-.73	82.8	83.0	82.0	87.0	85.0	79.2	240	J	100	45
2366256	25	575	60	1.15	26.8	22500	30.0	25700	1.01-1.25	82.8	83.0	82.0	87.0	85.0	79.2	192	J	80	35
2366566	30	200	60	1.15	90.9	26900	104.0	31100	.10-.12	82.5	83.0	82.6	87.5	85.4	80.3	653	J	300	125
2366066	30	230	60	1.15	79.0	26900	90.4	31100	.12-.15	82.5	83.0	82.6	87.5	85.4	80.3	568	J	250	100
2366166	30	460	60	1.15	39.5	26900	45.2	31100	.48-.60	82.5	83.0	82.6	87.5	85.4	80.3	284	J	125	50
2366266	30	575	60	1.15	31.6	26900	36.2	31100	.78-.95	82.5	83.0	82.6	87.5	85.4	80.3	227	J	100	40
2366176	40	460	60	1.15	53.5	35600	62.0	42350	.32-.40	83.2	83.4	82.9	85.8	83.6	77.6	397	J	150	70
2366276	40	575	60	1.15	42.8	35600	49.6	42350	.53-.59	83.2	83.4	82.9	85.8	83.6	77.6	318	J	125	70
2366186	50	460	60	1.15	67.7	45100	77.0	52200	.25-.32	82.5	83.0	82.7	85.2	84.0	80.0	414	H	200	90
2366286	50	575	60	1.15	54.2	45100	61.6	52200	.39-.48	82.5	83.0	82.7	85.2	84.0	80.0	331	H	150	70
2366196	60	460	60	1.15	80.5	53500	91.0	61700	.22-.27	84.2	84.5	84.0	85.0	83.3	78.0	518	H	250	100
2366296	60	575	60	1.15	64.4	53500	72.8	61700	.35-.39	84.2	84.5	84.0	85.0	83.3	78.0	414	H	200	80
8 Inch																			
2391006	40	460	60	1.15	53.0	37000	60.0	42000	.264-.292	82.0	81.3	79.3	87.3	86.4	83.7	342	H	175	70
2391106	40	575	60	1.15	42.4	37000	48.0	42000	.424-.468	82.0	81.3	79.3	87.3	86.4	83.7	274	H	125	70
2391016	50	460	60	1.15	66.0	44000	75.0	51000	.194-.216	84.4	84.0	82.5	85.5	84.5	81.0	433	H	200	90
2391116	50	575	60	1.15	52.8	44000	60.0	51000	.300-.332	84.4	84.0	82.5	85.5	84.5	81.0	346	H	150	70
2391026	60	460	60	1.15	77.0	53000	89.0	61000	.150-.166	85.5	85.0	83.5	87.5	86.7	83.6	560	J	225	100
2391126	60	575	60	1.15	61.6	53000	71.2	61000	.240-.268	85.5	84.0	83.5	87.5	86.7	83.6	448	J	200	80
2391036	75	460	60	1.15	97.0	66000	110.0	76000	.114-.126	85.2	85.0	83.6	87.1	86.0	82.7	750	J	300	125
2391136	75	575	60	1.15	77.6	66000	88.0	76000	.180-.198	85.2	85.0	83.6	87.1	86.0	82.7	600	J	225	110
2391046	100	460	60	1.15	128.0	87000	148.0	102000	.080-.088	86.5	86.0	84.2	86.8	85.1	81.0	1000	J	400	175
2391146	100	575	60	1.15	102.4	87000	118.4	102000	.118-.130	86.5	86.0	84.2	86.8	85.1	81.0	800	J	300	150
2391056	125	460	60	1.15	165	109000	189	125000	.057-.063	86.3	86.0	84.2	83.6	82.0	77.0	1300	K	500	225
2391156	125	575	60	1.15	132	109000	151	125000	.090-.100	86.3	86.0	84.2	83.6	82.0	77.0	1040	K	400	175
2391066	150	460	60	1.15	193	128000	221	146000	.049-.054	88.0	87.6	86.0	85.0	83.0	78.0	1600	K	600	250
2391166	150	575	60	1.15	154	128000	177	146000	.073-.081	88.0	87.6	86.0	85.0	83.0	78.0	1280	K	450	200
2391076	175	460	60	1.15	218	150000	250	173000	.045-.050	87.2	87.0	85.7	87.0	86.0	82.8	1850	K	700	300
2391176	175	575	60	1.15	174	150000	200	173000	.067-.074	87.2	87.0	85.7	87.0	86.0	82.8	1480	K	500	225
2391086	200	460	60	1.15	245	169000	286	194000	.038-.042	88.2	88.0	87.2	87.2	86.6	84.3	2100	K	800	350
2391186	200	575	60	1.15	196	169000	229	194000	.060-.066	88.2	88.0	87.2	87.2	86.6	84.3	1680	K	600	300

Model numbers are three lead motors. Six lead motors with different model numbers have the same running performance, but when wye connected for starting have locked rotor amps 33% of the values shown.

Overload Protection Of Three Phase Submersible Motors

The characteristics of submersible motors are different from standard motors and special overload protection is required. If the motor is stalled, the overload protector must trip within 10 seconds to protect the motor windings. The installer must use SUBTROL or the quick-trip protection shown in these tables. All recommended overload selections are of the ambient compensated type to maintain protection at high and low air temperatures.

All heaters and amp settings shown are based on total line amps. When a six-lead motor is used with a Wye-Delta starter, heaters carrying phase amps must be selected or adjusted based on motor amps divided by 1.732.

The tables below list the correct selection and settings for several manufacturers. Approval of other types may be requested by phoning the Franklin Electric Hotline at 800-348-2420.

Refer To Notes On Page 17.

Table 14 60 Hertz 4" Motors

HP	Volts	NEMA Starter Size	Heaters For Overload Relays: Furnas (Note 1)	Allen Bradley	G.E. (Note 2)	Adjustable Relays See (Note 3): Set	Max.
1/2	200	00	K31	J16	L380A	3.13	3.4
	230	00	K29	J15	L343A	2.76	3.0
	460	00	—	J8	L174A	1.38	1.5
	575	00	—	J5	—	1.10	1.2
3/4	200	00	K36	J19	L510A	4.23	4.6
	230	00	K33	J18	L463A	3.68	4.0
	460	00	K23	J11	L232A	1.84	2.0
	575	00	K21	J8	L193A	1.47	1.6
1	200	00	K37	J21	L618A	5.06	5.5
	230	00	K36	J19	L561A	4.42	4.8
	460	00	K26	J12	L282A	2.21	2.4
	575	00	K23	J10	L211A	1.75	1.9
1.5	200	00	K43	J24	L825A	6.81	7.4
	230	00	K41	J22	L750A	5.89	6.4
	460	00	K29	J15	L380A	2.94	3.2
	575	00	K27	J13	L310A	2.39	2.6
2	200	0	K50	J26	L111B	8.46	9.2
	230	0	K43	J25	L910A	7.36	8.0
	460	00	K33	J18	L463A	3.68	4.0
	575	00	K29	J15	L380A	2.94	3.2
3	200	0	K54	J29	L135B	11.2	12.2
	230	0	K52	J28	L122B	9.75	10.6
	460	0	K37	J20	L618A	4.88	5.3
	575	0	K33	J18	L463A	3.86	4.2
5	200	1	K61	J34	L220B	18.4	20.0
	230	1	K61	J32	L199B	16.0	17.4
	460	0	K49	J25	L100B	8.00	8.7
	575	0	K42	J23	L825A	6.44	7.0
7.5	200	1	K68	J38	L322B	27.0	29.3
	230	1	K67	J36	L293B	23.5	25.5
	460	1	K55	J29	L147B	11.8	12.8
	575	1	K52	J27	L122B	9.38	10.2
10	460	1	K61	J33	L220B	17.5	18.8
	575	1	K57	J31	L181B	14.0	15.0

Table 15 60 Hertz 6" Motors

HP	Volts	NEMA Starter Size	Heaters For Overload Relays: Furnas (Note 1)	Allen Bradley	G.E. (Note 2)	Adjustable Relays (Note 3): Set	Max.
5	200	1	K61	J34	L220B	18.4	20.0
	230	1	K61	J32	L199B	16.0	17.4
	460	0	K49	J25	L100B	8.0	8.7
	575	0	K42	J23	L825A	6.44	7.0
7.5	200	1	K68	J38	L322B	27.0	29.3
	230	1	K67	J36	L293B	23.5	25.5
	460	1	K55	J29	L147B	11.8	12.8
	575	1	K52	J27	L122B	9.38	10.2
10	200	2(1)	K72	J40	L426B	34.0	37.0
	230	2(1)	K70	J38	L390B	29.6	32.2
	460	1	K58	J32	L181B	14.8	16.1
	575	1	K55	J30	L147B	11.9	12.9
15	200	3(1)	K76	J43	L622B	50.1	54.5
	230	2	K75	J42	L520B	43.6	47.4
	460	2(1)	K64	J35	L265B	21.8	23.7
	575	2(1)	K61	J33	L220B	17.5	19.0
20	200	3	K78	J45	L787B	64.1	69.7
	230	3(1)	K77	J44	L710B	55.8	60.6
	460	2	K69	J38	L352B	27.9	30.3
	575	2	K64	J35	L293B	22.3	24.2
25	200	3	K86	J71	L950B	79.4	86.3
	230	3	K83	J46	L866B	69.0	75.0
	460	2	K72	J40	L426B	34.5	37.5
	575	2	K69	J37	L352B	27.6	30.0
30	200	4(1)	K88	J72	L107C	95.7	104.0
	230	3	K87	J71	L107C	83.2	90.4
	460	3(1)	K74	J41	L520B	41.6	45.2
	575	3(1)	K72	J39	L390B	33.3	36.2
40	460	3	K77	J44	L710B	57.0	62.0
	575	3	K74	J42	L593B	45.6	49.6
50	460	3	K83	J46	L866B	70.8	77.0
	575	3	K77	J44	L701B	56.7	61.6
60	460	4(1)	K87	J71	L107C	83.7	91.0
	575	4(1)	K78	J45	L787B	67.0	72.8

Table 16 60 Hertz 8" Motors

HP	Volts	NEMA Starter Size	Heaters For Overload Relays: Furnas (Note 1)	Allen Bradley	G.E. (Note 2)	Adjustable Relays (Note 3): Set	Max.
40	460(4)	3	K77	J44	L710B	57.0	62
	575	3	K74	J42	L593B	45.6	49.6
50	460(4)	3	K83	J46	L866B	70.8	77
	575	3	K77	J44	L710B	56.7	61.6
60	460(4)	4(1)	K87	J71	L107C	83.7	91
	575	4(1)	K78	J45	L787B	67.0	72.8
75	460(4)	4(1)	K89	J73	L126C	101	110
	575	4(1)	K86	J70	L950B	81.0	88
100	460(4)	4	K94	J76	L155C	136	148
	575	4	K87	J73	L142C	108	118
125	460(4)	5	K29	J15	L111B	173	189
	575	5	K26	J13	L910A	139	151
150	460(4)	5	K32	J17	L122B	203	221
	575	5	K28	J14	L100B	163	177
175	460(4)	5	K33	J18	L147B	230	250
	575	5	K31	J16	L111B	184	200
200	460(4)	5	K34	J20	L165B	263	286
	575	5	K32	J17	L135B	211	229

Notice: Warranty on three phase submersible motors is void unless Subtrol or proper quick trip ambient compensated

Overload Protection Of Three Phase Submersible Motors

Notes for Overload Protection Tables (Page 16)

Footnotes:

Note 1: Furnas intermediate sizes between NEMA starter sizes apply where (1) is shown in tables, size 1 3/4 replacing 2, 2 1/2 replacing 3, and 3 1/2 replacing 4. Heaters listed apply to Innova 45 designs and Defenite Purpose Class 16 starters through their available range, and to standard starters in larger sizes. Overload relay adjustments should be set no higher than 100%, unless necessary to stop nuisance tripping with measured amps in all lines below nameplate maximum.

Note 2: General Electric heaters are type CR123 usable only on type CR124 overload relays. Adjustment should be set no higher than 100%, unless necessary to stop nuisance tripping with measured amps in all lines below nameplate maximum.

Note 3: Adjustable overload relay amp settings apply to approved types listed below. Relay adjustment should be set at the specified SET amps, and only if tripping occurs with amps in all lines measured to be within nameplate maximum amps should the setting be increased, not to exceed the MAX value shown.

Note 4: Heaters shown for ratings requiring NEMA size 5 starters are all used with current transformers per manufacturer standards. Adjustable relays may or may not use current transformers depending on design.

Some approved types may only be available for part of the listed motor ratings. When relays are used with current transformers, relay setting is the specified amps divided by the transformer ratio.

Approved Adjustable Overload Relays

AEG Series: B17S, B27S, B27-2
ABB Type: RVH 40, RVH65, RVP160
Allen Bradley: Bulletin 193
Fanal Types: K7 or K7D through K400
Fuji Types: TR-0Q, TR-0QH, TR-2NQ, TR-3NQ, TR-6NQ, RCa 3737-ICQ & ICQ11
Furnas Types: US15 48AG &48BG ESP100-Class 10 only
General Electric CR4G, GR7G
Klockner-Moeller Types: Z00, Z1, Z4, PKZM1,PKZM3& PKZ2
Lovato RC9, RC22, & RC80
Asco-Delta Types: DQ, LR1-D, LR1-F & LR2-D
Sprecher and Schuh Types: CT, CT1, CTA 1, CT3K, CT3-12 thruCT3-42
Siemens Types: 3UA50, -52, -54, -58, -59, -62, -66, -MSP, 3VE
Square D Class 9065, Types: TD, TE, TF, TG, TJ, TK, TR, & TJE
Telemecanique Type: LR1-D, LR1-F, & LR2-D
Westinghouse Types: FT13, FT23, FT33, FT43, K7D, K27D, & K67D
Westmaster: OLWROO and OLWTOO suffix D thru P

Other relay types from these and other manufacturers may or may not provide acceptable protection, and they should not be used without approval of Franklin Electric.

Notice: Warranty on three phase submersible motors is void unless Subtrol or proper quick trip ambient compensated protection is used on all three motor lines.

Power Factor Correction

In some installations, power supply limitations make it necessary or desirable to increase the power factor of a summersible motor. The table lists the capacitive KVAR required to increase the power factor of large Franklin three phase submersible motors to the approximate values shown at maximum input loading.

Capacitors must be connected on the line side of the overload relay, or overload protection will be lost.

Table 17 KVAR Required

Motor HP	Hertz	Motor P.F.	Required KVAR for P.F. of: .90	.95	1.00
5	60	.82	1.2	2.1	4
7.5	60	.83	1.7	3.1	6
10	60	.85	1.5	3.3	7
15	60	.85	2.2	4.7	10
20	60	.87	1.7	5.0	12
25	60	.87	2.1	6.2	15
30	60	.87	2.5	7.4	18
40	60	.86	4.5	11	24
50	60	.85	7.1	15	32
60	60	.85	8.4	18	38
75	60	.87	6.3	18	43
100	60	.86	11	27	60
125	60	.85	17	36	77
150	60	.85	20	42	90
175	60	.88	9.6	36	93
200	60	.87	16	46	110

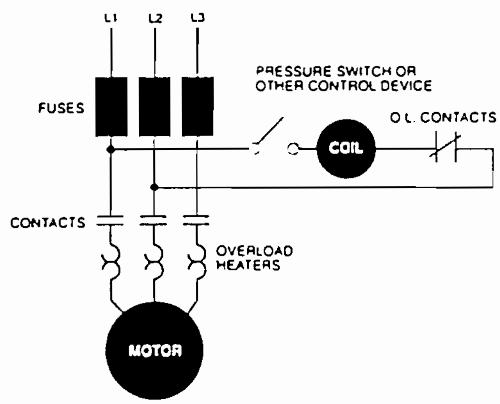
Three Phase Starter Diagrams

Three phase combination magnetic starters have two distinct circuits, a power circuit and a control circuit.

The power circuit consists of a circuit breaker or fused line switch, contacts, and overload heaters connecting incoming power lines, L1, L2, L3 and the three phase motor.

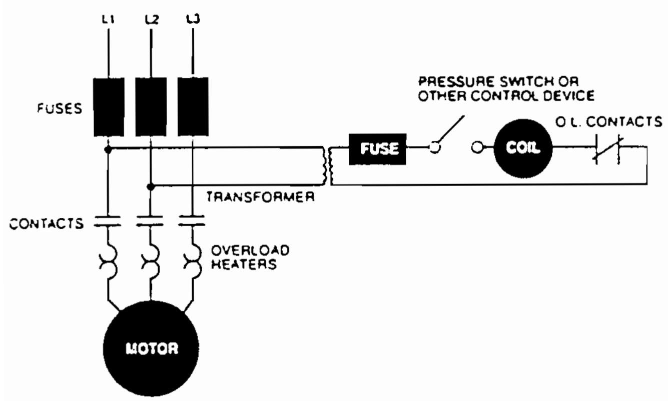
The control circuit consists of the magnetic coil, overload contacts and a control device such as a pressure switch. When the control device contacts are closed, current flows through the magnetic contactor coil, the contacts close, and power is applied to the motor. Hand-Off-Auto switches, start timers, level controls and other control devices may also be wired in series in the control circuit.

FIG 9 LINE VOLTAGE CONTROL



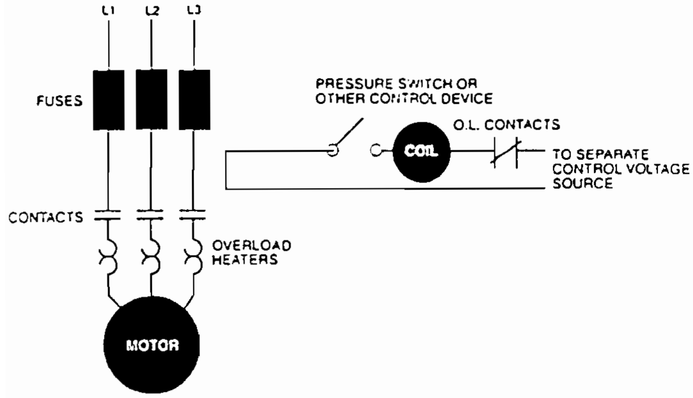
Probably the most common type of control encountered. Since the coil is connected directly across the power lines, L1 and L2, the coil voltage and frequency must match the line voltage.

FIG 10 LOW VOLTAGE TRANSFORMER CONTROL



Used when it is desirable to operate push buttons or other control devices at some voltage lower than the motor voltage. The transformer primary must match the line voltage and the coil voltage must match the secondary voltage of the transformer.

FIG 11 EXTERNAL VOLTAGE CONTROL



Control of a power circuit by a lower control circuit voltage can also be obtained by connecting to a separate control voltage source. The coil rating must match the control voltage source, such as 115 or 24 volts.

Three Phase Power Unbalance

A full three phase supply is recommended for all three phase motors, consisting of three individual transformers or one three phase transformer. So-called "open" delta or wye connections using only two transformers can be used, but are more likely to cause problems, such as poor performance overload tripping or early motor failure due to current unbalance.

Transformer ratings should be no smaller than listed in Table 2 on page 3 for supply power to the motor alone.

Phase designation of leads for CCW rotation viewing shaft end.

To reverse rotation, interchange any two leads.

Phase 1 or "A" – Black Motor Lead
Phase 2 or "B" – Yellow Motor Lead
Phase 3 or "C" – Red Motor Lead

NOTICE: Phase 1, 2 and 3 may not be L1, L2 and L3.

Checking and correcting rotation and current unbalance

1. Establish correct motor rotation by running in both directions. Change rotation by exchanging any two of the tree motor leads. The rotation that gives the most water flow is always the correct rotation.

2. After correct rotation has been established, check the current in each of the three motor leads and calculate the current unbalance as explained in 3 below.

If the current unbalance is 2% or less, leave the leads as connected.

If the current unbalance is more than 2%, current readings should be checked on each leg using each of the three possible hook-ups. Roll the motor leads across the starter in the same direction to prevent motor reversal.

3. To calculate percent of current unbalance:
   A. Add the three line amp values together.
   B. Divide the sum by three, yielding average current
   C. Pick the amp value which is furthest from the average current (either high or low).
   D. Determine the difference between this amp value (furthest from average) and the average.
   E. Divide the difference by the average.
   Multipy the result by 100 to determine percent of unbalance.

4. Current unbalance should not exceed 5% at service factor load or 10% at rated input load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If, on the three possible hookups, the leg farthest from the average stays on the same power lead, most of the unbalance is coming from the power source. However, if the reading farthest from average moves with the same motor lead, the primary source of unbalance is on the "motor side" of the starter. In this instance, consider a damaged cable, leaking splice, poor connection, or faulty motor winding.

	Hookup 1	Hookup 2	Hookup 3
Starter Terminals	L1 L2 L3	L1 L2 L3	L1 L2 L3
	T1 T2 T3	T1 T2 T3	T1 T2 T3
Motor Leads	R B Y	Y R B	B Y R

Example:

Hookup 1	Hookup 2	Hookup 3
R = 51 amps	Y = 50 amps	B = 50 amps
B = 46 amps	R = 48 amps	Y = 49 amps
Y = 53 amps	B = 52 amps	R = 51 amps
Total = 150 amps	Total = 150 amps	Total = 150 amps
÷ 3 = 50 amps	÷ 3 = 50 amps	÷ 3 = 50 amps
— 46 = 4 amps	— 48 = 2 amps	— 49 = 1 amps
4 ÷ 50 = .08 or 8%	2 ÷ 50 = .04 or 4%	1 ÷ 50 = .02 or 2%

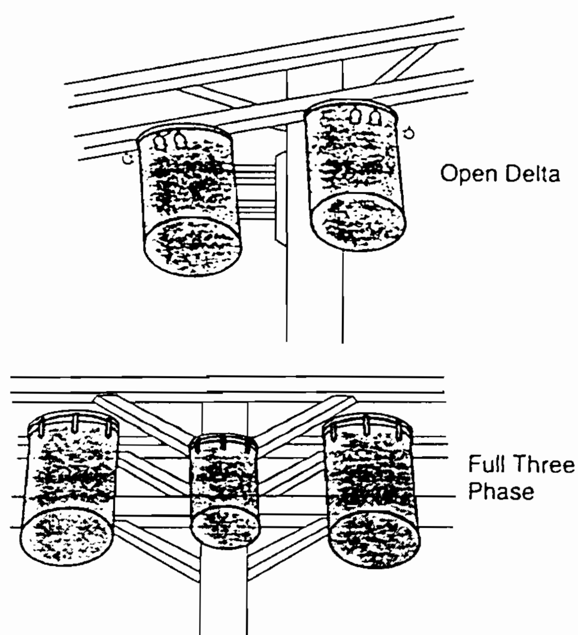


FIG 12

Phase Converters

THE WARRANTY ON ALL FRANKLIN THREE PHASE SUBMERSIBLE MOTORS IS VOID IF OPERATED FROM SINGLE PHASE POWER THROUGH A PHASE CONVERTER UNLESS APPROVAL OF THE SYSTEM (IN WRITING) HAS BEEN OBTAINED FROM THE FRANKLIN ELECTRIC FIELD SERVICE DEPARTMENT.

There are a number of types of phase converters available. Each is intended to allow the use of a three phase motor on a single phase power line. Some of these designs present problems which can lead to motor failure.

Phase converters, with the exception of solid state models, create a "manufactured voltage" leg by the use of capacitors, winding taps or adjustable relays. In all of these arrangements, the voltage balance is critical to the current balance. Some phase converters may be well balanced at one point on the system operating curve. Submersible pumping systems often operate at differing points on the curve as water levels and operating pressures fluctuate. Other converters may be well balanced at varying loads, but their output may vary widely with fluctuations in the input voltage.

The following guidelines have been established for submersible installations to be warrantable when used with a phase converter.

1. Limit pump loading to rated horsepower. Do not load into motor service factor.

2. Maintain at least three feet per second motor cooling. Use a flow sleeve when necessary.

3. Use time delay fuses or circuit breakers in pump panel. Standard fuses or circuit breakers do not provide secondary motor protection.

4. Subtrol Plus may be used on electro mechanical type phase converters, however special connections are required. Consult Subtrol Plus Manual for connections of receiver and lightning arrestor.

5. Subtrol Plus will not work with electronic solid state phase converters.

6. Current unbalance must not exceed 10% under varying load conditions.

7. Report system parameters on Form 2207, Submersible Motor Installation Record.

Send to:
Franklin Electric
400 E. Spring Street, Bluffton, IN 46714
Attention: Field Service Department

Upon receipt and analysis of the data and installation details supplied on Form No. 2207, Franklin engineers will advise by letter if the installation will be covered by Franklin's warranty.

Reduced Voltage Starters

All Franklin three phase submersible motors are suitable for full voltage starting. Under this condition the motor speed goes from zero to full speed within one half second or less. The load current goes from zero to locked rotor amps, about 5 to 7 times running amps, and drops to running amps at full speed. This may dim lights, cause momentary voltage dips to other electrical equipment and shock load power distribution transformers.

Power companies often require soft starters or limit motor KVA load that may be started "directly on line". There are also times when it may be desirable to reduce motor starting torque. This lessens the stress on shafts, couplings, and castings as well as the supporting discharge piping. A "strong" voltage supply and very little cable voltage drop produces high starting torque. In otherwords, this is an installation that is electrically and mechanically "stiff". Reduced voltage starters are often used to reduce starting KVA or torque, and sometimes to slow the immediate acceleration of the water on start up to control upthrust and waterhammer.

With maximum recommended cable length where there is a 5% voltage drop in the cable, there will be about 20% reduced starting current and about 36% reduced starting torque compared to having rated voltage at the motor. On some installations this may be enough reduction in starting current so that reduced voltage starters may not be required.

Standard 3 Ø motors have three line leads so only resistance, autotransformers, or solid state reduced voltage starters may be used. The autotransformer type is preferred over resistance and solid state types because it draws lower line current for the same starting torque. Wye-Delta starters are used with six lead Wye-Delta motors. All Franklin 6" and 8" three phase motors are available in six lead Wye-Delta construction. Consult the factory for details and availability. Part winding starters are not usable with Franklin Electric submersible motors.

When reduced voltage starters are used it is recommended the motor be supplied with at least 55% of rated voltage to ensure adequate starting torque.

Most autotransformer starters have 65% and 85% taps. Setting the taps on these starters depends on the percentage of the maximum allowable cable length used in the system. If the cable length is less than 50% of the maximum allowable, either the 65% or 80% taps may be used. When the cable length is more than 50% of the allowable, the 80% tap should be used.

Solid state reduced voltage starters may be used with submersibles, but may not be usable with Subtrol-Plus. Consult the factory.

Both electromechanical and solid state starters have adjustable time delays for starting. Typically they are preset at 30 seconds. They must be set so the motor is at full voltage within two to three seconds maximum to prevent overload trip and unnecessary motor heating.

Open transition starters, which momentarily interrupt power during the starting cycle, are not recommended. Should the motor/pump rotating parts be passing through their critical speed, as low voltage is removed and high voltage applied, the resulting stresses can break shafts and couplings. Only closed transition starters which have no interruption of power during the starting cycle should be used.

Variable Speed Submersible Pump Operation, Inverter Drives

Franklin three phase submersible motors are operable from variable frequency inverter drives when applied within guidelines specified below. These guidelines are based on present Franklin information for inverter drives, lab tests and actual installations, and must be followed for warranty to apply to inverter drive installations.

1. Variable speed drives should be variable frequency, constant volts per Hertz type, and may have sine wave, pulse width modulated (PWM) or six-step waveshape. The base voltage should be name plate voltage and frequency of the motor.

2. Overcurrent protection in the inverter or separately furnished must trip within 10 seconds at 5 times motor maximum nameplate amps in any line, and ultimately trip within 115% of motor maximum nameplate amps in any line.

3. Any application below 30 Hertz or above 80 Hertz must be specifically approved by Franklin Engineering. Operation at lower frequency can cause motor bearing failure, and at higher frequency can raise internal hydraulic losses to an unacceptable level.

4. Pump load must be selected so motor maximum nameplate amps are not exceeded under all running conditions.

5. Franklin-specified water temperature and flow past the motor must be maintained at speeds which load the motor up to maximum nameplate amps. At reduced speeds and loading, cooling flow must be adequate to maintain equivalent motor temperature.

6. Franklin Subtrol protection systems are not usable on inverter driven installations, because the non-sinusolidal waveshape from the inverter prevents proper Subtrol operation. The waveshape also reduces motor efficiency, typically about two percentage points.

7. To confirm whether an installation or system design is acceptable and warrantable, full details should be submitted to Franklin on Form 2207 along with inverter specifications.

Send to:
Franklin Electric
400 E. Spring Street, Bluffton, IN 46714
Attention: Field Service Department

Upon receipt and analysis of the data and installation details supplied on Form No. 2207, Franklin engineers will advise by letter if the installation will be covered by Franklin's warranty.

Submersible Motors Inline - Booster Systems

Franklin submersible motors are acceptable for booster pump (canned) applications provided the following conditions are taken into consideration in the system design.

1. **HORIZONTAL OPERATION:** Horizontal operation is acceptable as long as the pump transmits thrust to the motor and the entire assembly is supported sufficiently to prevent binding stresses.

2. The motor support assembly must not restrict the flow of cooling water around the full diameter of the motor. The motor supports must be on the motor endbell castings, and not on the stator shell.

3. **CONTROLS:** Franklin Subtrol-Plus is strongly recommended for all large submersibles. If Subtrol is not employed, properly sized ambient compensated quick-trip overloads must be utilized. In addition, a surge arrestor should be installed on all systems and properly grounded.

4. **WIRING:** Franklin lead assemblies are sized for submerged operation and may not be adequate for use in open air. Any wiring not submerged must comply with Franklin's cable charts.

5. **WATER TEMPERATURE:** The temperature of the water should be monitored at the inlet to each booster. When temperatures exceed 86°F (30°C), motor derating is required.

6. **INLET PRESSURE:** The inlet pressure on each booster should be monitored and not be allowed below the pump's specified Net Positive Suction Head Requirement (NPSHR). If NPSHR is unknown, at least 20 P.S.I. should be maintained at all times.

7. **DISCHARGE FLOW:** The flow rate for each pump should be monitored and never be allowed to drop below the minimum required to maintain cooling flow velocities. Pressure relieving valves should be employed to prevent running the pump at shut-off.

8. **DISCHARGE PRESSURE:** The discharge pressure should be great enough to prevent upthrust.

9. **CAN FLOODING:** An air bleeder valve must be employed on the booster can so total flooding may be accomplished prior to booster start-up.

IMPORTANT NOTES:

1. **HIGH PRESSURE TEST:** Motors intended for booster applications where the pressure exceeds 500 P.S.I. must be special ordered from the factory.

2. **STARTING:** Reduced voltage starting may be employed. This will reduce upthrust on start, starting current and mechanical stresses created by the motor's high starting torque. Reduced voltage starters, if used should accelerate the motor to full speed within two seconds. NOTE: Solid state reduced voltage starters are not compatible with Subtrol-Plus.

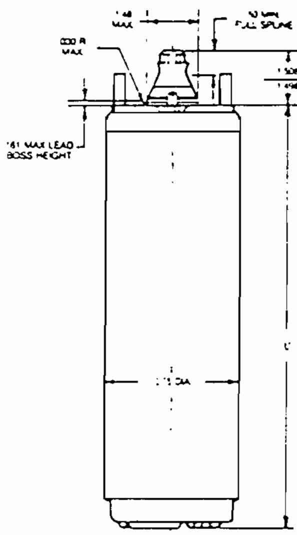
3. **DOCUMENTATION:** Form 2208, Submersible Booster Installation Record, must be completed for all Franklin submersible motor applied with inline booster pumps.

Send to:
Franklin Electric
400 E. Spring Street, Bluffton, IN 46714
Attn: Field Service Dept.

Upon receipt and analysis of the data and installation details supplied on Form No. 2207, Franklin engineers will advise by letter if the installation will be covered by Franklin's warranty.

4" Super Stainless

Dimensions



Availability

2-Wire, Split Phase, 60 HZ, 3450 RPM

hp	kw	volts	"L" Dimension in	Shipping Weight lbs
1/3	.25	115	8.78	16
		230		
1/2	.37	115	9.53	18
		230		
3/4	.55	230	10.66	20
1	.75	230	11.75	23
1 1/2	1.1	230	15.12	31

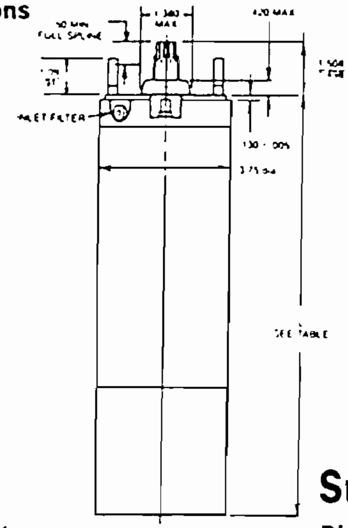
3-Wire, Capacitor Start, 60 Hz, 3450 RPM ①

hp	kw	volts	"L" Dimension in	Shipping Weight lbs
1/3	.25	115	8.78	16
		230		
1/2	.37	115	9.53	18
		230		
3/4	.55	230	10.66	20
1	.75	230	11.75	23
1 1/2	1.1	230	15.12	31
2	1.5	230	15.12	30

① Franklin Electric control box required

4' High Thrust

Dimensions



Availability ②

Single Phase Capacitor start, capacitor run

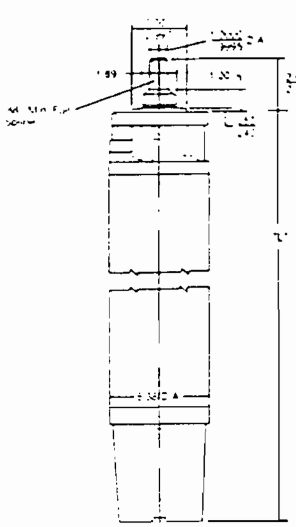
hp	kw	"L" Dimension in	Shipping Weight lbs
3	2.2	23.7	52
5	3.7	29.47	69

Three Phase

hp	kw	"L" Dimension in	Shipping Weight lbs
3	2.2	20.62	43
5	3.7	23.47	53
7.5	5.5	29.47	69
10	7.5	43.89	130

Super - 6"

Dimensions



Availability

Single Phase Capacitor start, capacitor run ①

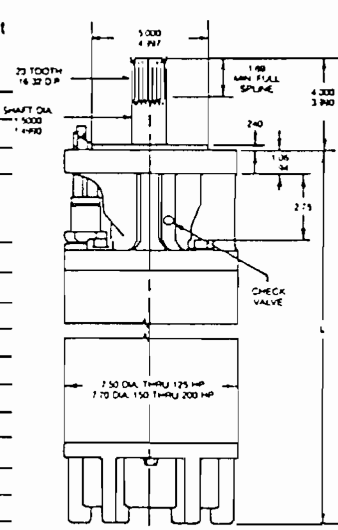
hp	kw	"L" Dimension in	Shipping Weight lbs
5/0	3.7	25.44	105
7.5	5.5	28.00	120
10.0	7.5	30.56	135
15.0	11.0	33.13	146

Three Phase

hp	kw	"L" Dimension in	Shipping Weight lbs
5	3.7	22.88	90
7	5.5	24.19	95
10	7.5	25.44	105
15	11.0	28.00	120
20	15.0	30.56	135
25	18.5	33.13	148
30	22.0	35.69	162
40	30.0	40.81	195
50	37.0	57.83	310
60	45.0	63.83	340

Super - 8"

Dimensions



Availability ②

8-Inch Pump Flange (5-inch rabbet)

hp	kw	"L" Dimension in	Shipping Weight lbs
40	30	39.78	366
50	37	42.78	401
60	45	45.78	436
75	55	50.78	483
100	75	58.78	644
125	90	68.78	719
150	110	77.78	815
175	130	85.78	919
200	150	94.78	1.031

6-Inch Pump Lang (3-inch rabbet)

hp	kw	"L" Dimension in	Shipping Weight lbs
40	30	39.53	336
50	37	42.53	372
60	45	45.53	408

② 50 Hz - Nominal 2,875 RPM

Submersible Pump Installation Check List

This check list is intended to help in making reliable submersible pump installations. Other data for specific pumps may be needed.

1. Motor Inspection

____ A. Verify that the model, HP or KW, voltage, phase and hertz on the motor nameplate match the installation requirements. Consider any special corrosion resistance required.

____ B. Check that the motor lead assembly is tight in the motor and that the motor and lead are not damaged.

____ C. Test insulation resistance using a 500 or 1000 volt DC megohmmeter, from each lead wire to the motor frame. Resistance should be at least 20 megohms, motor only, no cable.

____ D. Keep a record of motor model number, HP or KW, voltage, date code and serial number.

2. Pump Inspection

____ A. Check that the pump rating matches the motor, and that it is not damaged.

____ B. Verify that the pump shaft turns freely.

3. Pump/Motor Assembly

____ A. If not yet assembled, check that pump and motor mounting faces are free from dirt and uneven paint thickness.

____ B. Assemble the pump and motor together so their mounting faces are in contact, then tighten assembly bolts or nuts evenly to manufacturer specifications. If it is visible, check that the pump shaft is raised slightly by assembly to the motor, confirming impeller running clearance.

____ C. If accessible, check that the pump shaft turns freely.

____ D. Assemble the pump lead guard over the motor leads. Do not cut or pinch lead wire during assembly or handling of the pump during installation.

4. Power Supply and Controls

____ A. Verify that the power supply voltage, hertz, and KVA capacity match motor requirements.

____ B. Use a matching control box with each single phase three wire motor.

____ C. Check that the electrical installation and controls meet all safety regulations and match the motor requirements, including fuse or circuit breaker size and motor overload protection. Connect all metal plumbing and electrical enclosures to the power supply ground to prevent shock hazard. Comply with National and local codes.

5. Lightning and Surge Protection

____ A. Use properly rated surge (lightning) arrestors on all submersible pump installations unless the installation is operated directly from an individual generator and/or is not exposed to surges. Motors 5HP and smaller which are marked "Equipped with Lightning Arrestors" contain internal arrestors.

____ B. Ground all above ground arrestors with copper wire directly to the motor frame, or to metal drop pipe or casing which reaches below the well pumping level. Connecting to a ground rod does not provide good surge protection.

6. Electrical Cable

____ A. Use cable suitable for use in water, sized to carry the motor current without overheating in water and in air, and complying with local regulations. To maintain adequate voltage at the motor, use lengths no longer than specified in the motor manufacturer's cable charts.

____ B. Include a ground wire to the pump if required by codes or surge protection, connected to the power supply ground. Always ground any pump operated outside a drilled well.

7. Well Conditions

____ A. For adequate cooling, motors must have at least the water flow shown on its nameplate. If well conditions and construction do not assure this much water flow will always come from below the motor, use a flow sleeve as shown in the Application, Installation & Maintenance Manual.

____ B. If water temperature exceeds 30 degrees C (86 F), reduce the motor loading or increase the flow rate to prevent overheating, as specified in the Application, Installation & Maintenance Manual.

8. Pump/Motor Installation

____ A. Splice motor leads to supply cable using electrical grade solder or compression connectors, and carefully insulate each splice with watertight tape or adhesive-lined shrink tubing, as shown in motor or pump installation data.

____ B. Support the cable to the delivery pipe every 10 feet (3 meters) with straps or tape strong enough to prevent sagging. Use pads between cable and any metal straps.

____ C. A check valve in the delivery pipe is recommended, even though a pump may be reliable without one. More than one check valve may be required, depending on valve rating and pump setting. Install the lowest check valve below the lowest pumping level of the well, to avoid hydraulic shocks which may damage pipes, valve or motor.

____ D. Assemble all pipe joints as tightly as practical, to prevent unscrewing from motor torque. Recommended torque is at least 10 pound feet per HP (2 meter-KG per KW).

____ E. Set the pump far enough below the lowest pumping level to assure the pump inlet will always have at least the Net Positive Suction Head (NPSH) specified by the pump manufacturer, but at least 10 feet (3 meters) from the bottom of the well to allow for sediment build up.

____ F. Check insulation resistance from dry motor cable ends to ground as the pump is installed, using a 500 or 1000 volt DC megohmmeter. Resistance may drop gradually as more cable enters the water, but any sudden drop indicates possible cable, splice or motor lead damage. Resistance should meet motor manufacturer data.

9. After Installation

____ A. Check all electrical and water line connections and parts before starting the pump. Make sure water delivery will not wet any electrical parts, and recheck that overload protection in three phase controls meets requirements.

____ B. Start the pump and check motor amps and pump delivery. If normal, continue to run the pump until delivery is clear. If three phase pump delivery is low, it may be running backward because phase sequence is reversed. Rotation may be reversed (with power off) by interchanging any two motor lead connections to the power supply.

____ C. Connect three phase motors for current balance to within 5% of average, using motor manufacturer instructions. Unbalance over 5% will cause higher motor temperatures and may cause overload trip, vibration, and reduced life.

____ D. Make sure that starting, running and stopping cause no significant vibration or hydraulic shocks.

____ E. After at least 15 minutes running, verify that pump output, electrical input, pumping level, and other characteristics are stable and as specified.

10. Installation Data

Well Identification ______________________________

Checked By ______________________________

Date _____ / _____ / _____

Notes ____

____

____

____

____

____

____

Submersible Motor Installation Record

Date ____________ Filled In By ______________________________ RMA No. ________

Installation

Installer: ______________________________ Telephone (____) ______________

Street: ______________________ City ______________ State ______ Zip ________

Owner/User: ______________________ City______________ State ______ Zip ________

Well Identification, If Any: ______________________________

Well Is For: Home Farm ______ City/town______ Golf Course______ OR______________

Water Is Pumped To: Overhead Storage Tank ______ Distribution Piping ______ Or ______________

New Installation? Yes ______ No ______ . If No, It replaces ______________

Well

Well Diameter: ______ In. Well Depth ______ Ft. Cased ______ Or Uncased ______

Casing: ______ In. Length ______ Ft. Screened ______ Or Unscreened ______

Casing Is: Steel ______ Stainless Steel ______ Plastic ______ Or ______________

Screen ______ Or Perforated Casing ______ :From ______ Ft. To ______ Ft. & ______ Ft. To ______ Ft.

Static Water Level Is: ______ Ft. Water Temperature Is: ______ °F Or ______ °C

Drawdown Level Is: ______ Ft., After Pumping At ______ GPM Or ______ GPH For ______ Hours

Pump/Motor Is Set At: ______ Ft., On Steel Pipe ______ Rigid Plastic ______

Flexible Plastic ______ Or ______________

Flow Sleeve On The Motor? Yes ______ No ______ If Yes, Diameter is ______ In.

Check Valves In The System Yes ______ No ______ If Yes, Built-In ______ And/Or ______________

At The Pump Discharge ______ and ______ Ft. and ______ Ft. and ______ Ft.

Is There A Pump Control Valve? Yes ______ No ______ If Yes,

Mfr. ______________________ Size ______ Model ______________

Wiring

Transformers: KVA No. 1 ______ , No. 2 ______ No. 3 ______ Connected: Wye ______ Delta ______

Supply Cable: (Service Entrance To Control): ______ Ft. of No. ______ Copper ______ Alum. ______

Drop Cable: (Control To Motor) : ______ Ft. of No. ______ Copper ______ Alum. ______

Cable is: Flat ______ Round ______ Or 3 individual Conductors ______ . Jacketed: Yes ______ No ______

Insulation Is: Neoprone ______ PVC ______ Or ______________

Splice Is: Crimped ______ Or Soldered ______ And, Taped ______ Heat Shrink ______ Or ______

Controls and Protective Devices

Subtrol? Yes ______ No ______ If Yes, Warranty Registration No. ______________

If Yes, Overload Set? Yes ______ No ______ Set At ______

Underload Set? Yes ______ No ______ Set At ______

Reduced Voltage Starter? Yes ______ No ______ If Yes, Type ______________

Mfr. ____________ Setting ______________ % Full Voltage In ________ Seconds.

Pump Panel? Yes ______ No ______ If Yes, Mfr. ______________________ Size ______________

Magnetic Starter/Contactor: Mfr. ______________ Model ______________ Size ______________

Heaters: Mfr. ______________ No. ________ If Adjustable; Set At ______________

Fuses: Mfr. ______________ Size ________ Type ______________

Lightning/Surge Arrestor: Mfr. ______________________ Model ______________

Controls Are Grounded: to______________________ with No. ______________ Wire

Phase Converter? Yes ______ No ______ If yes, Mfr. ______________________ Model ______________

Form No. 2207 9/92

Submersible Motor Installation Record

Motor

Model No. ______________________ Serial No. ______________________ Date Code ______________

Horsepower _______ Voltage ______ Phase ______ Diameter ______

Pump

Mfr. ____________________ Model ________________ Rated _________ GPM At _________ Ft.

Operating Cycle

Pump/Motor Operates: Continuously (Non-Stop) ______ Or is controlled by:

Manual Switch ______ Pressure Switch ______ Float/Level Control ______ Flow Switch ______

Timer ______ Or ____

On

Off

_______ Minutes Or _______ Hours   _______ Minutes Or _______ Hours

Start Up Data

Insulation Check

Initial Megs: Motor & Lead Only Black _______ Yellow _______ Red _______

Installed Megs: Motor, Lead, & Cable Black _______ Yellow _______ Red _______

Voltage To Motor

Non-Operating: B-Y _______ Y-R _______ R-B _______

At Rated Flow of ______ GPM B-Y _______ Y-R _______ R-B _______

At Open Flow ______ GPM B-Y _______ Y-R _______ R-B _______

Amps To Motor

At Rated Flow Of ______ GPM Black _______ Yellow ______ Red ______

At Open Flow ______ GPM Black _______ Yellow ______ Red ______

At Shut Off* Black _______ Yellow ______ Red ______

*Do NOT Run at Shut Off more Than Two (2) minutes.

Warranty On Three Phase Submersible Motors Is Void Unless Subtrol Or Proper Quick Trip Ambient Compensated Protection Is Used On All Three (3) Motor Lines.

If you have any Questions or Problems, Call The Franklin Electric Toll Free Hot Line: 1-800-348-2420

Comments: ____

Submersible Motor Booster Installation Record

Date _____ /_____ / ______ Filled In By ____ RMA No. ______________

Installation

Owner/User: ____ Telephone (_____) ______________

Address: ____________________________________ City ______________ State _____ Zip ______

Installation Site, If Different: ____

Contact: ____ Telephone (_____) ______________

System Application ____

____

____

System Manufactured By: ____

Model ______________ Serial No. ____________

System Supplied By: ____________________________________ City ___________ State _____ Zip ______

Motor

Model No. ____________ Serial No. ____________ Date Code _____

Horsepower: _____ Voltage: _____ Single Phase _____ Or Three Phase _____ Dia: _____ In.

Slinger Removed? Yes _____ No _____ Check Valve Plug Removed? Yes _____ No _____

Pump

Manufacturer: ________________________________ Model ____________ Serial No. ____________

Stages: _____ Diameter ______ Flow Rate Of _____ GPM At _____ TDH

Booster Case: Internal Diameter: _____ Construction ________________________________

Controls and Protective Devices

Subtrol? Yes _____ No ______ If Yes, Warranty Registration No. ________________________

If Yes, Overload Set? Yes _____ No _____ Set At _____

Underload Set? Yes _____ No _____ Set At _____

Reduced Voltage Starter? Yes _____ No _____ If Yes, Type __________________

Mfr. ____________________ Setting __________ % Full Voltage In __________ Seconds

Pump Panel? Yes _____ No _____ If Yes, Mfr. ____________________________ Size ____________

Magnetic Starter/Contactor: Mfr. ________________________ Model ____________ Size ____________

Heaters: Mfr. ______________ No. ________ If Adjustable; Set At ________________________

Fuses: Mfr. ______________ Size ________ Type ______________________________________

Lightning/Surge Arrestor: Mfr. __________________ Model ______________________________

Controls Are Grounded: to _________________ with No. ______________ Wire

Inlet Pressure Control: Yes _____ No _____ If Yes, Mfr. _____________ Model ____________ Setting _______ PSI

Inlet Flow Control: Yes _____ No _____ If Yes, Mfr. _____________ Model ____________ _______ GPM

Outlet Pressure Contol: Yes _____ No _____ If Yes, Mfr. _____________ Model ____________ _______ PSI

Outlet Flow Control: Yes _____ No _____ If Yes, Mfr. _____________ Model ____________ _______ GPM

Water Temperature Control: Yes _____ No _____ If Yes, Mfr. _____________ Model ____________

Set At _____ °F Or _____ °C Located ______________________________________

Submersible Motor Booster Installation Record

Start Up Information

Date: ______ / ______ / ______ Filled In By ______________________________

Insulation Check (Motor Lead to Ground)

Initial Megs: Motor & Lead Only Black _______ Yellow _______ Red _______

Installed Megs: Motor, Lead, & Cable Black _______ Yellow _______ Red _______

Voltage To Motor

Non-Operating: B-Y ________ Y-R _______ R-B _______

At Rated Flow of ______ GPM B-Y ________ Y-R _______ R-B _______

At Open Flow _______ GPM B-Y ________ Y-R _______ R-B _______

Amps To Motor

At Rated Flow Of ______ GPM Black _______ Yellow ______ Red ______

At Open Flow _______ GPM Black _______ Yellow ______ Red ______

At Shut Off* Black _______ Yellow ______ Red ______

*Do NOT Run at Shut Off more Than Two (2) minutes.

Inlet Pressure: ________ PSI Outlet Pressure: ________ Water Temp: ________ °F Or _______ °C

Warranty On Three Phase Submersible Motors Is Void Unless Subtrol Or Proper Quick Trip Ambient Compensated Protection Is Used On All Three (3) Motor Lines.

If you have any Questions or Problems, Call The Franklin Electric Toll Free Hot Line: 1-800-348-2420

Comments: ______________________________

____

____

____

____

____

Please Sketch The System

Splicing Submersible Cables

When the drop cable must be spliced or connected to the motor leads, it is necessary that the splice be water tight. This splice can be made with commercially available potting or heat shrink splicing kits or by careful tape splicing.

Tape splicing should use the following procedure.

A) Strip individual conductor of insulation only as far as necessary to provide room for a stake type connector. Tubular connectors of the staked type are preferred. If connector O.D. is not as large as cable insulation, build-up with rubber electrical tape.

B) Tape individual joints with rubber electrical tape, using two layers; the first extending two inches beyond each end of the conductor insulation end, the second layer two inches beyond the ends of the first layer. Wrap tightly, eliminating air spaces as much as possible.

C) Tape over the rubber electrical tape with #33 Scotch electrical tape, (Minnesota Mining Co.) or equivalent, using two layers as in step "B" and making each layer overlap the end of the preceding layer by at least two inches.

In the case of a cable with three conductors encased in a single outer shealth, tape individual conductors as described, staggering joints.

Total thickness of tape should be no less than the thickness of the conductor insulation.

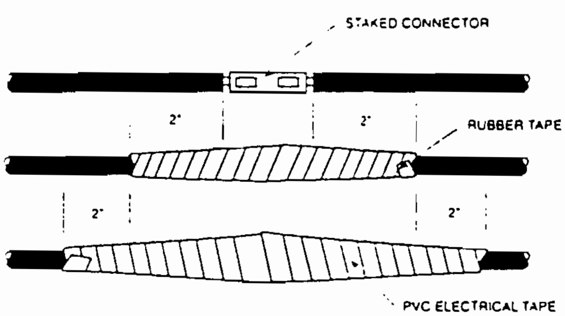


FIG 13

Tightening Motor Lead Connector Jam Nut

4" Motors-15 to 20 Lb. Ft. (2.1 to 2.8 Meter-KG)
6" Motors-60 to 70 Lb. Ft. (8.3 to 9.7 Meter-KG)
8" Motors-120 to 150 Lb. Ft. (16.6 to 20.7 Meter-KG)

A motor lead assembly should not be reused. A new lead assembly should be used whenever one is removed from the motor, because rubber set and possible damage from the removal may prevent proper resealing of the old lead.

All 6" & 8" motors returned to Franklin Electric or any FAMS for warranty consideration must have the motor lead returned with the motor.

Pump to Motor Coupling

Assemble coupling with non-toxic waterproof grease such as Mobil FM2, Texaco Regal AFB2, or equivalent. Besides prolonging spline life of motor and coupling, it prevents abrasives from entering the spline area.

Table 18 Shaft Height and Free End Play

Motor	Nominal Shaft Height	Dimension Shaft Height	Free End Play	
			Min.	Max.
4" Super Stainless	1 1/2"	1.508" / 1.498"	.010"	.045"
4" High Thrust	1 1/2"	1.508" / 1.498"	.010"	.045"
6"	2 7/8"	2.875" / 2.869"	.030"	.050"
8"	4"	4.000" / 3.990"	.008"	.020"
8" x 6"	2 7/8"	2.875" / 2.869"	.008"	.020"

1 Inch = 24.5 Millimeter

If the shaft height measured from the pump mounting surface of a motor is low and/or end play exceeds the limit, the motor thrust bearing is possibly damaged, and should be replaced.

System Trouble Shooting

Motor Does Not Start

Cause of Trouble	Checking Procedure	Corrective Action
A. No Power or incorrect voltage	Using voltmeter check the line terminals Voltage must be ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Fuses blown or circuit breakers tripped	Check fuses for recommended size and check for loose, dirty or corroded connections in fuse receptacle. Check for tripped circuit breaker.	Replace with proper fuse or reset circuit breaker.
C. Defective Pressure switch.	Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage.	Replace pressure switch or clean points.
D. Control box malfunction.	For detailed procedure, see page 29, 30 & 31.	Repair or replace
E. Defective wiring.	Check for loose or corroded connections Check motor lead terminals with voltmeter for power.	Correct faulty wiring or connections
F. Bound Pump.	Locked rotor conditions can result from misalignment between pump and motor or a sand bound pump. Amp readings 3 to 6 times higher than normal will be indicated.	If pump will not start with several trials it must be pulled and the cause corrected. New installations should always be run without turning off until water clears.
G. Defective cable or motor.	For detailed procedure, see pages 26, 27 & 28.	Repair or replace

Motor Starts Too Often

A. Pressure switch.	Check setting on pressure switch and examine for defects.	Reset limit or replace switch.
B. Check valve, stuck open.	Damaged or defective check valve will not hold pressure.	Replace if defective.
C. Waterlogged tank, (air supply)	Check air charging system for proper operation.	Clean or replace.
D. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.

System Trouble Shooting

Motor Runs Continuously

Cause of Trouble	Checking Procedure	Corrective Action
A. Pressure switch.	Switch contacts may be "welded" in closed position. Pressure switch may be set too high.	Clean contacts replace switch, or readjust setting.
B. Low level well.	Pump may exceed well capacity. Shut off pump, wait for well to recover. Check static and drawdown level from well head.	Throttle pump output or reset pump to lower level. Do not lower if sand may clog pump.
C. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.
D. Worn pump.	Symptoms of worn pump are similar to those of drop pipe leak or low water level in well. Reduce pressure switch setting, if pump shuts off worn parts may be at fault. Sand is usually present in tank.	Pull pump and replace worn impellers, casing or other close fitting parts.
E. Loose or broken motor shaft.	No or little water will be delivered if coupling between motor and pump shaft is loose or if a jammed pump has caused the motor shaft to shear off.	Check for damaged shafts if coupling is loose and replace worn or defective units.
F. Pump screen blocked.	Restricted flow may indicate a clogged intake screen on pump. Pump may be installed in mud or sand.	Clean screen and reset at less depth. It may be necessary to clean well.
G. Check valve stuck closed.	No water will be delivered if check valve is in closed position.	Replace if defective.
H. Control box malfunction.	See page 29, 30 & 31 for single phase.	Repair or replace

Motor Runs But Overload Protector Trips

A. Incorrect voltage	Using voltmeter, check the line terminals. Voltage must be within ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Overheated protectors.	Direct sunlight or other heat source can make control box hot causing protectors to trip. The box must not be hot to touch.	Shade box, provide ventilation or move box away from heat source.
C. Defective control box.	For detailed procedures, see pages 29, 30 & 31.	Repair or replace
D. Defective motor or cable.	For detailed procedures, see pages 26, 27 & 28.	Repair or replace
E. Worn pump or motor.	Check running current, See pages 11, 14 & 15.	Replace pump and/or motor.

Table 19 Preliminary Tests - All Sizes-Single & Three Phase

What Is to Be Done	The Results	What It Means
Measure resistance from any cable to ground. (Insulation resistance)	Ohms will be per Table 20	1. If the ohm value is normal, the motor windings are not grounded and the cable insulation is not damaged. 2. If the ohm value is below normal, either the windings are grounded or the cable insulation is damaged. Check the cable at the well seal as the insulation is sometimes damaged by being pinched.
Measure winding resistance. (Resistance between leads)	Ohms will be per Tables 8, 12 & 13.	1. If all ohm values are normal, the motor windings are neither shorted nor open, and the cable colors are correct. 2. If any one ohm value is less than normal, the motor is shorted. 3. If any one ohm value is greater than normal, the winding or the cable is open, or there is a poor cable joint or connection. 4. If some ohm values are greater than normal and some less on single phase motors, the leads are mixed. See page 28 to verify cable colors.

How to Measure Insulation Resistance.

1. Set the scale lever to R x 100K and set the ohmmeter on zero.

2. CAUTION

Open master breaker and disconnect all leads from control box or pressure switch (Q-D type control, remove lid) to avoid damage to meter or electric shock hazard. Connect one ohmmeter lead to any one of the motor leads and the other lead to the metal drop pipe. If the drop pipe is plastic, connect the ohmmeter lead to ground.

How to Measure Winding Resistance.

1. Set the scale lever to R x 1 for values under 10 ohms. For values over 10 ohms, set the scale lever to R x 10. Zero balance the ohmmeter.

2. CAUTION

Open master breaker and disconnect all leads from control box or pressure switch (Q-D type control, remove lid) to avoid damage to meter or electric shock hazard.

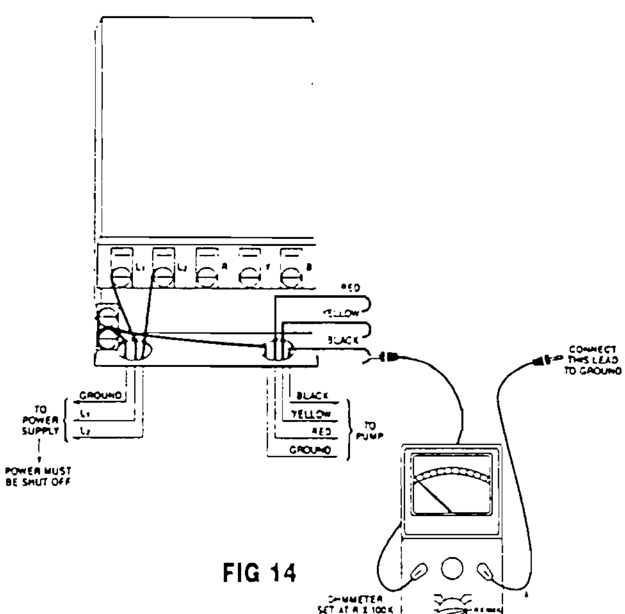


FIG 14

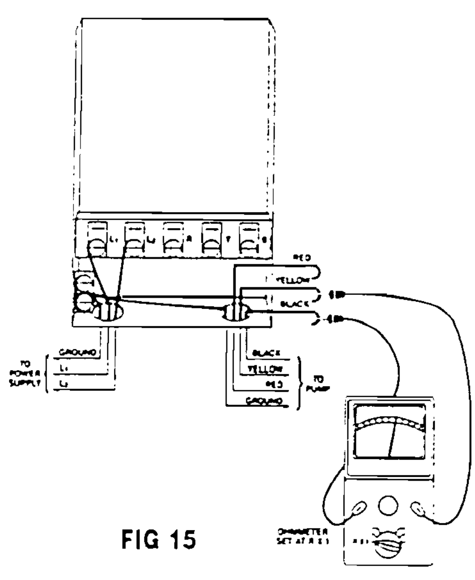


FIG 15

Insulation Resistance Readings

Table 20 Normal Ohm and Megohm Values Between All Leads and Ground

Insulation resistance varies very little with rating. Motors of all HP, voltage, and phase rating have similar values of insulation resistance.

Condition of Motor and Leads	OHM Value	MEGOHM Value
A new motor (without drop cable).	20,000,000 (or more)	20.0
A used motor which can be reinstalled in the well	10,000,000 (or more)	10.0
MOTOR IN WELL. Ohm readings are for drop cable plus motor.		
A new motor in the well.	2,000,000 (or more)	2.0
A motor in the well in reasonably good condition.	500,000 - 2,000,000	0.5 - 2.0
A motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason.	20,000 - 500,000	0.02 - 0.5
A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will not fail for this reason alone, but it will probably not operate for long.	10,000 - 20,000	0.01 - 0.02
A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced.	less than 10,000	0 - 0.01

Resistance of Drop Cable (Ohms)

The values below are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher for each foot of cable of the same size. To determine the actual resistance of aluminum drop cable, divide the ohm readings from this chart by 0.61. This chart shows total resistance of cable from control to motor and back.

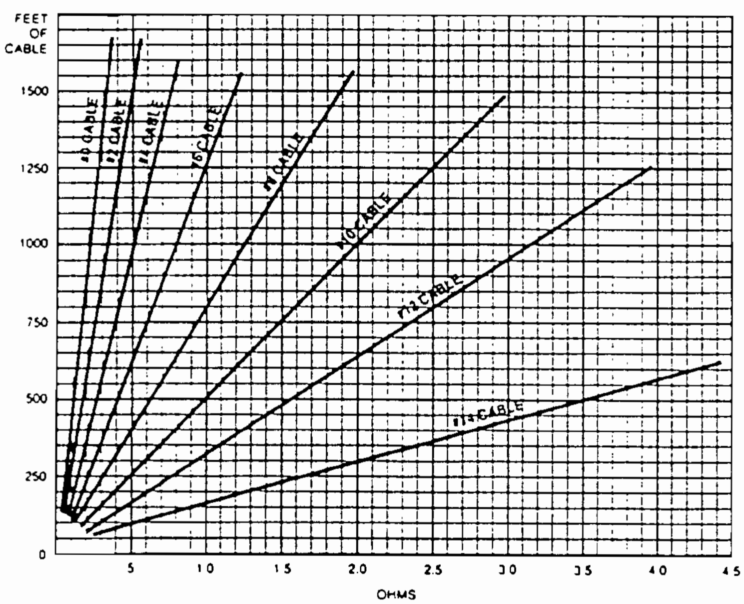


FIG 16

Winding Resistance Measuring

When measured as shown in FIG 15 page 26, motor resistance should fall within the values in Tables 8, 12 & 13. When measured through the drop cable, the resistance of the drop cable as determined from the chart at the left, must be subtracted from the ohmmeter reading to get the winding resistance of the motor.

Meter Connections for Motor Testing

FIG 17

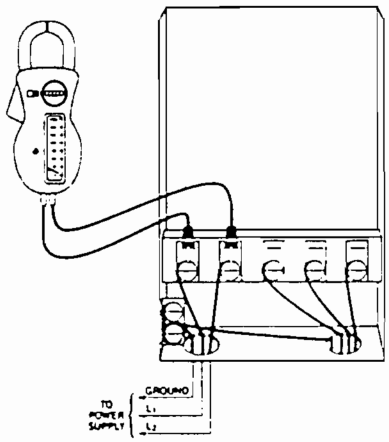
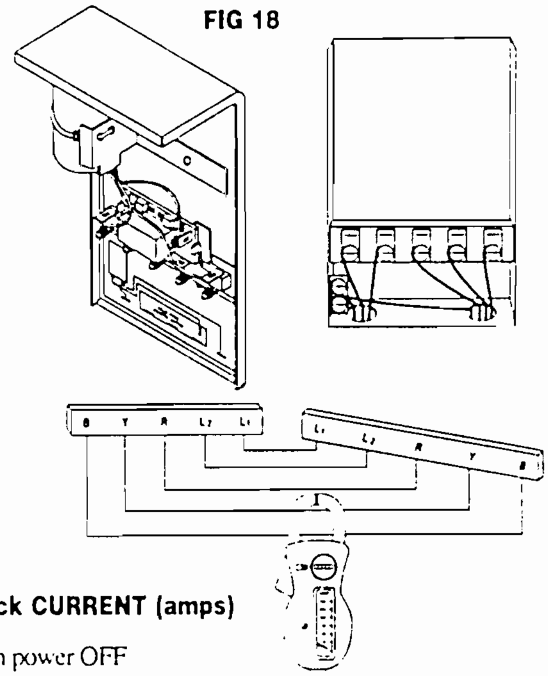


FIG 18



To Check VOLTAGE

1. Turn power OFF

2. Remove QD cover to break all motor connections.

CAUTION: L1 & L2 are still connected to the power supply.

3. Turn power ON.

4. Use voltmeter as shown.

To Check CURRENT (amps)

1. Turn power OFF

2. Connect test cord (No. 150961901) as shown.

3. Turn power ON.

4. Use hook-on type ammeter as shown.

CAUTION: Both voltage and current tests require live circuits with power ON.

Indentification Of Cables When Color Code Is Missing

(FOR SINGLE PHASE 3-WIRE UNITS ONLY)

If the colors on the individual drop cables cannot be found: that is, if no colored threads are visible and no identifying ribs are present and the leads cannot be identified.

With an ohmmeter, measure:
Cable 1 to cable 2
Cable 2 to cable 3
Cable 3 to cable 1

Find the highest resistance reading.

The lead not used in the highest reading is the yellow lead.

Use the yellow lead and each of the other two leads to get two readings:
Highest is the Red lead
Lowest is the Black lead

Example

Suppose that the ohmmeter readings were:
Cable 1 to cable 2---6 ohms
Cable 2 to cable 3---2 ohms
Cable 3 to cable 1---4 ohms

The lead not used in the highest reading (6 ohms) was
Cable 3---Yellow

From the Yellow lead, the highest reading (4 ohms) was
To Cable 1---Red

From the Yellow lead, the lowest reading (2 ohms) was
To Cable 2---Black

Singie Phase Control Boxes

Checking and Repairing Procedures (Power On)

CAUTION: Power must be on for these tests. Do not touch any live parts.

A. General Procedures:

1. Establish line power.
2. Check no load voltage (pump not running).
3. Check load voltage (pump running).
4. Check current (amps) in all motor leads.

B. Use of Volt/Amp meter:

1. Meter such as Amprobe Model RS300 or equivalent may be used.
2. Select scale for voltage or amps depending on tests.
3. When using amp scales, select highest scale to allow for inrush current, then select for midrange reading.

C. Voltage Measurements:

Step 1, no load.

1. Measure voltage at L1 and L2 of pressure switch or line contactor.
2. Voltage Reading: Should be ± 10% of motor rating.

Step 2, load.

1. Measure voltage at load side of pressure switch or line contactor with pump running.
2. Voltage Reading: Should remain the same except for slight dip on starting.

D. Current (Amp) Measurements:

1. Measure current on all motor leads. Use 5 conductor test cord for Q.D. control boxes.
2. Amp Reading: Current in Red lead should be momentarily high, then drop within one second to values on page 11. This verifies relay or solid state relay operation. Current in Black and Yellow leads should not exceed values on page 11.

E. Voltage Symptoms:

1. Excessive voltage drop on starting.
2. Causes: Loose connections, bad contacts or ground faults, or inadequate power supply.

F. Current Symptoms:

1. Relay or switch failures will cause Red lead current to remain high and overload tripping.
2. Open run capacitor(s) will cause amps to be higher than normal in the Black and Yellow motor leads and lower than normal or zero amps in the Red motor lead.
3. Relay chatter is caused by low voltage or ground faults.
4. A bound pump will cause locked rotor amps and overloading tripping.
5. Low amps may be caused by pump running at shutoff, worn pump or stripped splines.
6. Failed start capacitor or open switch/relay are indicated if the red lead current is not momentarily high at starting.

CAUTION:

The tests in this manual for components such as capacitors, relays, and solid state switches should be regarded as indicative and not as conclusive. For example, a capacitor may test good (not open, not shorted) but it may have lost some of it's capacitance and may no longer be able to perform its function.

To verify proper operation of solid state switches or relays, refer to operational test procedure described in paragraph D-2.

Single Phase Control Boxes

Checking and Repairing Procedures (Power Off)

CAUTION: Turn power off at the power supply panel and discharge capacitors before using ohmmeter.

A. General Procedures:

1. Disconnect line power.
2. Inspect for damaged or burned parts, loose connections, etc.
3. Check against diagram in control box for misconnections.
4. Check motor insulation and winding resistance.

B. Use of Ohmmeter:

1. Ohmmeter such as Simpson Model 372 or 260. Triplet Model 630 or 666 may be used.
2. Whenever scales are changed, short ohmmeter lead together and "zero balance" meter.

C. Ground (Insulation Resistance) Test:

1. Ohmmeter Setting: Highest scale Rx 10K, or Rx 100K
2. Terminal Connections: One ohmmeter lead to "Ground" terminal or Q.D. control box lid and touch other lead to the other terminals on the terminal board.
3. Ohmmeter Reading: Pointer should remain at infinity (∞).

Ohmmeter Tests Quick Disconnect (QD) Solid State Control Box

A. Start Capacitor

1. Meter Setting: R x 1,000.
2. Connections: Capacitor terminals.
3. Correct meter reading: Pointer should swing toward Zero, then back to infinity.

B. Solid State Switch

Step 1, Triac Test

1. Meter Setting: R x 1,000.
2. Connections: R(Start) terminal and orange lead on start switch.
3. Correct meter reading: Infinity for all models.

Step 2 Coil Test

1. Meter Setting: R x 1.
2. Connections: Y(Common) and L2.
3. Correct meter reading: Zero ohms for all models.

C. Potential (Voltage) Relay

Step 1, Coil Test

1. Meter setting: R x 1,000.
2. Connections: #2 & #5
3. Correct meter readings:
   For 115 Volt Boxes
   .7-1.8 (700 to 1,800 ohms).
   For 230 Volt Boxes
   4.5-7.0 (4,500 to 7,000 ohms).

Step 2, Contact Test

1. Meter setting: R x 1.
2. Connections: #1 & #2.
3. Correct meter reading: Zero for all models.

D. Current Relay

Step 1, Coil Test.

1. Meter setting: R x 1.
2. Connections: #1 & #3
3. Correct meter reading: Less than 1 ohm for all models.

Step 2, Contact Test

1. Meter setting: R x 1,000.
2. Connections: #2 & #4
3. Correct meter reading: Infinity for all models.

Additional Tests Solid State Capacitor Run (CRC) Control Box

E. Run Capacitor

1. Meter setting: R x 1,000
2. Connections: Red and Black leads
3. Correct meter reading: Pointer should swing toward zero, then drift back to infinity.

F. Inductance Coil

1. Meter setting: R x 1
2. Connections: Orange leads
3. Correct meter reading: Less than 1 ohm.

G. Solid State Switch

Step 1 Triac Test

1. Meter setting: R x 1,000
2. Connections: R(Start) terminal and Orange lead on start switch.
3. Correct meter reading: Should be near infinity after swing.

Step 2, Coil Test

1. Meter setting: R x 1
2. Connections: Y(Common) and L2.
3. Correct meter reading: Zero ohms.

Ohmmeter Tests
Integral Horsepower Control Box (Power Off)

A. OVERLOADS (Push Reset Buttons to make sure contacts are closed.
1. Meter Setting: R x 1.
2. Connections: Overload terminals.
3. Correct meter reading: Should not be more than 0.5 ohms.

B. CAPACITOR (Disconnect leads from one side of each capacitor before checking.)
1. Meter Setting: R x 1,000.
2. Connections: Capacitor terminals.
3. Correct meter reading: Pointer should swing toward zero, then drift back to infinity, except for capacitors with resistors which will drift back to 15,000 ohms.

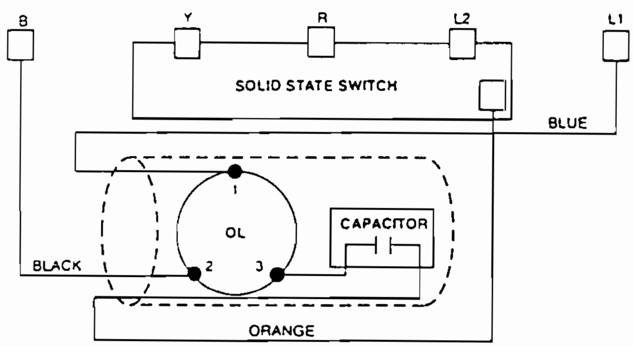
C. RELAY COIL (Disconnect lead from Terminal #5)
1. Meter Setting: R x 1,000.
2. Connections: #2 & #5.
3. Correct meter readings: 4.5-7.0 (4,500 to 7,000 ohms) for all models.

D. RELAY CONTACT (Disconnect lead from Terminal #1)
1. Meter Setting: R x 1.
2. Connections: #1 & #2.
3 Correct meter reading: Zero ohms for all models.

E. CONTACTOR COIL (Disconnect lead from one side of coil)
1. Meter Setting: R x 100.
2. Connections: Coil terminals.
3. Correct meter reading: 180 to 1,400 ohms

F. CONTACTOR CONTACTS
1. Meter Setting: R X 1.
2. Connections: L1 & T1 or L2 & T2.
3. Manually close contacts.
4. Correct meter reading: Zero ohms.

To Replace A Relay (Voltage Or Current) With A Solid State Switch.
FIG 19

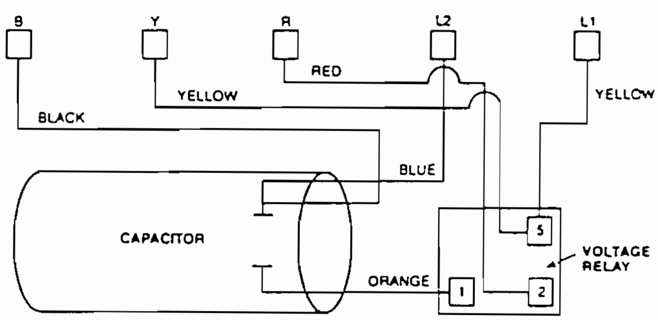


Control Box Wiring Diagram With Solid State Switch

1. Disconnect power to control box.
2. Remove control box cover. Disconnect all leads from the relay and terminal strip. Discard all loose leads.
3. Plug solid state switch into center terminals (Y, R, L2) on the side of the terminal strip nearest to the capacitor.
4. Connect all three leads from capacitor as follows:
   A. Blue lead to the "L1" terminal.
   B. Orange lead to the terminal on the solid state switch.
   C. Black lead to the "B" main terminal.

NOTE: **Do not** add running capacitors to standard production 1/3 through 1 HP control boxes which use current relays or solid state starting relays. **Adding capacitors will cause failures.** If the control box is converted to use a voltage relay, the specified running capacitance can be added.

To Replace A Solid State Switch With A Voltage Relay.
FIG 20



Control Box Wiring Diagram With Voltage Relay

1. Disconnect power to the control box.
2. Remove control box cover. Disconnect orange lead from the solid state switch. Disconnect the blue lead from the "L1" terminal.
3. Remove solid state switch from the three center terminals. Install voltage relay next to capacitor.
4. Connect orange and blue leads from capacitor as follows:
   A. Orange lead to relay terminal #1.
   B. Blue lead to "L2" terminal.
   C. Black lead stays on "B" (main) terminal.
5. Make a red jumper wire and connect it from "R" (start) terminal to relay terminal #2.
6. Make two yellow jumper wires. Connect one jumper from "Y" (common) terminal to relay terminal #5.
   Connect the other jumper from relay terminal #5 to "L1" terminal.
7. Replace cover on the control box and reconnect power.

Note: Voltage relay kits include necessary jumper wires and mounting hardware.

Table 21 QD Control Box Parts

HP	Volts	Control Box Model No.	Solid State Switch	Start Capacitor	MFD	Volts	Run Capacitor	MFD	Volts	Inductance Coil
1/3	115	2801024910	152138905	275464125	159-191	125				
	230	2801034910	152138901	275464126	43-53	250				
1/2	115	2801044910	152138906	275464201	250-300	125				
	230	2801054910	152138902	275464105	59-71	250				
	230	2824055010	152138912	275470115	43-52	220	155328101	15	370	155662901
3/4	230	2801074910	152138903	275464118	86-103	250				
	230	2824075010	152138913	275470114	108-130	220	155327108	23	370	155662901
1	230	2801084910	152138904	275464113	105-126	250				
	230	2824085010	152138914	275470114	108-130	220	155327108	23	370	155662901

FOOTNOTES:
(1) Control boxes supplied with solid state relays are designed to operate on nominal 230v systems. For 208 v systems or where line voltage is between 200v and 210v use cable 2 sizes larger, or use boost transformer to raise the voltage to 230 volts.
(2) Voltage relay kits 115 volt, 155 031 901 and 230 volt, 155 031 902 will replace either current voltage or solid state switch relays.
(3) Q-D control boxes produced H85 or later do not contain an overload in the capacitator. On winding thermal overloads were added to three-wire motors rated 1/3-1 hp in A85. If a control box dated H85 or later is applied with a motor dated M84 or earlier, overload protection can be provided by adding an overload kit to the control box.

Table 22 "QD" OVERLOAD KITS

HP	Volts	Kit Number
1/3	115	305091 901
1/3	230	305091 902
1/2	115	305091 903
1/2	230	305091 904
3/4	230	305091 905
1	230	305091 906

TABLE 23 Integral Horsepower Control Box Parts

Motor Rating HP, Dia.	Control Box (1) Model No.	Capacitors Part No.	Mfd. Units	Volts	Qty.	Overload (2) Part No.	Relay (7) Part No.	Contactor (2) Part No.
1 1/2-4"	282 3008 110	275 464 113 S	105-126	220	1	275 411 107	155 031 102	
		155 328 102 R	10	370	1			
	282 3007 202 or	275461 107 S	105-126	220	1	151496 922	151 031 102	
	282 3007 102	275 479 102 R (5)	10	370	1	151 033 946 (3)		
	282 3007 203 or	275 461 107 S	105-126	220	1	151 496 922	151031102	
	282 3007 103	155 328 102 R	10	370	1	151 033 946 (3)		
2-4"	282 3018 110	275 464 113 S	105-126	220	1	275 411 107 S	155 031 102	
		155 328 103 R	20	370	1	275 411 113 M		
	282 3018 202	275 464 113 S	104-126	220	1	275 411 107 S	155 031 102	
		275 479 105 R (5)	20	370	1	275 411 112 R		
	282 3018 203 or	275 464 113 S	104-126	220	1	275 411 107 S	155 031 102	
	282 3018 103	155 328 103 R	20	370	1	275 411 113 M		
2-4"	282 3018 310	275 464 113 S	105-126	220	1	275 411 107 S	155 031 102	155 325 102 L
DLX		155 328 103 R	20	370	1	275 411 112 M		
	282 3019 103	275 464 113 S	105-126	220	1	275 411 107 S	155 031 102	155 325 102 L
		155 328 103R	20	370	1	275 411 102R	155 031 102	155 325 102 L
3-4"	282 3028 110	275 463 111 S	208-250	220	1	275 411 108 S	155 031 102	
		155 327 102 R	35	370	1	275 411 115 M		
	282 3028 202	275 463 11 S	208-250	220	1	275 411 108 S	155 031 102	
		275 481 102 R (5)	35	370	1	275 406 120 M		
	282 3028 203 or	275 463 111 S	208-250	220	1	275 411 108 S	155 031 102	
	282 3028 103	155 327 102 R	35	370	1	275 406 120 M		
3-4"	282 302 8310	275 463 111 S	208-250	220	1	275 411 108 S	155 031 102	155 325 102 L
DLX		155 327 102 R	35	370	1	275 411 115 M		
	282 3029 103	275 463 111 S	208-250	220	1	275 411 108 S	155 031 102	155 325 102 L
		155 327 102 R	35	370	1	275 406 120 M		
5-4"	282 113 8110	275 468 118 S	216-259	330	1	275 411 102 S	155 031 102	
		155 327 101 R	30	370	2	275 406 103 M		
	282 1139 202	275 468 118 S	216-159	330	1	275 411 102 S	155 031 102 (6)	
		275 479 103 R (5)	15	370	4	275 406 103 M		
	282 1139 203 or	275 468 118 S	216-259	330	1	275 411 102 S	155 031 102 (6)	
	282 1139 003	155 327 101 R	30	370	2	275 406 103 M		
5-4" & 6"	282 113 8310	275 468 118 S	216-259	330	1	275 411 102 S	155 031 102	155 325 102 L
DLX		155 327 101 R	30	370	2	275 406 103 M		
	282 1139 303 or	275 468 118 S	216-259	330	1	275 411 102 S	155 031 102 (6)	155 325 102L
	282 1139 103	155 327 101 R	30	370	2	275 406 103 M		

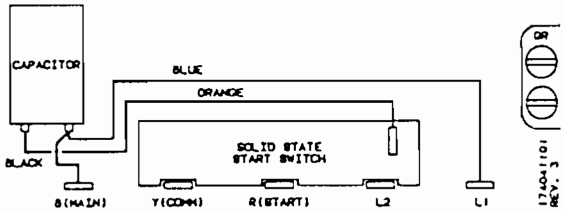
Table 24 Integral Horsepower Control Box Parts

Motor Rating HP. Dia.	Control Box (1) Model No.	Control				Overload (2) Part No.	Relay (7) Part No.	Contactor (2) Part No.
		Pat No.	Mtd. Units	Volts	Qty			
5-6"	282 2009 202	275 468 117 S	130-154	330	2	155 249 102	155 031 601	
		275 479 103 R (5)	15	370	2			
	282 2009 203	275 468 177 S	130-154	330	2	155 249 102	155 031 601	
		155 327 101 M	30	370	1			
DLX	282 2009 303	275 468 117 S	130-154	330	2	155 249 102	155 031 601	155 325 102 L
		155 327 101 M	30	370	1			
7 1/2-6"	282 201 9210	275 468 119 S	270-324	330	1	275 411 102 S	155 031 601	
		275 468 117 S	130-154	330	1	275 406 121 M		
		155 327 109 M	45	370	1			
	282 2019 202	275 468 117 S	130-154	330	3	155 249 101	155 031 601	
		275 479 103 R (5)	15	370	3			
	282 2019 203	275 468 117 S	130-154	330	3	155 249 101	155 031 601	
		155 327 101 M	30	370	1			
		155 328 101 M	15	370	1			
DLX	282 201 9310	275 468 119 S	270-324	330	1	275 411 102S	155 031 601	155 326 101 L
		275 468 117 S	130-154	330	1	275 406 121 M		
		155 327 109 M	45	370	1			
DLX	282 2019 303	275 468 117 S	130-154	330	3	155 249 101	155 031 601	155 326 101 L
		155 327 101 M	30	370	1			
		155 328 101 M	15	370	1			
10-6"	282 202 9210	275 468 119 S	270-324	330	2	275 406 103 S	155 031 601	
		155 327 102 M	35	370	2	155 409 101 M		
	282 2029 202	275 468 117 S	130-154	330	4	155 249 103	155 031 601 (4)	
		275 479 103 M (5)	15	370	5			
	282 2029 203	275 468 117 S	130-154	330	4	155 249 103	155 031 601 (4)	
		155 327 101 M	30	370	2			
		155 328 101 M	15	370	1			
DLX	282 202 9310	275 468 119 S	270-324	330	2	275 406 103 S	155 031 601	155 326 102 L
		155 327 102 M	35	370	2	155 409 101 M		
DLX	282 2029 207	275 468 119 S	270-324	330	2	155 409 101	155 031 102 (6)	155 325 102 S
		155 327 101 M	30	370	2			
		155 328 101 M	15	170	1			
DLX	282 2029 303	275 468 117 S	130-154	330	4	155 249 103	155 031 601 (4)	155 326 102 L
		155 327 101 M	30	370	2			
		155 328 101 M	15	370	1			
DLX	282 2029 307	275 468 119 S	270-324	330	2	155 409 101	155 031 102 (6)	155 326 102 L
		155 327 101 M	30	370	2			155 325 102 S
		155 328 101 M	15	370	1			
15-6"	282 203 9310	275 468 119 S	270-324	330	2	275 406 103 S	155 031 601	155 429 101 L
		155 327 109 M	45	370	3	155 409 102 M		
DLX	282 2039 303	275 468 119 S	270-324	330	2	155 409 102	155 031 102 (6)	155 429 101 L
		155 327 101 M	30	370	4			155 325 102 S
		155 327 101 M	15	370	1			

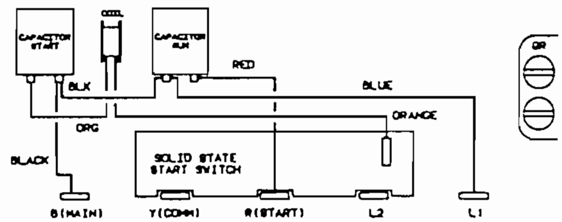
FOOTNOTES:
(1) Lightning arrestor 150 814 902 suitable for all control boxes
(2) S=Start M=Main L=Line
DLX = Deluxe control box with line contactor.
(3) Capacitor and overload ass'y.
(4) 2 required
(5) These parts may be replaced as follows:

Old	New
275 479 102	155 328 102
275 479 103	155 328 101
275 479 105	155 328 103
275 481 102	155 327 102

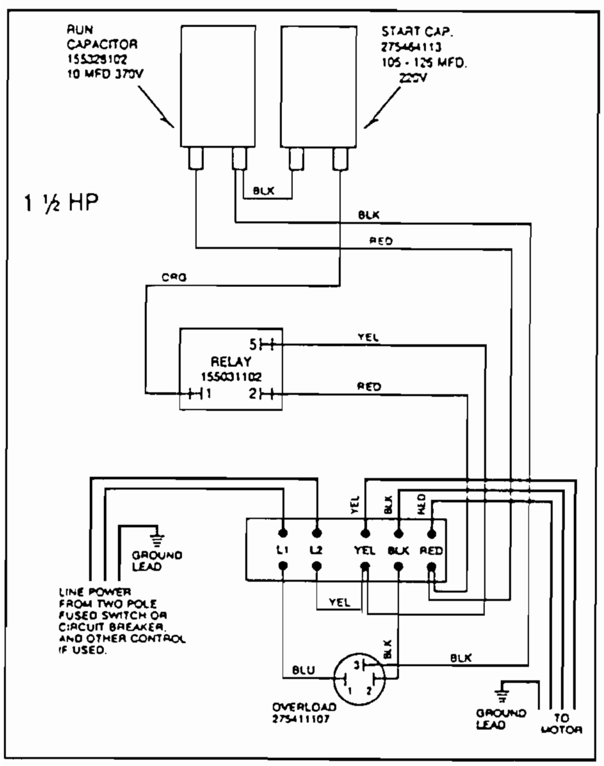
(6) May be replaced with 155 031 601 heavy duty relay.
(7) For 208v systems or where line voltage is between 200v and 210 volts special low voltage relays are required. Use relay part 155 031 103 in place of part 155 031 601, use cable 2 sizes larger, or boost transformer, to raise the voltage to 230 volts.



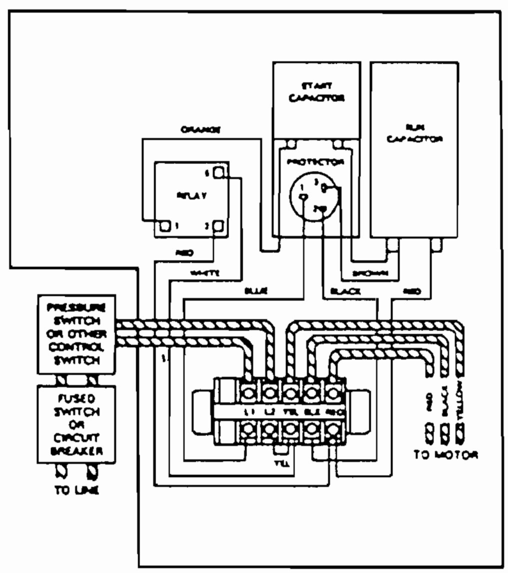
4"
1/3-1 HP Q.D.
280 10-4 910
Sixth digit depends on HP



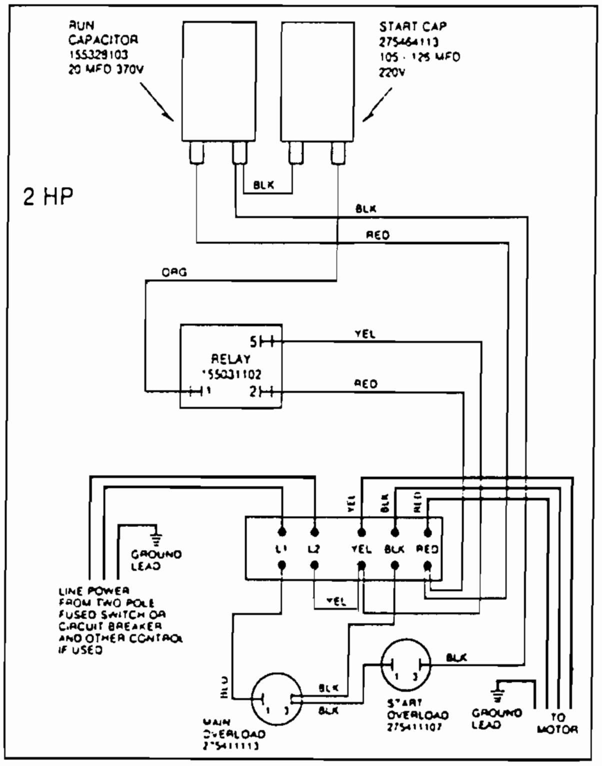
4"
1/2 - 1 HP CRC
282 40-5010
Sixth digit depends on HP



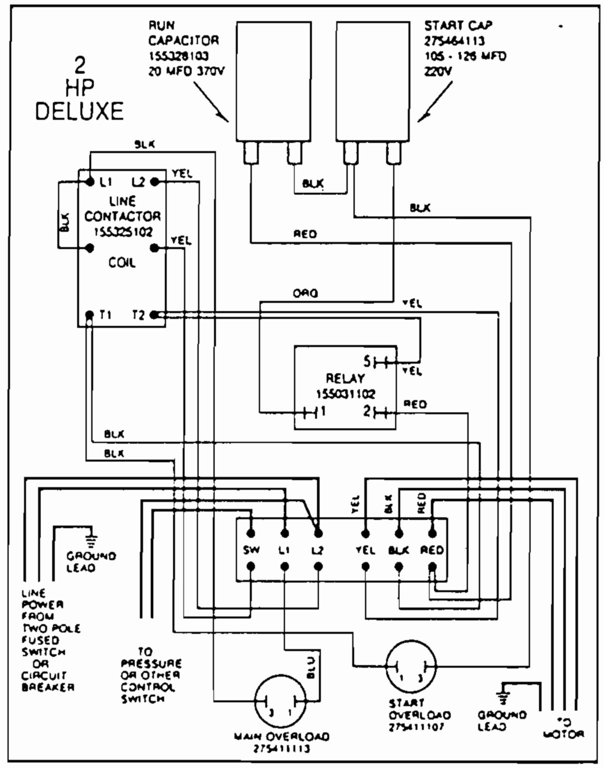
4" STANDARD
1 1/2 HP
282 300 8110



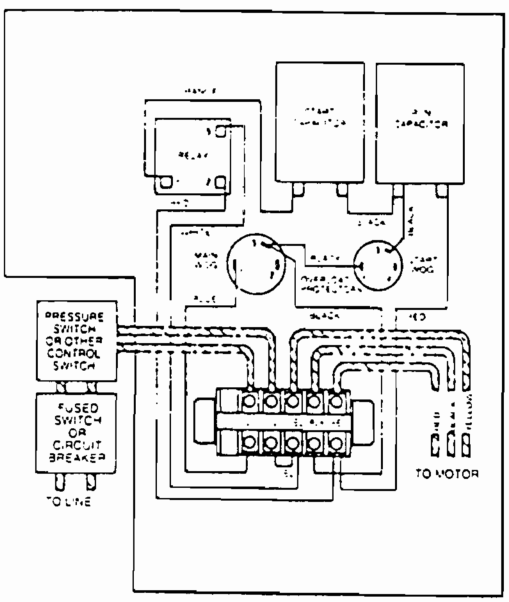
4"
1 1/2 HP
STANDARD
282 3007 103



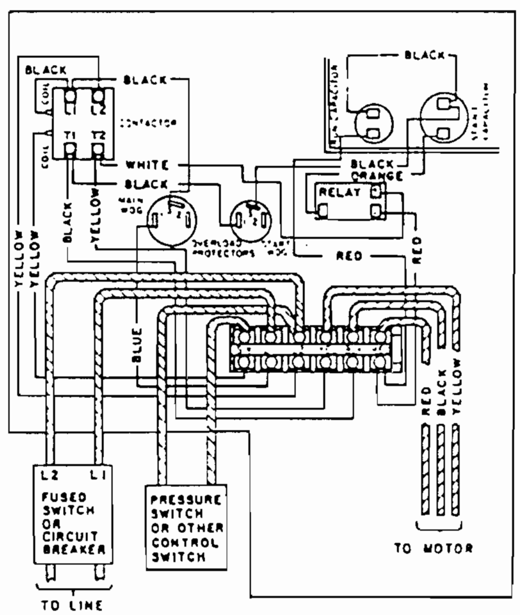
4" STANDARD
2 HP
282 301 8110



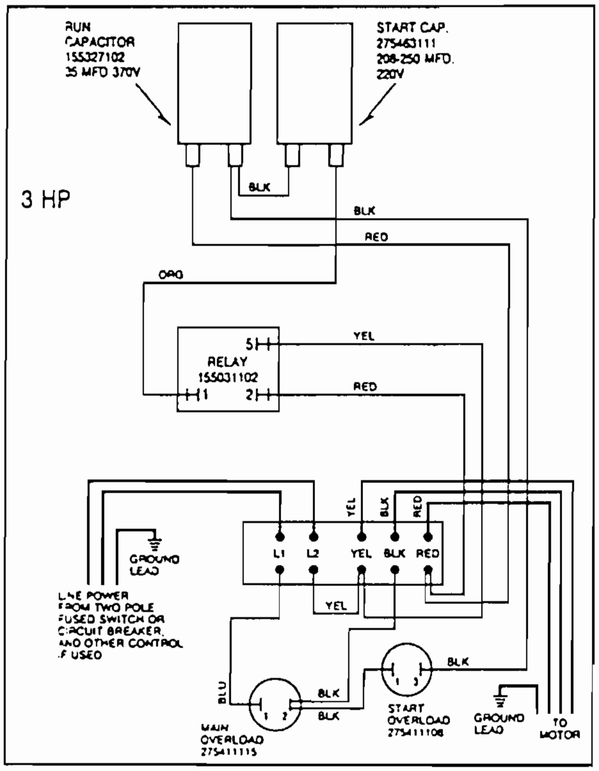
4" DELUXE
2 HP
282 301 8310



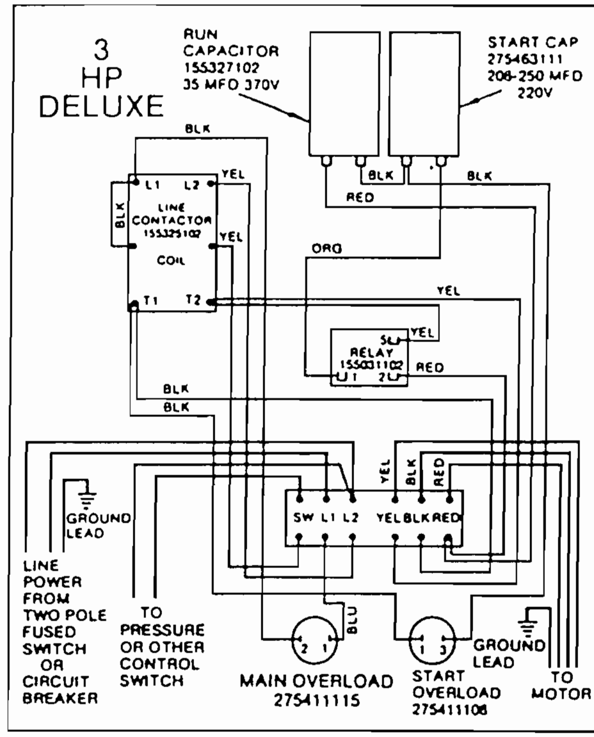
4"
2 AND 3 HP
STANDARD
282 3018 103
282 3028 103



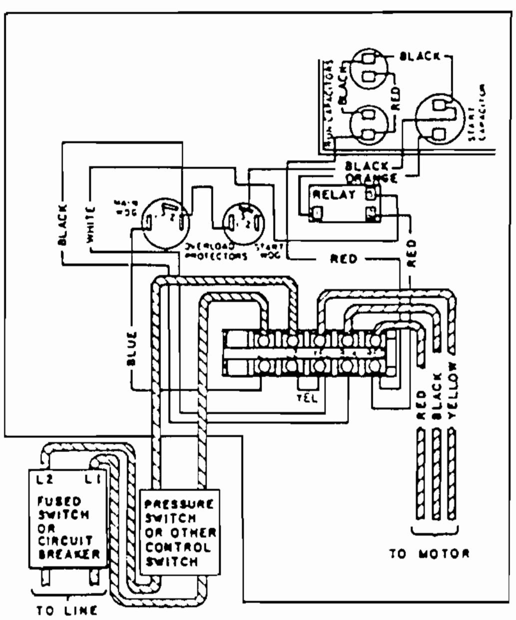
4"
2 AND 3 HP
DELUXE
282 3019 103
282 3029 103



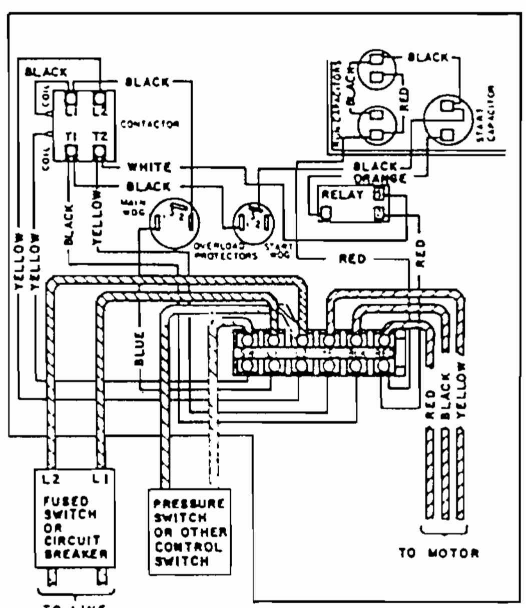
4" STANDARD
3 HP
282 302 8110



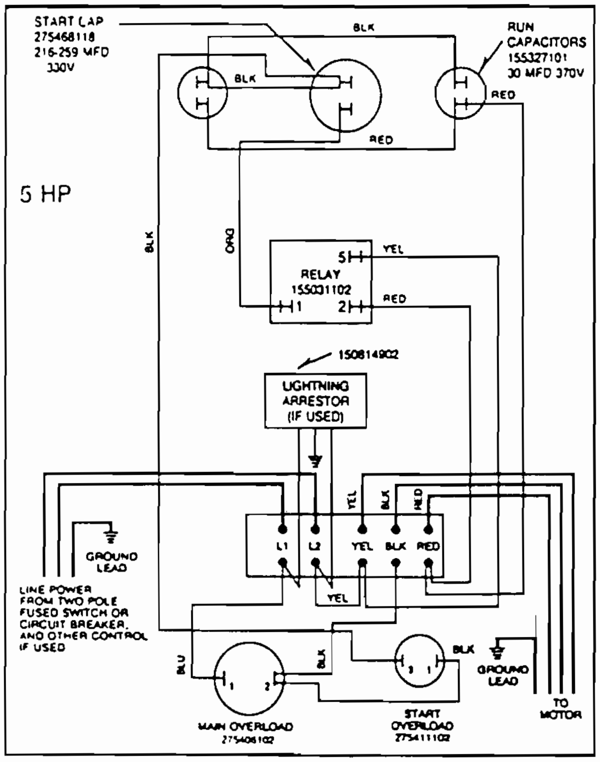
4" DELUXE
3 HP
282 302 8310



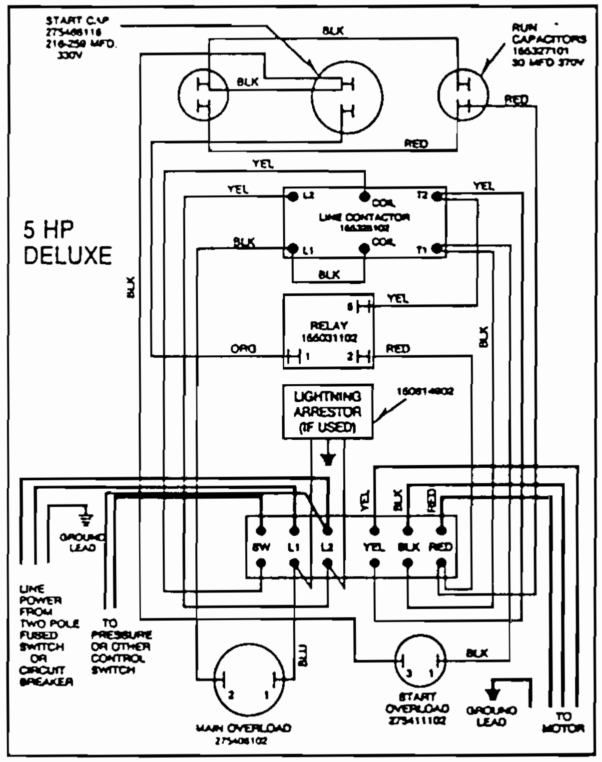
4"
5 HP
STANDARD
282 1139 003



4"
5 HP
DELUXE
282 1139 103



4" AND 6" STANDARD
5 HP
282 113 8110



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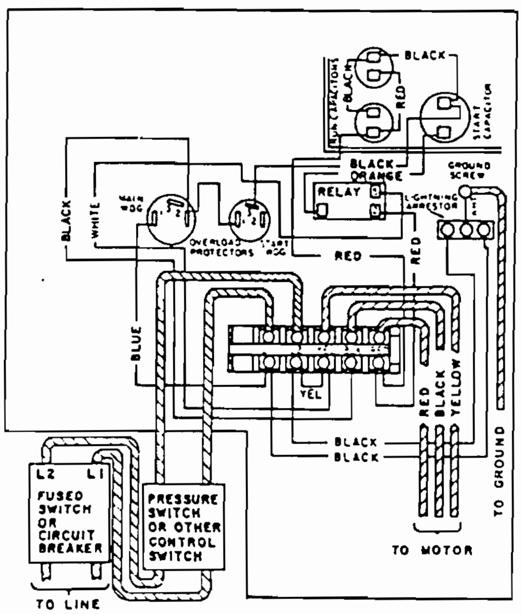

6"
5HP
STANDARD
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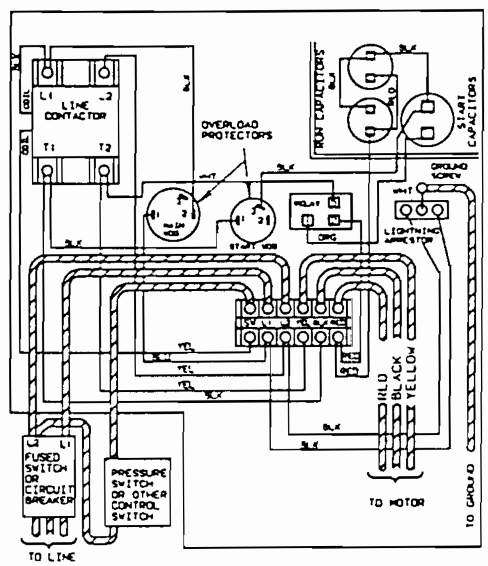

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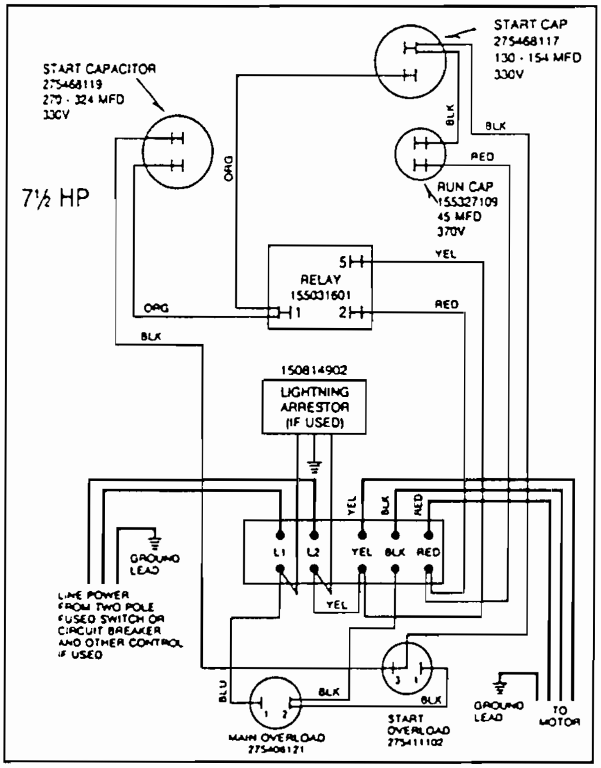

6" STANDARD
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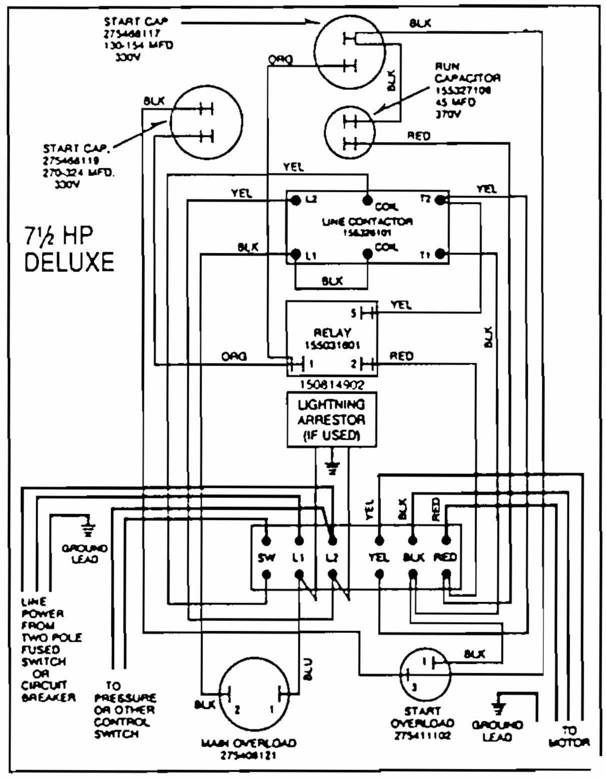

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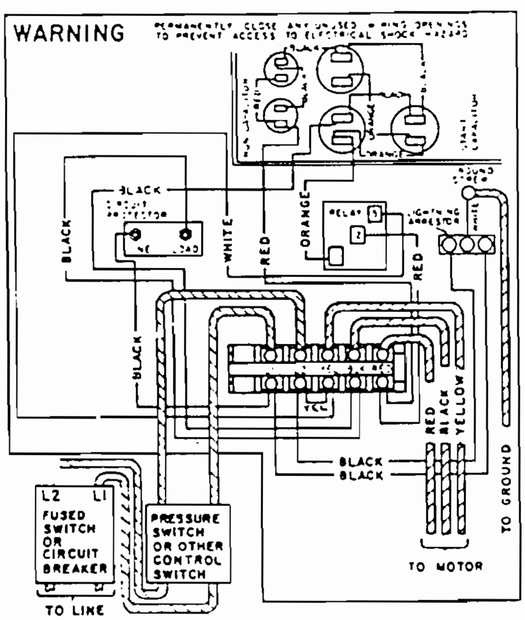

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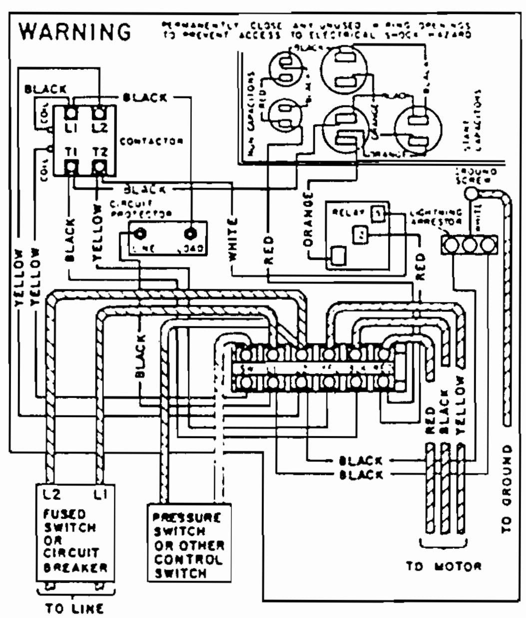

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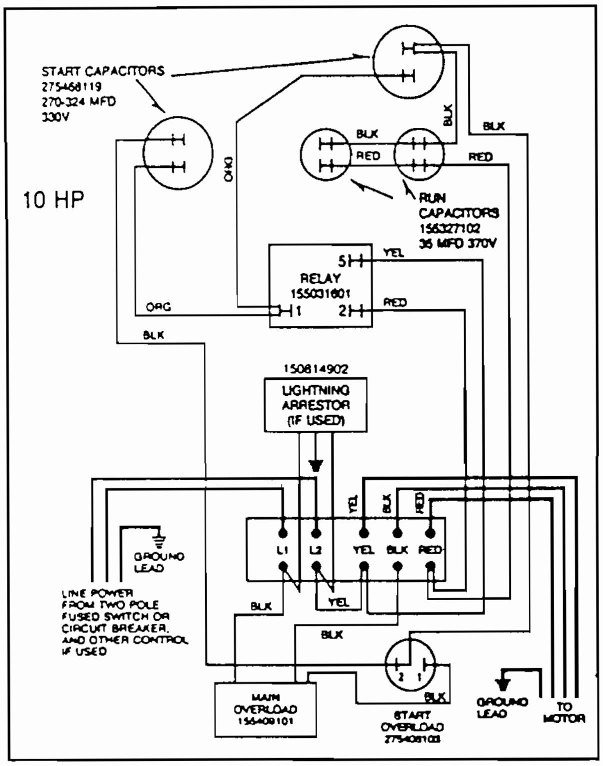
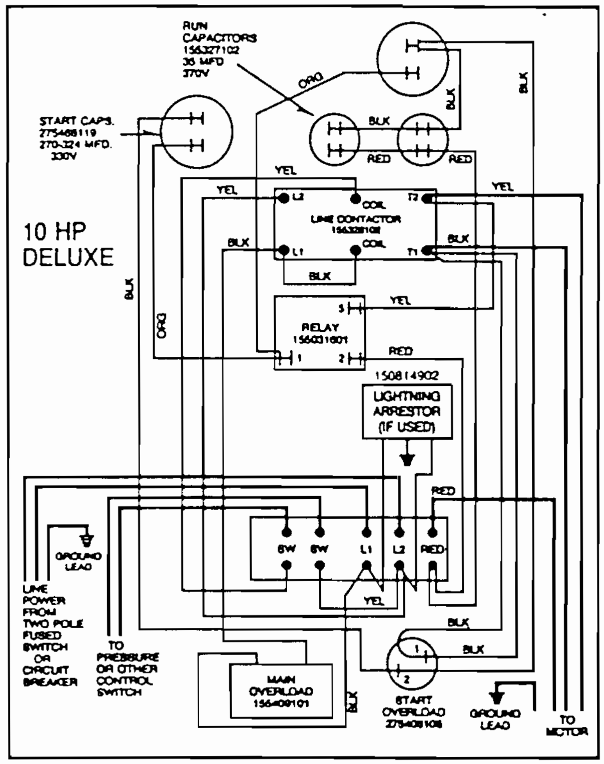


6" STANDARD
10 HP
282 202 9210



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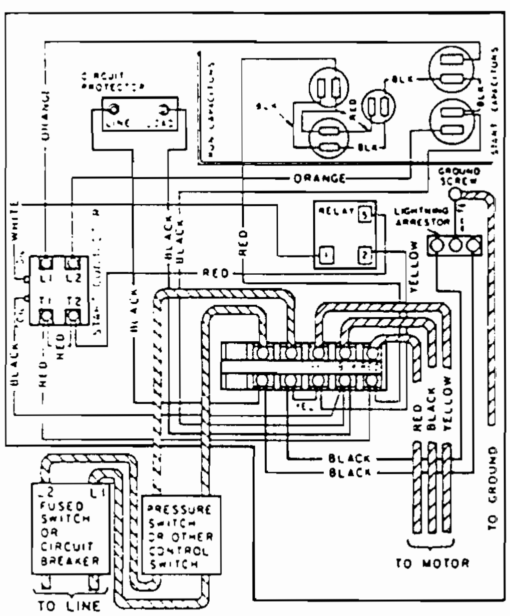

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STANDARD
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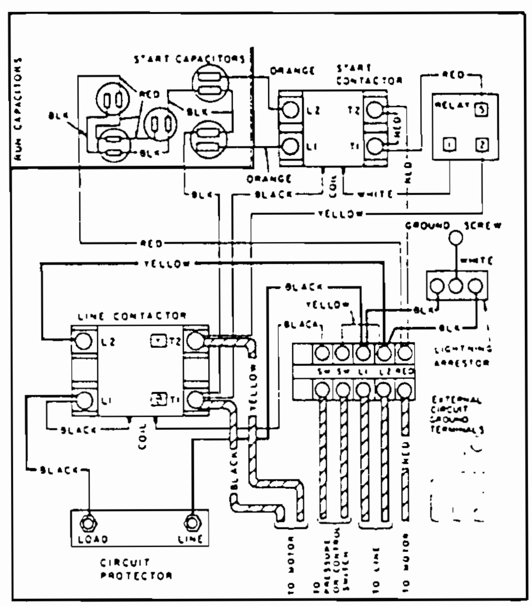

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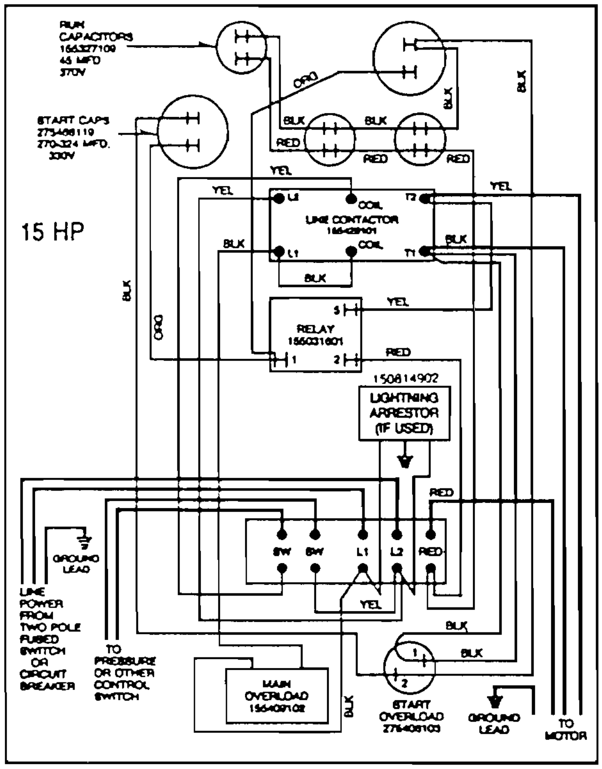

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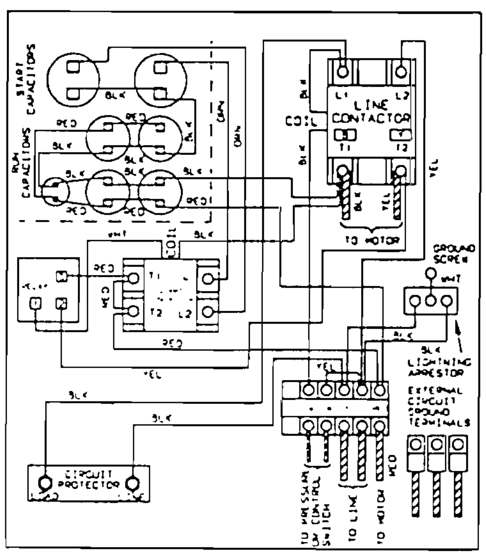

6"
15 HP
DELUXE

APPENDIX C

Flow Meter Specifications

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KENT POSITIVE DISPLACEMENT METER MODEL C-700 BRONZE, MAGNETIC DRIVE, EXTERNAL THREADED SPUDS, SIZES 3/4 x 3/4" - 1"

Specification Sheet

Description

Operation. The C-700 meter is a positive displacement type operating on the oscillating piston principle. This principle utilizes a piston which the water rotates in a measuring chamber, each piston revolution being equivalent to a known volume of water. The piston movement is transferred by appropriate reduction gearing and magnetic drive to a straight reading sealed register.

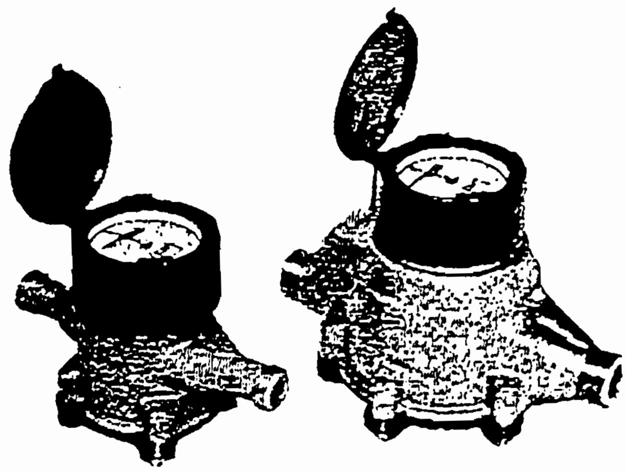
Compliance to Standards. The C-700 meter fully complies with the American Water Works Association Standard C700 as most recently revised.

Installation. The meter must be installed in a clean pipeline, free from any foreign materials. Install the meter with direction of flow as indicated by the arrow cast in the meter case. The meter may be installed in horizontal or inclined lines.

Application. *The meter is for use only with POTABLE COLD WATER up to 120°F (50°C) and working pressures up to 150 psi.* The meter will register accurately to 100% ± 1 1/2% within the normal flows. Both pressure loss and accuracy tests are made before shipment. No adjustments need to be made before installation.

Construction. The meter consists of a main case, oscillating piston, measuring chamber, polymer strainer, removable bottom plate, gasket, body bolts and a magnetically driven register assembly. The main case is cast in bronze with raised characters showing model, size and direction of flow. A choice of bottom plates for frost or non-frost areas is available. The self-flushing measuring assembly is a top-in and bottom-out design. It consists of the measuring chamber with division plate, thrust roller insert, piston, chamber top assembly, drive bar, magnet and a locator pin. It is held to its seat by a spacer between the chamber and bottom plate, which is sealed to the main case with a gasket and stainless steel bolts. Each register assembly is attached to the main case with a tamper-proof screw and is positioned with its hinge over the inlet throat. However, the register can may be rotated and locked in any 360 degree position therein.

Register. The roll-sealed register is permanently and hermetically sealed within a 90% copper alloy can which is filled with nitrogen gas and covered with a 1/4" tempered glass lens that resists breakage, scratching and abrasion. To insure easy reading, the totalizer wheels are large and color coded. The applicable size, model, registration, part number and date code are printed on the calibrated dial face. Moving clockwise during operation, the extra thin center sweep hand does not interfere with meter reading and



Specifications

Sizes:	3/4" x 3/4"	1"
97%-101% Accuracy GPM	1/2	3/4
100%±1 1/2% Accuracy GPM	2-30	3-50
Continuous Flow GPM	15	25
Maximum Flow GPM	30	50
Operating Pressure psi	150	150
Operating Temperature °F	120	120
Sweep Hand Registers:		
US Gallons	10	10
Cubic Feet	1	1
m^3-Cubic Meters	1/10	1/10
Imperial Gallons	10	10
Capacity of Register:		
US Gallons (millions)	10	100
Cubic Feet (millions)	1	10
m^3-Cubic Meters (millions)	1/10	1/10
Imperial Gallons (millions)	10	100
Register Type:	Hermetically sealed direct reading register.	
Materials:		
Main Case	Bronze	
Adapter Ring Set	ABS	
Bottom Plate	Bronze, Cast Iron or Plastic	
Bottom Gasket or Liner	Neoprene Rubber	
Measuring Chamber	Compounded Thermoplastic	
Thrust Bearing Insert	Molybdenum Loaded Nylon	
Piston	High Grade Thermoplastic	
Division Plate	Molybdenum Loaded Nylon	
Driving Bar	Glass Sphere Loaded Nylon	
Magnet	Polymer	
Strainer	Polypropylene	
Register Can	90% Copper Alloy	
Register Lens	Tempered Glass	
Register Gears and Wheels	Polyacetal Resin	
Register Housing	Polyacetal Resin or Bronze	
Register Lid	Polypropylene or Bronze	
Register Support Ring	ABS	

Magnetic Drive. The magnetic drive design facilitates coupling between the measuring chamber and the external register. The coupling is absolute at all rated flows.

Connections. Meter casing spuds have external straight threads conforming to ANSI B2.1. Bronze or polymer coupling nuts and tailpieces are available. Only bronze is available in 1". Both coupling nuts and tailpieces have external taper pipe threads conforming to ANSI B2.1. Their lengths and thread sizes are as specified by AWWA Standards.

Maintenance. The measuring chamber assembly can be removed, repaired or replaced without removing the main case from the service line. Pretested measuring chamber assemblies are available for exchange or purchase, and spare parts are available from Kent's central warehouse or designated regional locations. Kent staffs and operates a repair facility at its US manufacturing plant in Ocala, Florida.

Remote Meter Read (RMR). Kent's RMR system permits visual remote reading from basements, pits, or inaccessible meter settings. Each register pulse is equal to a predetermined volume of water throughput. The pulses are carried by a 2-conductor wire to a remote wall unit. Pulses are accumulated and displayed on the wall unit totalizer.

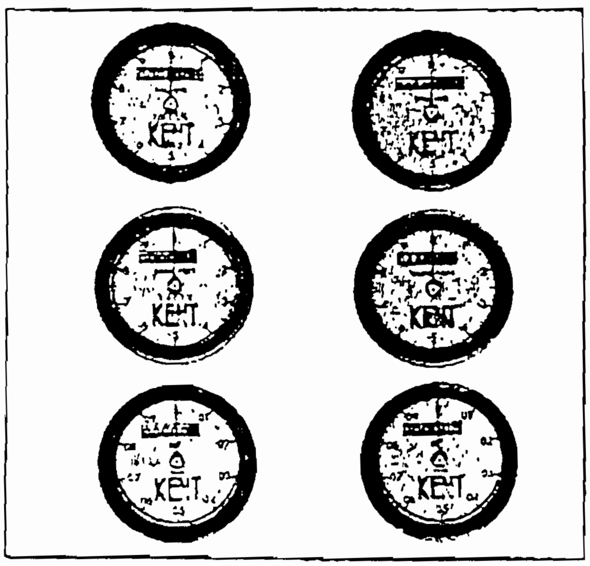
SCANCODER® Electronic Meter Read (EMR). Kent's EMR system permits electronic interrogation of the register's six number wheels. Kent's visual display ScanReader, unique Multi-Gun or other manufacturer's hand-held is interfaced with a wall mounted or pit-lid installed ScanPad. Meter readings are displayed on an LCD screen and may be stored in memory for later processing and billing.

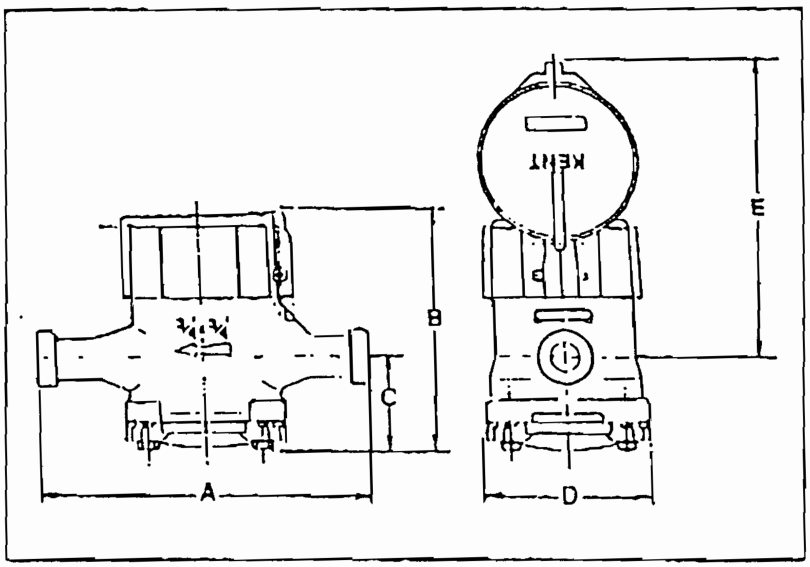
AMR/TelScan™ Automatic Meter Read. The utility's computerized reading equipment accesses an outbound Meter Interface Unit (MIU) through the telephone company's Central Office Access Control (COAC), or an inbound MIU communicates directly with the utility's computer via the telephone line. Wired to the encoder, generator or pulse-type register and connected to the utility customer's telephone protector block, the MIU sends meter readings and other data to the utility's office without interfering with the subscriber's personal use of the telephone.

AMR/RadioScan. An inbound MIU communicates by radio with the utility's computer through a system of radio frequency transceivers. Wired only to the encoder, generator or pulse-type register, the MIU sends meter readings and other data to the utility's office without using a hard wire carrier like telephone, TV cable or electrical distribution lines.

Dimensions and Net Weights

Meter Size	Dimensions (inches)					Weight (lbs.)
	A	B	C	D	E	
3/4" x 3/4"S	7 1/2	6 7/16	2 1/2	4 1/2	10 7/16	6 1/2
3/4" x 3/4"	9	6 7/16	2 1/2	4 1/2	10 7/16	6 3/4
1"	10 3/4	7 3/4	2 3/16	7 1/4	11 7/16	14 1/2





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The company's policy is one of continuous product improvement and the right is reserved to modify the specifications contained herein without notice. These products have been manufactured with current technology in accordance with applicable AWWA Standards.

Kent Meters, Inc.
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Mississauga, Ontario
Canada L4W 2S7
Tel: 416-238-9622

Distributed by:

Kent

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Model R-100
Rate Indicator-Totalizer
Model R-420
Rate Indicator/Transmitter Totalizer with 4-20 mA Signal

Specification Sheet

Description

The models R100 & R420 micro processor based rate Indicator/transmitter totalizer, affords you the ability to display rate, total and (low/high) set points. The transmitter also supplies outputs for driving lights, alarms, totalization for remote and 4-20 mA signal (R420 model) for communication with recorders or like equipment.

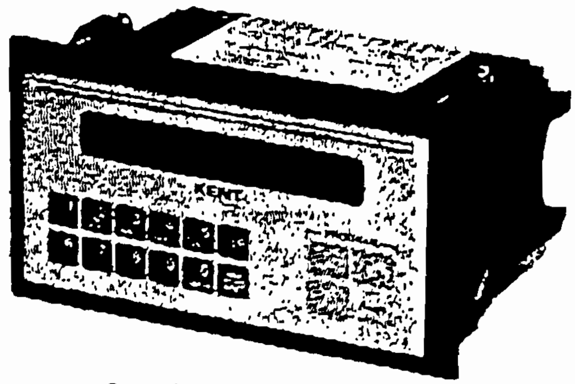
A special mode gives you the capability of viewing two parameters such as rate and set points at the same time or total & rate. The R100 & R420 contain a set point lockout system to prevent unauthorized changes from the front panel.

The R100 & R420 are equipped with an easy to use menu system for programming. The transmitter features a 10 year memory back-up of all program settings, in case of power failure.

The R100 & R420 has RS-485 communications for interfacing with a computer.

Features

* High visibility, 16 character, vacuum fluorescent display.
* Single Key access to display values or set points.
* Simultaneous Display of two values.
* Four electronic outputs for control and remote totalization.
* Set points may be locked to prevent changes.
* 5 control inputs for remote operation.
* Easy menu programming.
* Programming password.
* Built-in power supply for transmitters.
* 10 year memory.
* RS-485 communications.
* Field Programmable.



Specifications

(Flow) Input:
Pulse or Contact Closure. Internal 5.8K ohm pull-up resistor to 5VDC.

Input A:
Flow input, frequency: 7500 HZ max.
Averaging may be performed to smooth pulsating flow conditions (requires programming).

Control Inputs:
Pulse or contact closure. There are five wired control inputs that can be used for remote operations.
1. Unlatched totalizer set point output.
2. Reset totalizer count.
3. Unlatched rate Hi/Lo set point output.
4. Unlatched totalizer and rate set point outputs.
5. Reset totalizer count, unlatch totalizer and rate Hi/Lo set point outputs.

Current output:
(R-420 Model) 4-20 mA. Loop power is obtained from the international 24VDC supply.

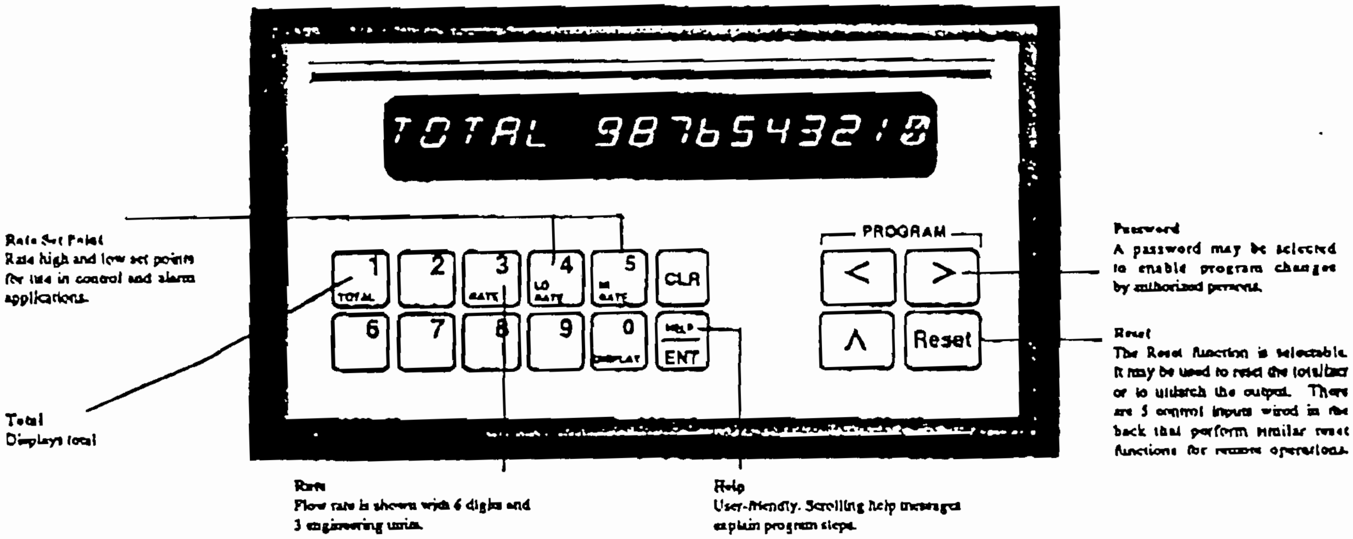
Load impedance: 1000 Ohms at 24VDC.

Response Time: 0.5 Sec. or (follows rate indicator).

Accuracy: ± 0.1% of point at 70° F.
± 0.25% over temp. range.

Control Output:
Four electronic outputs may be used to drive electromechanical devices, light, alarms, computer.
Outputs are capable of controlling loads up to 150 mA max., 30 VDC max.
1. Scaled pulse output with designated pulse width.
2. Totalizer set point output.
3. Low rate set point output.
4. High rate setpoint output.

(Note: See back page.)



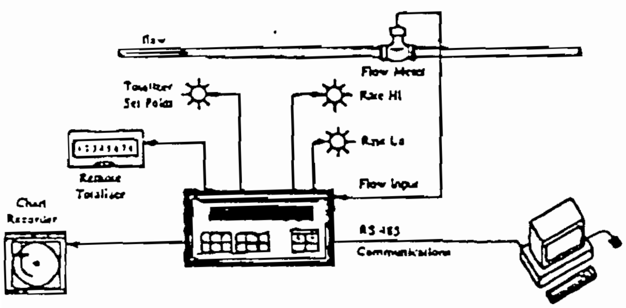
Specifications (Continued)

Note: Rate HI/Lo Set point output operations may either: follow the flow; be latched; or be timed from 0.1 to 999.9 seconds. The totalizer set point output operation may be either: latched; or timed from .01 to 99.99 seconds.

Accuracy: ± 0.05% of point.
K Factor: 0.0001 to 99999
Rate Update: 99 sec. max. to 0.5 sec. min.

Rate Smoothing: Designate 0.5 to 7.5 second dynamic averaging on 0.5 second increments appropriate to flow input speed to 2 HZ and above.

Typical Application



Temperature:
Operating: 32 to 131° F. (0 to 55° C.)
Storage: -40 to 158° F. (-40 to 70° C.)

Power Supply:
115 VAC. when powered from AC source, the R420 will output 24 VDC at 100 milliamps max. or [24 VDC (18 to 27 VDC)].

Display:
Six digit flow rate indication.
Three alphabetical character display flow rate units.
Ten digit flow totalization.

Enclosure:
Panel Mount: Key Pad is NEMA 4x with gasket.

Communication:
Type: RS-485 multidrop wiring terminals.

Wiring Terminals:
14 AWG max.; detachable.

Weight: 2 lbs.

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FAX: 416-238-5640

Distributed by:

APPENDIX D

Telemetry System Manufacturer's Literature

Sensor Modem Manual

12/14/90 - Revision 1.0 First Printing
08/23/91 - Revision 1.1
01/15/92 - Revision 2.0 Features Update
04/15/92 - Revision 2.1 Add Average and Totalize, misc. changes
08/01/92 - Revision 2.2 Miscellaneous Updates
12/30/92 - Revision 2.5 Reformat
01/03/93 - Revision 2.6 Reformat and Updates
02/07/93 - Revision 2.7 Reformat and Updates
03/02/93 - Revision 2.8 Reformat and Updates, Chapter 6
04/09/93 - Revision 3.0 Remove Appendix and incorporate in Chapter 8, Updates
05/04/93 - Revision 3.1 Revise chapter 7 to include Report by Exception RTUs.
05/18/93 - Revision 3.2 Revise chapter 8 to update wiring diagrams.
06/24/93 - Revision 3.3 General clarification throughout.

Table of Contents

Table of Contents

Chapter 1
Introduction

1. Welcome

Thank you for purchasing the Sensor Modem! This chapter explains the basic concept behind Sensor Modem and contains information about:

- What you'll need to operate the Sensor Modem
- Overview of operation
- Description of Sensor Modem
- Using this manual
- Reaching NBT technical support

1.1. Introduction

If you already have a strong background in Modicon PLC programming and your Microsoft Windows or DOS application, you'll be acquiring data in no time. Chapter 2, *Overview Concepts* of provides a quick outline of how to use the Sensor Modem.

1.2. General

The Sensor Modem family of products provides a sophisticated set of products for the implementation of a variety of monitoring, control and communications requirements. They provide the features of an RTU, a PLC, a communications controller, a modem, and a complete, built-in operator interface.

Their sophisticated features are combined with ease of use features to permit quick and economical systems implementation, service and operation.

Sensor Modem now provides the means to easily implement complex systems solutions without extensive technical expertise or training.

The broad and comprehensive options also contribute to efficient total systems cost by minimizing related sensor and wiring costs.

All industry standard features are augmented with advanced communications and data recording support to address an unparalleled range of requirements for utility, commercial and industrial systems.

Sensor Modem products address all types of wide area system networks and localized plant or building complexes.

1.3. Product Features

1.3.1. I/O Capabilities

- Low cost, high density I/O options.
- Low density, distributed I/O modules.
- Built in minimum Base I/O.

1.3.2. Communications Support

- RTU and/or Master modes of operation.
- Hierarchical configurations
- Multiple channels
- Mixed Communications Media
    - Dial Access
    - Radio Modem
    - Wire Line Modem
    - RS485/RS422
    - RS232
    - Programmable Instrument I/F

1.3.3. Programmable control strategies.

- Boolean Arithmetic Calc Points
- Specialized Control Calculations
- User defined BASIC routines.

1.3.4. Complete SCADA system functions at every station:

- Database Attributes
    - Point Names
    - Scaling
- Man-machine functions
    - Display/Entry
    - Operating
    - Selectable Criteria
    - Configuration
    - Printer option
- Alarming
    - Alarm State
    - Alarm Acknowledge
    - Alarm Enable
    - Delayed Alarms
    - Logging
- Daily Summary Statistics
    - Current Day
    - Previous Day1
    - Previous Day2
- Historical Data Recording
    - Removeable Storage
    - Assignable Intervals/Pts

1.4. Configurations

The Sensor Modem product family has been designed to include virtually all functional components related to data monitoring, control, communications and man-machine sub-systems. The Sensor Modem is the nucleus of any large SCADA or telemetry system and includes a true multi-tasking and multi-user operating system.

The design is extremely modular such that those functions that are not required for particular applications can be eliminated. In this way, the same family of products address an extremely wide range of applications in an extremely cost effective manner.

The entry level of functionality and size is competitive with other simple RTU type products. However, the comprehensive design and use of current technology provides unmatched flexibility in adapting to the unique requirements of individual projects.

Unique opportunities are provided by Sensor Modem products for reducing installation costs in both labor and wiring. The advantages of distributed systems can now be practical to more applications.

1.5. Example Applications

- Stand-Alone Unit
    - Data Logger,
    - Event Monitor,
    - Programmable Controller
- Point to Point
    - I/O Multiplexer,
    - Single RTU Systems
- Multi-drop, Single Master System-
    - SCADA System,
    - Telemetry Systems
- Hierarchical System
    - Distributed SCADA,
    - Telemetry Systems,
    - Data Concentrators,
    - Localized Control Sub-systems
- Mixed Mode Communications System
    - Dial Access to Remote System,
    - Dedicated line access to Radio System
- Intelligent Central Repeater Configuration
    - Remote PC Operator Stations

1.6. Related Documents and Products

Each Extended I/O module comes with its own detailed setup and operation manual.

An optional panel mount keypad / display option is available for use with Sensor Modem stations.

The Sensor Modem family of equipment are completely compatible with the ***Tele-Graf***$_{tm}$ monitoring and control system.

Tele-Graf$_{tm}$ provides a complete, full graphic operator interface for a PC-AT (IBM compatible). All SCADA functions are supported and a co-processor based, dual port communications interface allows fast access to larger systems of I/O.

In addition to Sensor Modem support, most standard PLC's are supported by ***Tele-Graf***$_{tm}$.

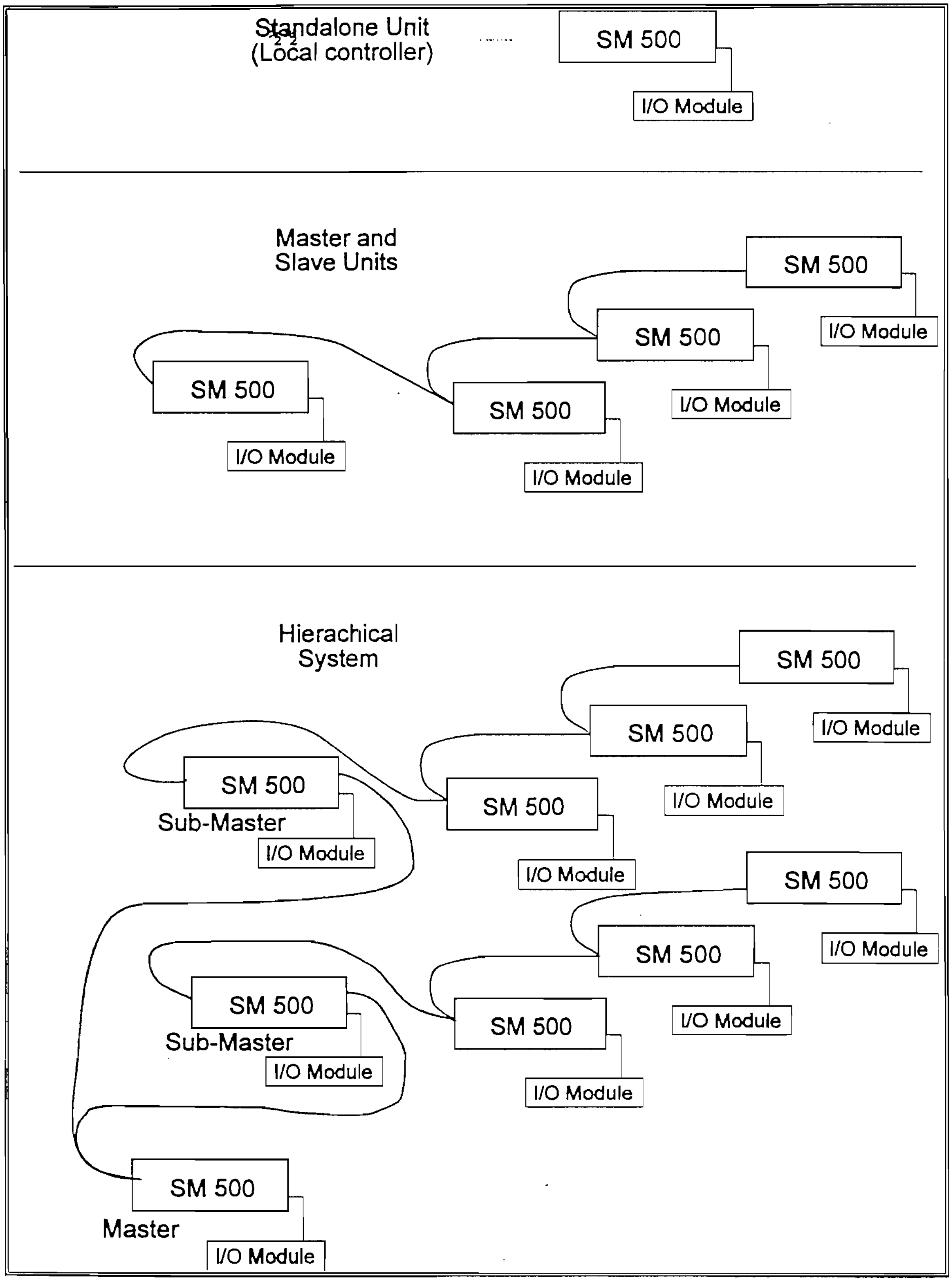

Figure 1.1
System Configurations

Chapter 2
System Overview

2. Overview Concepts

2.1. Systems

Systems can be comprised of a single base unit and I/O (referred to as a "station"), or can be a large number of stations inter-connected by communications paths. Each station consists of a base unit and the attached I/O cards and modules.

A station can serve as a slave to an external "master" station. This is the typical master-slave, multi-drop type of connection.

In addition, a station may also be the "master" for a set of slave stations. The "Remote station" display contains parameters to setup the stations to be interrogated, amount of data to read (or write) and the sequence of scanning.

A single station can simultaneously be serving as a "master" for a set of subordinate stations, and also be serving as a "slave" to a higher level system "master".

Because of this flexible communications support, complex and unusual systems requirements can easily be accommodated. However, the terminology can be confusing in discussing the configurations. For the purposes of this manual, remote I/O will in general refer to subordinate stations (slaves) relative to the station being discussed.

2.2. Remote Stations

The setup of remote (slave) stations is required only when a unit is serving as a "master" for those stations. Otherwise, when the unit is being configured as a stand-alone unit or as a slave unit to a separate master station, only the local I/O needs to be configured.

The setup of remote stations is accomplished through the "Remote Station" display. It is presented in a "spread sheet" type of array of rows and columns. Each row represents a single remote station.

Entries include the remote station address, On/Off scan, the type of data to be read (and/or written) and the specific "register" addressing for read (and/or write) data. Additional display fields for operator viewing include communications status and display of the read data registers.

Once a remote station is enabled, it is interrogated periodically in the sequence specified by the remote station parameters. (e.g., in the row order of the display in Table 2.)

The data read from the remote stations is stored in holding registers. These holding registers are referred to as "remote I/O registers" and more commonly as Table 2 registers.

Table 2 registers can also be accessed by a superior master station or by local I/O registers in Table 1.

The total number of remote stations supported by a station and the total number of Table 2 holding registers is dependent on the model number of the unit. Typically a minimum of 20 remote stations and 900 holding registers is provided.

2.3. Local Station Input/Output

Local input and output data (I/O) is handled by several options

2.3.1. Internal I/O points

Each base unit has internal provisions for 2 digital inputs, 2 digital outputs, and 4 analog input points. (The associated hardware for these points is called the I/O termination card.)

2.3.2. Internal digital expansion points.

The base unit also has internal configuration which provides 8 digital inputs. (The associated hardware for these points is called the Mini I/O card.)

2.3.3. External digital expansion points.

Expansion I/O modules are connected by ribbon cable and are located adjacent to the base unit. There are modules for digital input and output and analog input and output. Various voltages and currents are available.

2.3.4. Extended I/O modules.

Extended I/O modules are connected by serial (RS485) twisted pair cables and permit I/O modules to be located up to 6000 ft from the base unit.

2.3.5. Scanning and Calculations.

Internal I/O and expansion cards are automatically detected and scanned by the base unit. Scanning of the extended I/O modules is done as required, based on the configured points in the base unit.

2.4. Point Setup

Setup of points is accomplished by "entering" the appropriate parameters in the point data display. This display is presented in a "spread sheet" type array of rows and columns. Each row represents one point of data and its associated information.

The data and related parameters for each local I/O point is held in a local memory area known as Table 1. Current data and related summary data are accessible for access from a superior master station, as well as for local use and "remote scan" use.

Each local point contains the necessary hardware identification as well as necessary parameters to maintain cycle counts, on time duration, last alarm times, alarm status, minimum/maximum values, conversion values, high/low alarm values, recording criteria, and other operating parameters.

Local points include "calculated points" in addition to those points thar are referring to the physical I/O. Calculated points, as the name implies, derive a value from other points or registers or combinations of points. They are defined by calculation type, which specifies the operations involved in creating the current value. Typical calculation types include boolean operations (logical and/or, etc.) and arithmetic operations (sum, difference, etc.). In addition, several control related and time related functions allow the implementation of common control requirements.

To illustrate the tables contained in the Sensor Modem and their relationships, refer to Figure 2.1.

The parameters that are set into Table 1, Table 2 and station information (station address, name, etc.) are collectively refered to as the "data base" for the station. This data base defines the functionality and operation of the unit.

Station 1 Pmp Stat TABLE1_DATA-CUR/SUM Thursday 08:04:05 06/24/93

	File =	TODAY'S	06/24/93	Scan is	Enabled	ALLPoints	NoAlmQual
	A	B	C	D	E	F	G
	PT_NAME	PT TYPE	CURVALUE	UNITS	ALARM	UNACK	MAXVAL
01	Tank Lvl	ANL IN	75.0	FEET		UNACK	99.8
02	P_1 Lvl	ANL IN	75.0	FEET		UNACK	99.8
03	P_2 Lvl	ANL IN	75.0	FEET	ALARM HI	UNACK	152.9
04	P_1 ctrl	DIG IN	OFF	En		UNACK	545
05	P_2 ctrl	DIG IN	OFF	En		UNACK	20
06	P1_REQ	DIG OUT	OFF	En		UNACK	26
07	P2_REQ	DIG OUT	OFF	En		UNACK	199
08	P1_RUN	DIG IN	OFF	En		UNACK	13
09	P2_RUN	DIG IN	OFF	En		UNACK	10
10	P1_FAIL	DIG IN	OFF	En		UNACK	37
11	P2_FAIL	DIG IN	OFF	En		UNACK	27

Figure 2.1
Display of Table 1

Chapter 3
Quick Startup

3. Quick Startup Checklist - Initial Power Up

This section provides a brief overview of the steps associated with setting up and configuring a system. Please refer to the appropriate sections for additional detailed information.

Check that required options are present, required expansion I/O modules are available, and that connecting cables and power sources are included.

NOTE	It is not mandatory to connect I/O modules to the base unit in order to power up and configure the unit. If expansion I/O modules are connected at this time, confirm the connections.

Setup requires connection to a terminal or computer via a serial cable. The Sensor Modem has a 9 pin male connector. The computer must have a communications program that provides terminal emulation using the Heath 19 protocol. Procomm is a commercial package for this purpose.

A suitable display device is required to access the built-in set-up and programming facilities. If you are using a terminal emulation package on a PC, you may have to install that software at this time. See the directions accompanying your terminal emulation package. Note that serial port parameters, as well as terminal emulation parameters must be set. See Appendix B for details of the serial port pin-outs and jumper options. The default serial port configuration is DCE, which allows direct connection to a PC. Normal terminal parameters are 9600 baud, 8 data bits, 1 stop bit, no parity.

NOTE:	Use of PCPLUS (Datastorm Technologies, Inc.) for terminal emulation of Heath 19 terminal is recommended. PCPLUS parameter files for use with Sensor Modem are available.

Steps required to initially power up a Sensor Modem Unit for configuration are:

1. Connect module interconnect cables, and serial cables.
2. Set front panel DIP Switches as required.
3. 12V power supply to power connector (DIN plug).

	Up (Normal)	Down
Sw 1	Online Mode	Maintenance Monitor
Sw 2	BASIC Autoexec OFF	BASIC Autoexec ON
Sw 3	Master Unit	Slave Unit
Sw 4	9600 Baud	2400Baud (Port 0)
Sw 5	9600 Baud	1200Baud (Port 0)
Sw 6	Default Password	Assigned Password
Sw 7	Use internal configuration	Clear memory & use memory card configuration
Sw 8	Not Used	Not Used

Figure 3.1
DIP Switch Settings

Note	Normally all switches should be UP, except Sw 3 which must be down for remote (slave) units.

CAUTION	Set switch 7 to UP before doing custom setup to prevent the overwriting of your setup information by data on the Memory Card or clearing memory if there is no Card.

Other optional connections include:

Expansion I/O Port.

For expansion I/O, connect expansion I/O cards to the 26 pin header on the rear and set the card address jumpers so that each module has a unique module address (1 thru 31).

Internal I/O Termination Card.

Connect the I/O termination card to the 20 pin header on the rear (labeled "I/O - RS485").

When power is applied, all of the front panel LED's should momentarily light up. If switch 1 is up (normal condition) there will not be anything written to the CRT screen until the user begins the Logon procedure described in the next section. If the LED's do not light up when power is applied, check the power source and check for shorts in the power connections. If this does not remedy the problem check the fuses inside the Sensor Modem case.

If power is present, but there is a problem encountered in logging on to the unit from the CRT (PC), you may try powering the unit up with switch 1 in the down (maintenance) position. When power is applied in this condition, there should be a message displayed on the attached display which says "Sensor Modem Monitor", ...etc. This will verify power and serial port (display) connections. If there are still problems, check the serial cable connections, baud rate switch and the baud/port parameters of the attached display.

Also, review connection information in Chapter 8 and see Chapter 4 for a more detailed discussion of Log-on procedures.

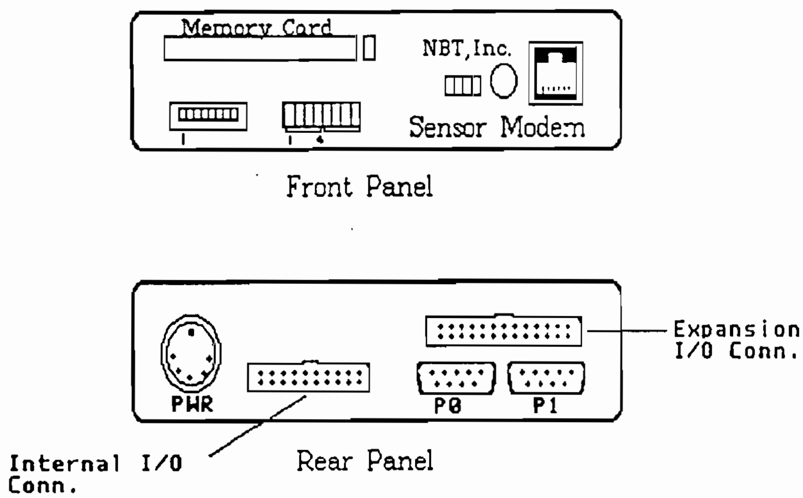

Figure 3.2
Front & Rear Panels

Chapter 4
Operator Access

4. Operator Access – Display Data Interface

Each Sensor Modem Base Unit has a complete display and entry capability built into the firmware. This is available locally and/or remotely depending on configuration and connection. This display interface provides access to operating data, setup parameters, and programming facilities.

This section of the manual is intended to illustrate the "operator" usage of the system. That is, the access to process data for operating purposes. It is assumed that the initial setup has been completed.

4.1. Terminal (or PC) User Access

Connect a terminal or PC using terminal emulation **"Heath 19"** to the local RS232 port. Setting should be 9600 baud, 8 data bits, no parity, 1 stop bit.

Terminal emulations for ANSI, ADM, VT100 and a standard keypad/LCD display panel are available. (See section 5 for additional detail) (Notify NBT at order time if other than Heath 19 is required)

The recommended PC communications package for access to Sensor Modem is PCPLUS (ProCOMM+) by Datastorm Technology, Inc. NBT will provide script files for both the DOS and Window versions of ProCOMM+.

4.1.1. Overview

Access to the internal functions of the unit from a CRT terminal (PC) are protected by password security. The user must Logon to the Command Level, and then specify the internal function that is desired.

This secure access method is used for both local connections and remote access (when available). Selected functions are inhibited depending on the access level of the password. For example, editing of data base fields requires an operator level of password. (See section 6 for additional information.)

The internal functions available include:

- Real-Time Display / Setup
- BASIC Compiler
- Host Mode File Transfer
- Dial Modem
- Hardware Ports

```
Enter Password:
SM010>?
LINK,BASIC
LINK,P0
LINK,P1
LINK,HOST
LINK,BAS7
LINK,RTSYS
LINK,RT2
LINK,COMM
UNLINK
LOGOFF
ONLINE
?
SM010>
```

Figure 4.1
LOGON and COMMAND LEVEL HELP

4.1.2. Entry to Command Level

Access to the Command Level is available at any time by entering the Command Level Escape sequence. This sequence is three ^X characters entered within 1 second followed by 1 second of no activity. (Note: ^X is read as Control X and is generated by pressing the Ctrl key and simultaneously pressing the X key)

Once this sequence is sent, Command Level entries are allowed and any previously active function is suspended. If no Logon is active, the user will be prompted for entry of a password. (See below) The possible Command Level entries can be displayed by entering a "?" (or help request).

(Refer to section 6 for more detailed information on individual commands)

4.1.3. Exiting Command Level

To go to (or return to) the online state in the selected function, simply enter "ONLINE". This will return you to the online mode in the currently selected function.

To terminate the access, enter "LOGOFF". This will terminate any further access until a new Logon is completed.

4.1.4. Logon and Security Functions

There is no response from the base unit until a logon is completed. Access to the logon is accomplished by entering an "Escape" sequence to enter command level. This "Escape" sequence is three ^X entries (simultaneous press Ctrl and X keys) within 1 second.

The response is an output of: "Enter Password:". At this point enter a previously entered password or the default password of "QWERTY". Successful entry of a password will result in the output of the prompt:

"SMxxy>"where xx is the station number of the base unit and y is the "linked" function

After the prompt appears, a list of available functions can be viewed by entering a "?".

As an example, selection of the Real-Time System for parameter setup and operation displays is made by entering "LINK,RTSYS".

Acceptance will be indicated by the output of the prompt ("SMxxy") with the "y" parameter indicating the selected "link" code. (this is non-zero if a link is made)

Link Commands and resulting Prompt Codes:		
	0-	Unlinked
LINK,RTSYS	9-	Real-Time Displays (user 1)
LINK,RT2	A-	Real-Time Displays (user 2)
LINK,BASIC	7-	BASIC Compiler
LINK,P0	3-	Aux Serial Port
LINK,P1	1-	Aux Serial Port
LINK,HOST	8-	Aux BASIC Programmed
LINK,PRTR	2-	Parallel Port
LINK,COMM	4-	Internal Dial Modem Port

Figure 4.2
Link Commands

To exit the command level and "go online" with the previously selected "link function", enter "ONLINE". At this point you (your PC or terminal) are connected logically to the selected function.

Interaction in the on-line mode is evidenced by echoed output of keyboard entries or refreshing of display screens. For the RTSYS selection, simply hit the HOME key to refresh the screen.

4.2. Real Time Keyboard Entry

Note	You get here by completing: LINK,RTSYS & ONLINE commands

Standard keys	for real time display controls:
Arrows	Cursor Field Selection
Page Up/Down	Cursor Field Selection
+	Page Right
-	Page Left
HOME	Home
END	Refresh Screen
/	Activate Menu Line
INSERT	Entry to Current Field
ESC	Cancel Operation
ENTER	Complete Operation

Figure 4.3
Keyboard Mapping

Note: The specific keys used for a function can be assigned by the user in PCPLUS. The keys listed above are the "standard" assignments made by NBT and provided in the PCPLUS parameter files. (See section 6 for additional key information)

The next figure shows a typical key mapping template that is provided for PCPLUS users.

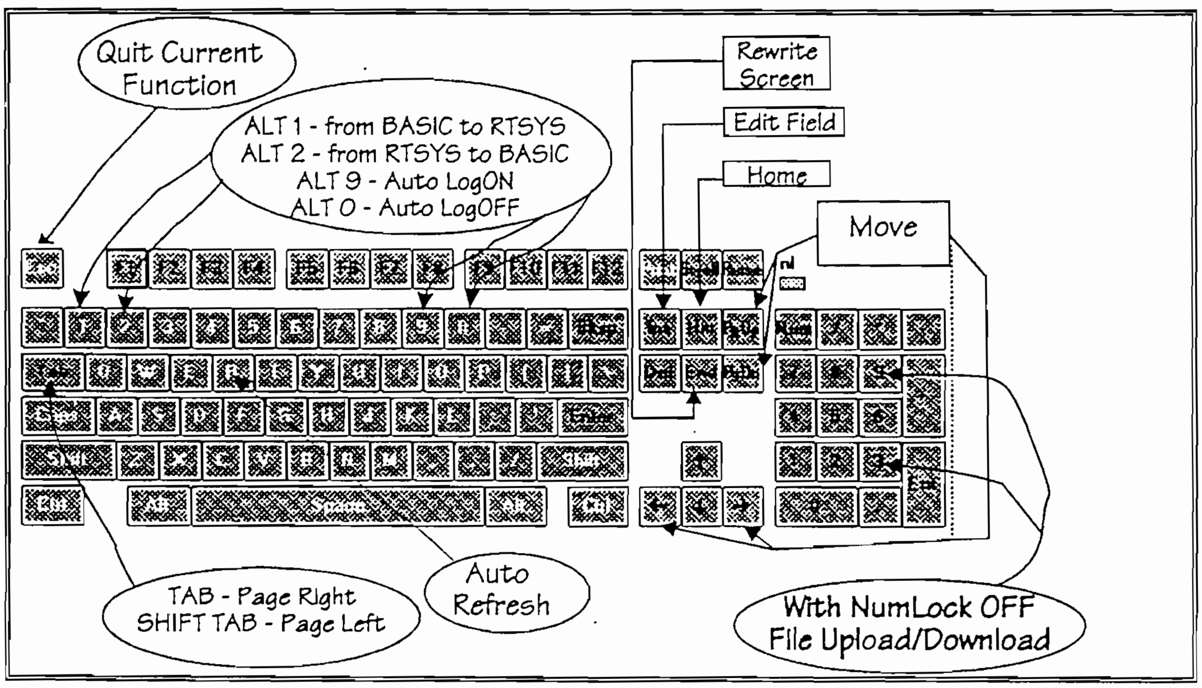

Figure 4.4
Keyboard Keys

4.3. Real Time Menu Functions

The Menu Line is accessed from the real-time display by pressing the "/" key. The Menu Line presents a list of choices which can be selected by using the left or right arrow keys to high-light the desired field. Return to the data portion of the display without any selection can be accomplished by pressing the "Esc" key.

The Menu structure for real time data displays is as follows:

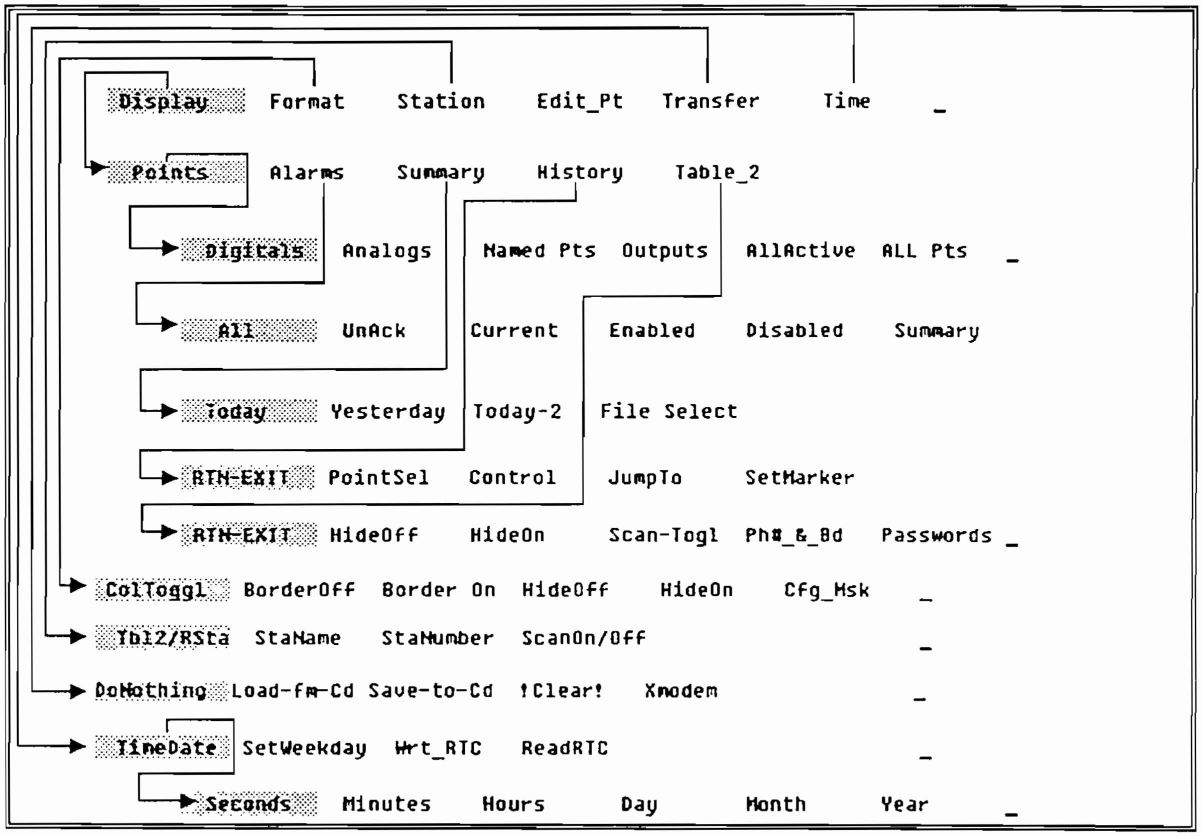

Figure 4.5
Menu Structure

```
    Station          1 Master  TABLE1_DATA-CUR/SUM Monday      14:12:51  01/04/93

Display       Format     Station    Edit_Pt    Transfer     Time      _

    File -      TODAY'S     01/04/93    Scan is  Enabled   ALLPoints  NoAlmQual
        A          B           C            D          E          F          G
    PT.NAME     PT TYPE    CURSTATE   ALM ENBL    ALARM     UNACK      CYCLES
01  11          DIG IN      OFF            En                                0
02  AC PWRIN    ANL IN     -     .1   VOLT        ALARM LO    UNACK      879.9
03  LCL-DI0     DIG IN      OFF            En                 UNACK         24
04  LCL-DI1     DIG IN      OFF            En                 UNACK         23
05  LCL-AI0     ANL IN     -      1   MV          ALARM LO    UNACK      32767
06  RMT-DI0     DIG IN      OFF            En                 UNACK         28
07  RMT-DI1     DIG IN      OFF            En                 UNACK         30
08  RMT-AI0     ANL IN        498     MV          ALARM HI    UNACK        511
09  LCL-LED0    DIG OUT     OFF            En                 UNACK         29
10  LCL-LED1    DIG OUT     OFF            En                 UNACK         31
11  LCL-DO0     DIG OUT     OFF            En                 UNACK         22
12  LCL-DO1     DIG OUT     OFF            En                 UNACK         24
13  RMT-DO0     DIG OUT     OFF            En                 UNACK         23
14  RMT-DO1     DIG OUT     OFF            En                 UNACK         22
15  RMT-POT     ANL OUT    -      2   MV          ALARM LO    UNACK      32766
```

Figure 4.6
MAIN MENU LINE

4.4. Viewing Real-Time Data (Table 1)

The Real Time System displays are initially accessed from the command level by entering "LINK,RTSYS" followed by "ONLINE". (Alternately, "LINK,RT2")

The Real Time System function provides display and entry capabilities for all of the points defined in the RTU. Display is provided in a "spread sheet " format. Each point (or point group) is displayed as a row in the spread sheet. The row number is the logical point number used for referencing the point.

Within each row are all of the setup and operational fields for the point, one to a column. Each point type has parameters relevant to that point type. The selected field is displayed as a highlited field. Selection of a field is accomplished by using the cursor movement keys (arrow keys) or page keys or + (page right) or - (page left).

The Real Time displays are comprised of 5 areas:

1) the BANNER line which indicates the Station Name and Address
2) the display Title and the time and date;
3) the MENU line area which presents a list of choices or is blank if not in the menu mode; press the "/" key to activate the MENU line.
4) the HEADER area which displays parameters showing current display conditions as selected by the user;

5) the DATA area which is the body of the display and shows a selected portion of the data base.

Note:	There are additional display pages for Remote station parameters and Historical data display. Return to the CURRENT/SUMMARY display can be accomplished from the Menu Line.

4.4.1. Qualifying Display Points

By selecting the DISPLAY item from the main menu and then selecting POINTS, you can specify the type of points to be displayed. Selected qualifiers include:

- Digital Points Only
- Analog Points Only
- Named Active Points
- Output Points Only
- All Active Points
- ALL Points

Named active points (for display qualifier purposes) have a non-blank, displayable character in the first character position of the point name field. By leaving the first character position as a blank, it will be considered unnamed (for qualifier purposes) and will not be included in the set of qualifying points. This is a handy way of suppressing the display of calculated points which are not relevant to Operator use.

By selecting the DISPLAY item from the main menu and then selecting ALARMS, you can limit the points displayed by current alarm status. Selected qualifiers include:

- Any Alarm Condition (All points)
- Unacknowledged Points Only
- Currently Active Alarms Only
- Points w/ Alarms Enabled Only
- Points w/ Alarms Disabled Only
- Summary alarms

Combinations of point type qualifier and alarm qualifier may be selected to further narrow point display.

Alarm qualifiers are a handy way of focusing attention on those points which are currently in alarm (Active) or which have changed condition since last observed (Unacknowledged).

Station 1 Master TABLE1_DATA-CUR/SUM Monday 14:24:52 01/04/93

Digitals Analogs Named Pts Outputs AllActive ALL Pts

File = TODAY'S 01/04/93 Scan is Enabled Named_Pts NoAlmQual

	A	B	C	D	E	F	G
	PT NAME	PT TYPE	CURSTATE	ALM ENBL	ALARM	UNACK	CYCLES
01	11	DIG IN	OFF	En			0
02	AC PWRIN	ANL IN	- .1	VOLT	ALARM LO	UNACK	879.9
03	LCL-DI0	DIG IN	OFF	En		UNACK	24
04	LCL-DI1	DIG IN	OFF	En		UNACK	23
05	LCL-AI0	ANL IN	- 1	MV	ALARM LO	UNACK	32767
06	RMT-DI0	DIG IN	OFF	En		UNACK	28
07	RMT-DI1	DIG IN	OFF	En		UNACK	30
08	RMT-AI0	ANL IN	489	MV	ALARM HI	UNACK	511
09	LCL-LED0	DIG OUT	OFF	En		UNACK	29
10	LCL-LED1	DIG OUT	OFF	En		UNACK	31
11	LCL-DO0	DIG OUT	OFF	En		UNACK	22
12	LCL-DO1	DIG OUT	OFF	En		UNACK	24
13	RMT-DO0	DIG OUT	OFF	En		UNACK	23
14	RMT-DO1	DIG OUT	OFF	En		UNACK	22
15	RMT-POT	ANL OUT	- 2	MV	ALARM LO	UNACK	32766

Figure 4.7
Viewing Named Points Only

4.4.2. Display Formatting Functions

Selection of the Format entry on the menu line allows the user to selectively display or hide columns in the display. Also, the Border feature will keep the Point Name column present as the left most column regardless of which other columns are displayed.

Columns can selectively be marked for <u>exclusion</u> from the display. This is known as marking a column for Hiding. When a column is marked for Hiding, but the Hide function is not enabled, the marked column will display a caret (^) preceding the column ID letter.
(i.e., ^A)

When the Hide function is enabled, any marked column is excluded from the display. This is convenient for viewing a particular group of columns all in one 'page'.

Note that the Configuration Mask selection on the Format menu line is a special case of the hide feature to present the set of columns most relevant to configuring new points in the system.

Note columns B,D,E,F,G,H,I,J,K,L,M,N,O and R are all hidden.

Station 1 Master TABLE1_DATA-CUR/SUM Tuesday 08:14:48 01/05/93

File = TODAY'S 01/05/93 Scan is Enabled ALLPoints NoAlmQual

	A	C	P	Q	S	T	U
	PT.NAME	CURVALUE	HW TYPE	PT TYPE	MOD ADDR	REG/PT	RANGE/FS
01	ALARM	OFF	INTERNAL	DIG IN	0	0	4
02	AC PWRIN	- .1	INTERNAL	ANL IN	0	5	27.5
03	LCL-DI0	OFF	INTERNAL	DIG IN	0	0	0
04	LCL-DI1	OFF	INTERNAL	DIG IN	0	0	1
05	LCL-AI0	- 1	INTERNAL	ANL IN	0	0	0
06	RMT-DI0	OFF	TABL2/RS	DIG IN	1	0	1
07	RMT-DI1	OFF	TABL2/RS	DIG IN	1	0	0
08	RMT-AI0	483	TABL2/RS	ANL IN	1	2	0
09	LCL-LED0	OFF	INTERNAL	DIG OUT	0	1	0
10	LCL-LED1	OFF	INTERNAL	DIG OUT	0	1	1
11	LCL-DO0	OFF	INTERNAL	DIG OUT	0	0	1
12	LCL-DO1	OFF	INTERNAL	DIG OUT	0	0	0
13	RMT-DO0	OFF	TABL2/RS	DIG OUT	2	0	0
14	RMT-DO1	OFF	TABL2/RS	DIG OUT	2	0	1
15	RMT-POT	- 2	TABL2/RS	ANL OUT	2	1	0

Figure 4.8
HIDING COLUMNS

4.4.3. Dynamic Data Display

The display is normally static after being presented for viewing. The data area and the Banner Line will refresh if the 'R' key is pressed. As long as there is no other intervening keystrokes, the screen will be refreshed at about a 10 second interval.

The END key will do a "one-shot" re-write of the screen including all fields of the screen.

4.5. Viewing Remote Station Data (Table 2)

By selecting the STATION item on the main menu, the parameters relating to the station and remote stations may be displayed and/or entered.

Each line of the Remote Station display contains the information relative to a exchange of data with a remote terminal unit RTU. It defines the location and number of input and output registers (in Table 2) to be read or written, the register types, and the station number, or address, of the station. Additionally, the data register contents are shown in columns K thru AZ. (a maximum of 30 registers are displayed, even though a request may contain up to 255 registers)

Note that references from Table 1 points to remote station data in Table 2 use the position (or Index) indicated at the left end of each data display line, as opposed to the actual station address. (Multiple lines may contain requests to a particular station address)

Station 1 Master TABLE1_DATA-CUR/SUN Tuesday 16:19:17 01/12/93

File - TODAY'S 01/12/93 Scan is Enabled ALLPoints NoAlmQual

	A	B	C	D	E	F	G
	PT.NAME	PT TYPE	CURSTATE	ALM ENBL	ALARM	UNACK	CYCLES
01	ALARM	DIG IN	OFF	En		UNACK	1
02	AC PWRIN	ANL IN	13.5	VOLT		UNACK	13.9
03	LCL-DI0	DIG IN	OFF	En		UNACK	1
04	LCL-DI1	DIG IN	OFF	En		UNACK	0
05	LCL-AI0	ANL IN	422	MV	ALARM HI	UNACK	433
06	RMT-DI0	DIG IN	OFF	En		UNACK	2
07	RMT-DI1	DIG IN	OFF	En		UNACK	1
08	RMT-AI0	ANL IN	460	MV	ALARM HI	UNACK	511
09	LCL-LED0	DIG OUT	OFF	En		UNACK	1
10	LCL-LED1	DIG OUT	OFF	En		UNACK	0
11	LCL-DO0	DIG OUT	OFF	En		UNACK	2
12	LCL-DO1	DIG OUT	OFF	En		UNACK	1
13	RMT-DO0	DIG OUT	OFF	En		UNACK	1
14	RMT-DO1	DIG OUT	OFF	En		UNACK	0
15	RMT-POT	ANL OUT	422	MV	ALARM HI	UNACK	432

Figure 4.9
STATION MENU LINE

4.6. Operator Entries / Alarm Ack

Operator entries in the main data portion of the real-time displays can be made by moving the cursor to the desired field in the data display area and pressing the "Insert" key. This will cause the field location (row/col, ie, B05) and the entry prompt to be displayed on line 4 (just below the menu line).

At this point the operator may enter a new value for the field. If it is a numeric field, simply enter the new numeric value. If it is a string field (alpha-numeric), enter the desired ASCII letters and/or numbers. If it is a List type of field (pre-defined list of options), use the up/down arrow keys to select a new choice from the presented list of choices.

To complete a selection, press the "Enter" key.

The entry of numeric and string fields may be aborted by pressing the "Escape" key. List items are updated as soon as the selection is made.

Alarms may be acknowledged by selecting the desired field in the Alarm Ack column, and hitting the up or down arrow key to toggle the entry from "Unack" to blank (acknowledged).

```
    STATION         1 Master   TABLE2_DATA-REM.STA Tuesday   15:31:27  01/12/93

 Points      Alarms     Summary     History     Table_2

RECPh#1:..................1Ph#2:..................1Ph#3:..................H
 ONPh#4:.................. Ph#5:.................. Ph#6:..................UTO
    MASTER MODB      Use MENU For PWs.  P1BAUD= 9600        Scan is  Enabled
01       E           F           G           H           I           ^J          K
03 PFUNCTION  1ST IN     NBR IN     1ST OUT    NBR OUT    REG.TYPE  R-OFFSET
01  TBL2/RAW     3000          9          0          0    Allocate         0
02  TBL2/RAW        0          0          0          2    Allocate         9
```

Figure 4.10
REMOTE STATION DISPLAY

4.7. Viewing Summary Data

Daily summary data is maintained for two previous days. The summary data consists of a snap shot of Table 1 at midnight. Pertinent data includes the day-end point values, and the following daily information:

For Digital Points:

- Last recorded state
- Number of Cycles
- Duration of On-time (minutes)
- Time of last On transition
- Time of last Off transition

For Analog Points:

- Last value
- Daily Maximum Value
- Daily Minimum Value
- Time of last Alarm
- Time of Maximum Value

The summary data can be viewed by selecting DISPLAY on the Main Menu, followed by the SUMMARY selection. At this point, the operator can choose TODAY for return to current data, or YESTERDAY or TODAY-2 to display previous day's data. The data is presented in the same spread sheet form as current data.

Indication of the day selected is shown on the "Description Line", just above the column labels.

4.8. Viewing Sampled History

Accumulated sample data may be displayed by selecting "Display", "Historical" from the menu line. Start by pressing the HOME key to refresh the display and automatically set the first displayed sample to the newest (most recent) recorded sample.

Samples will be displayed in reverse chronologic order (newest first). Each sample will be displayed with month, day, time, point number, point name, and value fields. Viewing of additional samples can be accomplished by using the "Page up" and "Page down" keys.

```
     STATION          1 Master      HISTORICAL DATA   Tuesday   15:23:19  01/12/93


RECORDING:       CURRENT POS      MAX POSITION     MARK POSITION    OVERWR:  ON
 ON                    9            12415                1          AUT/MN:  AUTO
    DISP_CRIT> PT1:      1    PT2:      0    STA:       1             TRIG PT:

SAMPLE#     DAY   TIME      STATION / POINT#     TYPE      NAME         VALUE _
```

Figure 4.11
SAMPLED HISTORY DISPLAY

The Header area of the display indicates the general status of the Historical recording function, including, if recording is enabled, if a memory cartridge has been detected as present and what its capacity is. If the Max Samples field indicates 0, it means that either a memory cartridge is not present or that historical recording has not been enabled.

4.9. Selection of Displayed Samples

Either "All samples" or only samples for a selected point can be displayed. There are 2 menu selectable points which can be specified for 'selected points only' display. A menu selection to limit the display to points from a specified station is also available for situations where points from more than one station are on the same memory cartridge. The default for the point selections and station selection are zero, which allows any sample to be displayed.

4.10. Control Parameters

The History display also provides access to several control parameters for controlling the recording of samples. Historical recording can be manually enabled or disabled. Overwriting the oldest samples can be enabled or disabled. If this feature is disabled, recording will stop when the historical storage area is full.

Auto disable allows for automatically suspending sampling after a disturbance. This insures that the disturbance related samples are preserved for after the fact analysis.

Return to the current data display can be selected from the menu line.

Chapter 5
Functional Descriptions

5. Functional Descriptions

5.1. Communications

5.1.1. Hierarchical Systems

Each Sensor Modem station (or node) is capable of simultaneously operating as both a master and a slave in two different communication networks.

SCADA systems, or telemetry systems, typically employ a single master station and several multi-dropped remote stations. The use of a PC as computer based master is a common implementation of a master/slave system.

Sensor Modem supports multi-drop communications for the typical master and multiple slave systems. In addition, Sensor Modem has the ability to support dial telephone links and secondary multidrop networks. This allows a Sensor Modem station (node) to act as a master to a set of remote stations as well as acting as a slave to a superior master station. Thus, cascaded configurations are practical and easily implemented. The scan of subordinate stations can run independently of the up-stream master station.

This capability not only addresses extended systems configurations but is useful in large systems where Sensor Modems can serve as data concentrators.

An increasingly common requirement is to have an intelligent radio repeater site which acts as the systems communication master. One or more remotely located PC based systems are used for operations (as operator workstations). The computer nodes must then be updated from the central radio site. Repeater operation is easily supported by the Sensor Modem.

5.1.2. Interactive Access

Sensor Modem supports a true interactive access for on-line operation or for configuration and maintenance access. The Sensor is multi-user and multi-tasking in that both local and remote access can occur simultaneously.

5.1.3. Serial Instrument Interface/Protocol Conversion

Sensor Modem supports up to three serial ports. So in addition to participating as a station (or node) in a SCADA system configuration, the secondary serial ports provides the ability to interface to ancillary instruments. In fact, it is possible to interface to other systems and/or networks that use a "foreign" protocol. This feature is totally user and field configurable.

The presence of a complete BASIC compiler allows for easy implementation of secondary serial protocols and necessary intelligence for operation of connected instruments.

Data retrieved from such customized links can be manipulated and stored in Sensor Modem database registers.

5.2. Real-Time Data Input/Output

5.2.1. Current Data Storage

Data can be obtained from several sources. Regardless of the hardware source, storage registers (holding registers) are provided in memory to maintain a current image of the actual I/O data.

There are two primary register tables for maintaining current real-time data. They are the Local Register Table (Table 1) and the Remote Register Table (Table 2). There are other tables for maintaining summary and historical data, etc.

The Remote Register Table (Table 2) is comprised of 900 word sized registers (16 bits). These registers can be allocated or assigned in any fashion to hold the data read from, or to be sent to, remote stations. The setup of the remote station scan list, along with the number of registers read and/or written, will automatically reserve the appropriate registers for that station.

The Local Register Table (Table 1) contains storage space for local I/O hardware and "local" calculated points. This table also has several additional parameters for generating alarms, recording "ON" times, minimum and maximum values (along with the time of occurance), last time ON and last time OFF for digitals, etc.

5.2.2. Input/Output Hardware

The Sensor Modem Controller provides several types of field connections for Digital Inputs and Outputs, Analog Inputs and Outputs and Pulse Accumulator (counting) inputs.

The I/O configuration and control strategies are set locally using the serial port and a standard communication program. The information is saved in nonvolatile memory.

Both high density expansion boards and RS485 distributed I/O modules can be utilized in conjunction with the Sensor Modem. This allows either having all the I/O terminations done in a single enclosure, or utilizing a distributed terminal with I/O terminations done at each equipment location.

5.3. Point Processing

Each point is configurable for hardware type and address. The digital inputs can have time delays associated with them for filtering or "de-bouncing" of inputs. The point information can be logically manipulated in several ways by the Sensor Modem. Data can be re-routed to an output module or can be used in a monitoring/control strategy. All common boolean (logical) operators and arithmetic operators can be used to create "calculated points. These points can then be used for physical outputs or alarming criteria.

Similar to many PLC's (programmable logic controllers), the Sensor Modem internally has data registers which receive the input data from the field I/O points (sensors).

In addition to reporting the contents of these data registers, the Sensor Modem can also report internal error conditions (such as the loss of AC power, module communications, etc.).

5.3.1. Logical Point Types

Point types include:

- Digital Inputs (discrete ON/OFF states)
- Digital Outputs
- Analog Inputs (measurement values)
- Analog Outputs
- Totalize
- Average
- PWI 3-35 (pulse width)
- AI w/DBA (analog with deadband)
- Calculated Points
- Slave Points

Slave points are points which are extracted from other scanned points which contain multiple bits packed in a byte or word (8 or 16) in order to minimize scan delays. Slave points have all of the scan point attributes.

Calculated points are derived through a calculation process from scanned points or other calculated points.

5.3.2. Point Attributes

Digital points automatically provide the following information:

- Last On Time
- Last Off Time

- Duration of On Time (daily minutes)
- Number of Cycles (daily)

Analog points automatically provide the following information:

- Maximum Value (daily)
- Minimum Value (daily)
- Last Alarm Time
- Time of Maximum
- Time of Minimum

All points provide indication of current alarm state, alarm enable/disable, alarm ack status, and hardware communications status.

Additional parameters allow selection of display characteristics (decimal point, EU labels (Engineering Unit), Point Name, etc.), inversions, change delays, sampling periods, etc.

See section 6.2.1 for a complete list of fields related to the different point types.

5.3.3. Digital Output linking

Digital Output points will "send" their current state values to the destination specified. The current state can be set by several means:

1) Manually
2) by a calculated point
3) from a BASIC program
4) from a remote Table write operation
5) from another "linked" point

A digital output can be linked to another point by entering a non-zero point number in the LINK_PT field of the digital output point. (Column X) The current state of the digital output will then "follow" the current state of the "linked" source point.

5.3.4. Processing Speeds

The internal scan cycle is paced at approximately a 200MS cycle. This results in about 5 cycles per second, relatively independent of the number of active points.

Processing speeds of points is about 100us per point. Internal and local I/O is scanned once per complete scan cycle. I/O scan times are:

Internal Analog Points	5 ms/point
Expansion I/O Module	20 ms/ Module

The remote station scan cycle is dependent on the number of stations being scanned (enabled), the amount of data transferred, and the number of communications errors encountered. The remote scan does not impact the internal and local expansion I/O scan cycle.

5.4. Data Storage Functions

5.4.1. Daily Summary Data

The base unit provides for storage of the current day's summary data and two previous days' summary data. This data is selectable for display purposes and is presented in the same format as the current value data.

Summary registers can be scanned by a remote master or retrieved from a remote slave station for the current day, yesterday and for the day before yesterday. For digital points, four registers are returned for each point consisting of # of cycles, On-time duration (in minutes), last "On" time and Last "Off" time (times are in packed format). For analog points, four registers are returned for each point consisting of maximum value, minimum value, Time of Maximum and Time of Minimum.

5.4.2. Removable Data Cartridges & Historical RAM memory.

The "credit card sized" memory cartridge comes in 128K and the RAM memory is available in 128K and 256K configurations. This option allows the storage of system setup parameters, BASIC programs, and historical data in a portable form suitable for offsite storage or analysis.

A maximum of approximately 12,000 samples can be stored on a 128 KB removable cartridge and the 256 is over 24,000 samples. The storage of historical samples can be done in a circular fashion so as to overwrite the oldest samples with new data.

5.4.3. Historical Data

NOTE: A data cartridge or data RAM memory is required for historical data storage.

Individual points can be selected for storage of historical samples. Sampling criteria can be either time based and/or event triggered. Selection of points for historical sampling is done via the Sampling Criteria field. Multiple points may be enabled by a single trigger point. Cycle timer points can be used to control sampling at various sampling periods.

Samples record the following information: month, day, hour, minutes, seconds, point number, timed/event flag, analog/digital flag, and point value at the sampling time.

Samples are recorded in chronological order and will be recorded at the speed of the I/O scan (typically each expansion requires about 10 ms – the complete scan cycle time depends on configuration). Time stamps display a resolution of 2 seconds.

See section 6.6.2 for details on configuring historical recording.

5.5. Program / Configuration Storage

5.5.1. Real Time Configuration Storage

The configuration is stored in nonvolatile memory and is permanently resident. It may be cleared to a default configuration by setting DIP SW6 down at power-up.

NOTE:	the previous configuration information is lost if the default configuration is loaded.

Transport of configuration files is facilitated by allowing load /save operations to the removeable data cartridge. The load / save operations are accessed from the menu line of the real-time displays. One configuration file can be stored on the memory cartridge.

The current data base configuration can be offloaded to a computer file using the XMODEM transfer function. Downloading a configuration from a computer file is also supported.

It is recommended that a copy of station configurations be maintained in computer files for maintenance and updating purposes. Should a unit fail and have to be replaced, the replacement unit can easily be configured to match by downloading the configuration file.

5.5.2. BASIC Program Storage

Two file storage areas are provided for storing BASIC programs; file device 1 is in internal nonvolatile memory; file device 2 is in the removable memory cartridge. Up to 9 programs (1 through 9) may be stored in each of the file devices, depending on the size of the programs.

Access to these files/file devices is via the BASIC direct commands LOAD and SAVE. There are two parameters associated with the command to specify the file; the device (first digit) and the file number (second digit).

Examples are: LOAD 11

LOAD 23

Also, see the FILEFORMAT command in the BASIC section (Chapter 9) for details of initializing the file devices.

File device 1 (internal memory) is 12KB in size. File device 2 is 24KB in size. This allows enough space for several programs to be stored locally. Program files may also be uploaded or downloaded from a PC.

5.6. Real Time System Display/Entry

Real time data display is effected through an easy to use "spread sheet" type array of rows and columns. Each row contains the parameters associated with a point (in Table 1). Individual cells in the display can be modified by the operator. Cursor selection allows selection of the desired field which is indicated by being highlighted. Cursor movements can also cause paging operations, either up/down or left/right.

A Lotus style menu line is used for selection of other operator actions. The menu line is accessed via the "/" key. Return to the data mode from the menu line can be done with the "Esc" key.

5.6.1. Display Point Selection Criteria

Effective display of operating data is facilitated by allowing the operator to select the type of point or alarm condition of interest. Point type qualifiers include:

- All Active Points
- Digital Points Only
- Analog Points Only
- Output Points Only
- Calculated Points Only
- ALL Points (including inactives)
- Alarm selection criteria include:
- All Alarm Points
- Currently Active Alarm Points
- Unacknowledged Alarm Points
- Disabled Alarm Points
- Enabled Alarm Points

These criteria can be used independently or in combination.

The current selection criteria are displayed on the screen. Selection of these qualifiers is made via the Menu Line.

5.6.2. Display Formatting

Several display Formatting features allow the operator to display data in a convenient manner.

A "Border" column can be enabled so that the Point Name column is always visible, regardless of the portion of data displayed.

Individual columns can be "hidden" so that selected columns can be viewed on one screen. The "hidden column" function can be globally enabled or disabled without affecting the columns marked as hidden. Hidden columns are indicated by a "^" character preceding the column identifier. This is visible only when the hidden column feature is disabled.

5.6.3. Data Entry Modes

There are three types of data entry field:

1. Numeric
2. Alphanumeric (String)
3. List (cursor selection from pre-defined list of choices)

Selection of an entry field is accomplished in CURSOR mode by using the cursor movement keys to highlight the desired field, and pressing "INSERT". The actual insert command is "ED<Enter>" if the insert key has not been programmed.

Selection of an entry field may also be accomplished via the MENU mode. The Menu Line is accessed by pressing the "/" key. Canceling the MENU mode is accomplished by pressing the "Esc" key.

Chapter 6
Table 1 Setup

6. Table 1 Setup

6.1. Overview

The Real Time System displays are initially accessed from the command level by entering "LINK,RTSYS" followed by "ONLINE". (Alternately, "LINK,RT2")

The Real Time System function provides display and entry capabilities for all of the points defined in the RTU. Display is provided in a "spread sheet " format. Each point (or point group) is displayed as a row in the spread sheet. The row number is the logical point number used for referencing the point.

Within each row are all of the setup and operational fields for the point, one to a column. Each point type has parameters relevant to that point type. The selected field is displayed as a highlited field. Selection of a field is accomplished by using the cursor movement keys (arrow keys) or page keys or + (page right) or - (page left).

6.1.1. Disabling the Scan

It is not mandatory to disable the scanning (processing) of points during data base editing and setup. However, editing changes while the scan is active may cause an inadvertent I/O operation. The scan can be manually disabled from the STATION menu line and re-enabled after editing is complete.

6.1.2. The "Configuration" Mask

In order to facilitate the setup or configuration of points in the data base (Table 1), a specialized "Cfg-MSK" is accessible from the FORMAT menu line. This mask is a pre-defined Hide-Mask which suppresses display of several of the columns in the CURRENT/SUMMARY display. This is intended to allow the user to focus his/her attention on the key setup parameters for configuring points.

After the points are initially defined, the user can return to the normal HIDE OFF condition which shows all columns for "fine tuning" and entry of remaining operating parameters.

Note columns B,D,E,F,G,H,I,J,K,L,M,N,O and R are all hidden.

Station A _DATA-CUR/SUM Sunday 19:31:50 01/10/93

File = TODAY'S 01/10/93 Scan is Enabled ALLPoints NoAlmQual

	A	C	P	Q	S	T	U
	PT.NAME	CURSTATE	HW TYPE	PT TYPE	MOD ADDR	REG/PT	BIT POS
01	ALARM	OFF	INTERNAL	DIG IN	0	0	4
02	AC PWRIN	13.7	INTERNAL	ANL IN	0	5	27.5
03	LCL-DI0	OFF	INTERNAL	DIG IN	0	0	0
04	LCL-DI1	OFF	INTERNAL	DIG IN	0	0	1
05	LCL-AI0	424	INTERNAL	ANL IN	0	0	0
06	RMT-DI0	OFF	TABL2/RS	DIG IN	1	0	1
07	RMT-DI1	OFF	TABL2/RS	DIG IN	1	0	0
08	RMT-AI0	459	TABL2/RS	ANL IN	1	2	0
09	LCL-LED0	OFF	INTERNAL	DIG OUT	0	1	0
10	LCL-LED1	OFF	INTERNAL	DIG OUT	0	1	1
11	LCL-DO0	OFF	INTERNAL	DIG OUT	0	0	1
12	LCL-DO1	OFF	INTERNAL	DIG OUT	0	0	0
13	RMT-DO0	OFF	TABL2/RS	DIG OUT	2	0	0
14	RMT-DO1	OFF	TABL2/RS	DIG OUT	2	0	1
15	RMT-POT	422	TABL2/RS	ANL OUT	2	1	0

Figure 6.1
Config Mask Display

6.1.3. Viewing "Inactive" Points

In order to define new points (those which are currently "Inactive"), the user must first make them visible. This can be accomplished by Menu line selection. First select DISPLAY, POINTS, and then ALL POINTS, from the menu line choices. This will display all points including those which are currently inactive.

6.1.4. Point Numbers - Activating

The number shown at the left end of each point line in the data portion of the display is its point number. When a point is activated (e.g., Hardware Type field is other than Inactive) it is processed in the scan cycle by the appropriate portions of the scan program.

Regardless of the display formatting or point display qualifiers selected, a particular point will always remain and be referenced by that point number.

6.2. Display / Entry Operations

Standard keys used for real time display controls are:

Arrows	Cursor Field Selection
Page Up/Down	Cursor Field Selection
+	Page Right (Alt: Tab)
-	Page Left
HOME	Home
END	Refresh Screen
/	Activate Menu Line
INSERT	Edit the Current Field
ESC	Cancel Operation
ENTER	Complete Operation
R	Refresh Data w/ Dynamic repeat

Figure 6.2
Standard Key Mapping

Note: Since some keyboards do not have arrow keys, END, HOME, or INSERT keys, generic keys are defined for most operator actions. The generic keys are listed below. The arrow and page keys have numeric equivalents based on the numeric keypad of a PC. For example the '8' key on a numeric keypad also shows an up arrow, etc.

Function	Generic	Mapped
Edit field	ED<Enter>	Insert
Refresh	R	R
Re-write	1	End
Home	7	Home
Page Up	9	Page Up
Page Down	3	Page Down
Arrow Up	8	Arrow Up
Arrow Down	2	Arrow Down
Arrow Left	4	Arrow Left
Arrow Right	6	Arrow Right
Page Left	-	ShiftTab (or -)
Page Right	+	Tab (or +)
Menu	/	/
Cancel	Esc	Esc
Complete Entry	Enter	Enter

Figure 6.3
Generic key assignment table

Station 1 Master TABLE1_DATA-CUR/SUN Sunday 19:38:46 01/10/93

	File =	TODAY'S	01/10/93	Scan is	Enabled	ALLPoints	NoAlmQual
	A	B	C	D	E	F	G
	PT_NAME	PT TYPE	CURSTATE	ALM ENBL	ALARM	UNACK	CYCLES
01	ALARM	DIG IN	OFF	En		UNACK	1
02	AC PWRIN	ANL IN	13.4	VOLT		UNACK	879.9
03	LCL-DI0	DIG IN	OFF	En		UNACK	30
04	LCL-DI1	DIG IN	OFF	En		UNACK	26
05	LCL-AI0	ANL IN	417	MV	ALARM HI	UNACK	32767
06	RMT-DI0	DIG IN	OFF	En		UNACK	29
07	RMT-DI1	DIG IN	OFF	En		UNACK	32
08	RMT-AI0	ANL IN	452	MV	ALARM HI	UNACK	511
09	LCL-LED0	DIG OUT	OFF	En		UNACK	35
10	LCL-LED1	DIG OUT	OFF	En		UNACK	34
11	LCL-DO0	DIG OUT	OFF	En		UNACK	23
12	LCL-DO1	DIG OUT	OFF	En		UNACK	26
13	RMT-DO0	DIG OUT	OFF	En		UNACK	29
14	RMT-DO1	DIG OUT	OFF	En		UNACK	25
15	RMT-POT	ANL OUT	416	MV	ALARM HI	UNACK	32766

Figure 6.4
Real-Time Data Display

Point displays will display the appropriate column titles according to one of four general point types selected by the highlighted field. These column titles can be refreshed by hitting the END key. Most of the columns contain the same information, regardless of point type.

Refer to Figure 6.2.1 for a summary list of column names for each generic point type. From this list, you can see that each Table 1 point has a variety of parameters associated with it that allow it to be first defined, and then used in an operational environment.

For example, in column C of the Current Data Displays, the Current State is shown for Digital type points, and the Current Value is shown for Analog type points. The column heading and the data values are displayed according to the point type. The CALC_DIG and CALC_ANL menus appear when the HW TYPE (Column P) is set to either CALC_DIG or CALC_ANL

The next four figures show the entire column listings for each of the four general point types, namely, DIGITAL, ANALOG, CALC_DIG and CALC_ANL.. A complete alphbetical listing of all of the column names with an explantion for each one follows the displays.

A	B	C	D	E	F	G
PT.NAME	PT TYPE	CURSTATE	ALM ENBL	ALARM	UNACK	CYCLES
ALARM	DIG IN	OFF	En		UNACK	2
H	**I**	**J**	**K**	**L**	**M**	**N**
DURATION	Last ON	Last OFF	N.U.	NU/HILIM	NU/LOLIM	ALM ENBL
15	14:33:08	14:59:00				En
O	**P**	**Q**	**R**	**S**	**T**	**U**
ModulSTS	HW TYPE	PT TYPE	Famly/#P	MOD ADDR	REG/PT	BIT POS
Comm. OK	INTERNAL	DIG IN	0	0	0	4
V	**W**	**X**	**Y**	**Z**	**AA**	**AB**
N.U.	Resol/LZ	Link Pt.	INVERT	LabelSel	CURSTATE	N.U.
	0	0	NO-INVRT	0	OFF	
AC	**AD**	**AE**	**AF**	**AG**		
DEC.PT.	AlmType	AlmAct'n	AlmDelay	SmplType		
0	0	0	0	0		

Figure 6.5
DIGITAL Point Menu Line

A	B	C	D	E	F	G
PT.NAME	PT TYPE	CURVALUE	UNITS	ALARM	UNACK	MAXVAL
AC PWRIN	ANL IN	13.6	VOLT		UNACK	14.2
H	**I**	**J**	**K**	**L**	**M**	**N**
MINVAL	LstAlarm	TimeOfMx	TimeOfMn	HI LIMIT	LO LIMIT	ALM ENBL
.0	13:19:24	13:34:44	11:54:56	26.0	8.5	En
O	**P**	**Q**	**R**	**S**	**T**	**U**
ModulSTS	HW TYPE	PT TYPE	Famly/#P	MOD ADDR	REG/PT	RANGE/FS
Comm. OK	INTERNAL	ANL IN	0	0	5	27.5
V	**W**	**X**	**Y**	**Z**	**AA**	**AB**
OFFSET	Resol/LZ	N.U.	INVERT	UNITS	N.U.	N.U.
.0	1		NO-INVRT	VOLT		
AC	**AD**	**AE**	**AF**	**AG**		
DEC.PT.	AlmType	AlmAct'n	AlmDelay	SmplType		
1	0	0	0	251		

Figure 6.6
ANALOG Point Menu Line

A	B	C	D	E	F	G
PT.NAME	PT TYPE	CURSTATE	ALM ENBL	ALARM	UNACK	CYCLES
ALARM	DIG IN	ON	En	ALARM	UNACK	4

H	I	J	K	L	M	N
DURATION	Last ON	Last OFF	N.U.	NU/HILIM	NU/LOLIM	ALM ENBL
7	13:50:48	00:01:00				En

O	P	Q	R	S	T	U
ModulSTS	HW TYPE	PT TYPE	Famly/#P	CALCTYPE	IN PT 1	IN PT 2
Comm. OK	CALC-PT	DIG IN	0	BAND	0	0

V	W	X	Y	Z	AA	AB
IN PT 3	CONST.	Link Pt.	INVERT	LabelSel	CURSTATE	N.U.
0	4	0	NO-INVRT	0	ON	

AC	AD	AE	AF	AG	AG
DEC.PT.	AlmType	AlmAct'n	AlmDelay	SmplType	SmplType
0	0	0	0	0	0

Figure 6.7
CALC_DIG Point Menu Line

A	B	C	D	E	F	G
PT.NAME	PT TYPE	CURVALUE	UNITS	ALARM	UNACK	MAXVAL
AC PWRIN	ANL IN	13.7	VOLT		UNACK	14.2

H	I	J	K	L	M	N
MINVAL	LstAlarm	TimeOfMx	TimeOfMn	HI LIMIT	LO LIMIT	ALM ENBL
.0	13:19:24	13:34:44	11:54:56	26.0	8.5	En

O	P	Q	R	S	T	U
ModulSTS	HW TYPE	PT TYPE	Famly/#P	CALCTYPE	IN PT 1	IN PT 2
Failed	CALC-PT	ANL IN	0	BAND	5	0

V	W	X	Y	Z	AA	AB
IN PT 3	CONST.	Link Pt.	INVERT	UNITS	N.U.	N.U.
0	27.5	1	NO-INVRT	VOLT		

AC	AD	AE	AF	AG
DEC.PT.	AlmType	AlmAct'n	AlmDelay	SmplType
1	0	0	0	251

Figure 6.8
CALC_ANL Point Menu Line

The following definitions clarify the abreviated column heading listed above, the following list is in alphabetical order by name, following this is a list ordered by Column.

6.2.1. Menu Name Listing ordered by name.

ALARM	E	Shows current alarm status.
ALM ENBL	D	Shows point alarm enable condition.
ALM ENBL	N	Shows point alarm enable condition.
AlmAct'n	AE	Allows suppression of alarm acknowledge for return to normal or new alarm. 0=Normal alarming, 1=Supress Unack on Set or Return, 2=Supress Unack on Return, 4=Flash DO(expansion I/O) on Set, 6=Flash DO(expansion I/O) on Set, not on Return.
AlmDelay	AF	Number of seconds of delay before indicating an alarm condition. If used with a digital input, the status of the input (set or reset) is not updated until after the delay time. Digital outputs are not affected.
AlmType	AD	Allows selection as a member of Major and Minor Alarm groups for common alarms. 1=Major, 2=Minor, 3=Major & Minor.
BIT POS	U	For digitals, the bit position of the data within the register.
CALCTYPE	S	For calculated points (Column P, HW TYPE set to CALC-PT), selects type of calculation to be performed.
CONST.	W	Constant entry for calculated points.
CURSTATE	AA	Current state of this point, for digital points, N.U. for analog points.
CURSTATE	C	Current state of this point, for digital points.
CURVALUE	C	Current value of this point, for analog points.
CYCLES	G	Indicates the number of OFF to ON transitions since midnight, for digital points.
DEC.PT.	AC	Selection of decimal point position for display purposes.
DURATION	H	Indicates the duration of ON state (in minutes) since midnight, for digital points.
Famly/#P	R	Designates module type for DGH Extended I/O modules.
HI LIMIT	L	High limit for analog points.

HW TYPE	P	Data source type: Internal registers, Expansion I/O module, or Table 2 register, etc.
IN PT 1	T	For calculated points, first parameter used by the calculation (argument 1), usually identifies another table 1 point.
IN PT 2	U	For calculated points, second parameter used by the calculation (argument 2), usually identifies another table 1 point.
IN PT 3	V	For calculated points, third parameter used by the calculation (argument 3), usually identifies another Table 1 point.
INVERT	Y	Indicates if source data should be logically inverted before using or storing.
LabelSel	Z	Selects label pair for digital point display: ON/OFF, RUN/STOP, ARMED/DISARM, etc.
Last OFF	J	Time of last transition to the OFF state, for digital points.
Last ON	I	Time of last transition to the ON state, for digital points.
Link Pt	X	Allows linking a point to another line for input or output.
LO LIMIT	M	Low limit for analog points.
LstAlarm	I	Time of last alarm, for analog points.
MAXVAL	G	Maximum value for analog points.
Membr/LZ	W	Designates module type for DGH Extended I/O modules.
MINVAL	H	Minimum value for analog points.
MOD ADDR	S	Data source address for all points except CALC-PT type. Either expansion module address, or Table 2 station index. (0 for internal registers)
ModulSTS	O	Communications status for origin of data.
N.U.	AA	Vacant column for analog points.
N.U.	AB	Vacant column
N.U.	K	Vacant column for digital points.
N.U.	V	not used for digital point.
NU/HILIM	L	Vacant column for digitals, shows High limit for analogs.
NU/LOLIM	M	Vacant column for digitals, shows Low limit for analogs.

OFFSET	V	Offset parameter for scaling analog points. (see 6.5 for scaling information)
PT TYPE	B	Assignment for this point: DIG IN, DIG OUT, ANL IN, ANL OUT, TOTALIZE, AVERAGE, PWI 3-15, AI w/DBA.
PT TYPE	Q	Assignment for this point: DIG IN, DIG OUT, ANL IN, ANL OUT, TOTALIZE, AVERAGE, PWI 3-15, AI w/DBA.
PT.NAME	A	User assigned name for point.
RANGE/FS	U	Full scale reading when the A-D converter is at maximum. (see 6.5 for scaling information)
REG/PT	T	Selects which source register if there are multiple registers in source module, for digital and analog points.
Resol/LZ	W	For analog inputs only, selects scaling resolution 0=10 bit, bipolar, hardware full scale=512 1=10 bit, unipolar, hardware full scale=1023 2=12 bit, bipolar, hardware full scale=2047 3=12 bit, unipolar, hardware full scale=4095
SmplType	AG	Shows sampling criteria assigned. 1-180= index point to use for trigger; 250=record when change of state or alarm limit; 251=1 every Minute; 252=once a day (at midnight).
TimeOfMn	K	Time of Minimum value, for analog points.
TimeOfMx	J	Time of Maximum value, for analog points.
UNACK	F	Shows current alarm acknowledge status.
UNITS	D	Shows Engineering Unit label for analog points.
UNITS	Z	Shows Engineering Unit label for analog points.

6.2.2. Menu Name Listing ordered by column.

PT.NAME	A	User assigned name for point.
PT TYPE	B	Assignment for this point: DIG IN, DIG OUT, ANL IN, ANL OUT, TOTALIZE, AVERAGE, PWI 3-15, AI w/DBA.
CURVALUE	C	Current value of this point, for analog points.
CURSTATE	C	Current state of this point, for digital points.
ALM ENBL	D	Shows point alarm enable condition.
UNITS	D	Shows Engineering Unit label for analog points.
ALARM	E	Shows current alarm status.
UNACK	F	Shows current alarm acknowledge status.
MAXVAL	G	Maximum value for analog points.
CYCLES	G	Indicates the number of OFF to ON transitions since midnight, for digital points.
MINVAL	H	Minimum value for analog points.
DURATION	H	Indicates the duration of ON state (in minutes) since midnight, for digital points.
LstAlarm	I	Time of last alarm, for analog points.
Last ON	I	Time of last transition to the ON state, for digital points.
TimeOfMx	J	Time of Maximum value, for analog points.
Last OFF	J	Time of last transition to the OFF state, for digital points.
N.U.	K	Vacant column for digital points.
TimeOfMn	K	Time of Minimum value, for analog points.
HI LIMIT	L	High limit for analog points.
NU/HILIM	L	Vacant column for digitals, shows High limit for analogs.
LO LIMIT	M	Low limit for analog points.
NU/LOLIM	M	Vacant column for digitals, shows Low limit for analogs.
ALM ENBL	N	Shows point alarm enable condition.
ModulSTS	O	Communications status for origin of data.
HW TYPE	P	Data source type: Internal registers, Expansion I/O module, or Table 2 register, etc.
PT TYPE	Q	Assignment for this point: DIG IN, DIG OUT, ANL IN, ANL OUT, TOTALIZE, AVERAGE, PWI 3-15, AI w/DBA.

Famly/#P	R	Designates module type for DGH Extended I/O modules.
CALCTYPE	S	For calculated points (Column P, HW TYPE set to CALC-PT), selects type of calculation to be performed.
MOD ADDR	S	Data source address for all points except CALC-PT type. Either expansion module address, or Table 2 station index. (0 for internal registers)
IN PT 1	T	For calculated points, first parameter used by the calculation (argument 1), usually identifies another table 1 point.
REG/PT	T	Selects which source register if there are multiple registers in source module, for digital and analog points.
RANGE/FS	U	Full scale reading when the A-D converter is at maximum. (see 6.5 for scaling information)
IN PT 2	U	For calculated points, second parameter used by the calculation (argument 2), usually identifies another table 1 point.
BIT POS	U	For digitals, the bit position of the data within the register.
N.U.	V	not used for digital point.
OFFSET	V	Offset parameter for scaling analog points. (see 6.5 for scaling information)
IN PT 3	V	For calculated points, third parameter used by the calculation (argument 3), usually identifies another Table 1 point.
CONST.	W	Constant entry for calculated points.
Membr/LZ	W	Designates module type for DGH Extended I/O modules.
Resol/LZ	W	For analog inputs only, selects scaling resolution 0=10 bit, bipolar, hardware full scale=512 1=10 bit, unipolar, hardware full scale=1023 2=12 bit, bipolar, hardware full scale=2047 3=12 bit, unipolar; hardware full scale=4095
Link Pt	X	Allows linking a point to another line for input or output.
INVERT	Y	Indicates if source data should be logically inverted before using or storing.
UNITS	Z	Shows Engineering Unit label for analog points.
LabelSel	Z	Selects label pair for digital point display: ON/OFF, RUN/STOP, ARMED/DISARM, etc.

N.U.	AA	Vacant column for analog points.
CURSTATE	AA	Current state of this point, for digital points, N.U. for analog points.
N.U.	AB	Vacant column
DEC.PT.	AC	Selection of decimal point position for display purposes.
AlmType	AD	Allows selection as a member of Major and Minor Alarm groups for common alarms. 1=Major, 2=Minor, 3=Major & Minor.
AlmAct'n	AE	Allows suppression of alarm acknowledge for return to normal or new alarm. 0=Normal alarming, 1=Supress Unack on Set or Return, 2=Supress Unack on Return, 4=Flash DO(expansion I/O) on Set, 6=Flash DO(expansion I/O) on Set, not on Return.
AlmDelay	AF	Number of seconds of delay before indicating an alarm condition. If used with a digital input, the status of the input (set or reset) is not updated until after the delay time. Digital outputs are not affected.
SmplType	AG	Shows sampling criteria assigned. 1-180= index point to use for trigger; 250=record when change of state or alarm limit; 251=1 every Minute; 252=once a day (at midnight).

6.3. Point Parameter Setup

Each active point has parameters which include point name, current state(value), alarm enable, alarm state, alarm delay, alarm action, display format, etc. Additionally, points include fields which are dependent on point type.

Figure 5.3 shows the fields associated with different categories of points. The fields are arranged by column ID (letter) with the related column header listed (parameter name).

The setup of local points (Table 1) is relatively intuitive, and parameters associated with a point may be altered at will.

Note that if only raw point values are needed (for transmission to a master station), you may not need to configure Table 1 points. See Table 2 setup section for discussion of accessing local expansion I/O raw values.

Table 1 points provide the ability to perform calculations, scale, alarm, sample, and other common functions. Table 1 points can be defined to place individual points (or associated parameters like run-time, # of starts, etc.) in Table 2.

The following sections illustrate the initial steps to defining (activating) points of various types. Enter the indicated parameters in the appropriate columns of the display. Note that the parameters listed below define the point type and the hardware that is associated with the point. These are necessary entries for the definition of a point. All of the other parameters, such as Point Names and Alarm Limits, should then also be entered as desired.

6.3.1. Digital Points

To define a scanned point:

1)	enter point type	(Column Q)
2)	enter hardware type	(Column P)
3)	enter hardware address	(Column S)
4)	enter register number	(Column T)
5)	enter bit number	(Column U)

Occasionally a "slave" point is defined to extract a specified bit from another point. To define a slave point:

1)	enter point type	(Column Q)
2)	enter hardware type= Slave Pt	(Column P)
3)	enter source pt # = scanned pt #	(Column T)
4)	enter bit position in scanned pt byte	(Column U)

For both digital and analog points, the Hardware type field specifies whether Internal I/O, or Expansion I/O, or Remote Station I/O registers are the source (or destination) of this point's data. Other Hardware types are defined but generally not used.

The number of data registers and/or bits of data available from a particular I/O module is a function of its physical construction. Trying to access a register beyond the capacity of the module, or trying to address a non-existent module, will result in a "communication status" (column O) indication of FAILED.

6.3.2. Analog Points

To define a scanned analog point,

1)	enter point type	(Column Q)
2)	enter hardware type	(Column P)
3)	enter hardware address	(Column S)
4)	enter hardware family (DGH module)	(Column R)
5)	enter register number	(Column T)

6.3.3. Calculated Points

To define a calculated point,

1)	enter point type	(Column Q)
2)	enter hardware type= CALC PT	(Column P)
3)	enter calc type	(Column S)
4)	enter calc input 1 param. (point #)	(Column T)
5)	enter calc input 2 param. (point #)	(Column U)
6)	enter calc input 3 param. (point #)	(Column V)

The possible calculation types and their parameter inputs are listed in Section 5.4.

Generally, a calculated point will use another Table 1 point (or points) as the source of data, and will perform a "calculation" on that input data, and store the result in an output Table 1 point. Calculated points can either be "input" points (where it receives the result data) or as an "output" point (where it stores the result data into a destination point).

6.3.4. Average (Analog) Points

Setup is similar to Analog Input points. AVERAGE points differ from Analog Input points in that the current value is the one minute average of the source data, and the Maximum field contains the most recent Hourly Average of the source data.

CAUTION	Do not change any values in the TimeOfMx (Col K), TimeOfMn (Col J) or MINVAL (Col H) columns as they contain internal numbers used in the calculations.

6.3.5. Totalize (Analog) Points

The setup of a Totalize point is similar to Analog Input points and the source data may be scaled just as an analog input is scaled. TOTALIZE points differ from Analog Input points in that the current value is the one minute average of the source data. Since the averages are for one minute, the engineering units that are being totalized must be in a rate per minute (i.e. GPM, RPM, etc). The rate value being totalized should be less than 10,000.

The Minimum and Maximum fields contain the Totalized reading of the source data. The least significant 4 digits in the Minimum field, the 4 most significant digits in the Maximum field. The accumulated total is then, **Total = (Maximum field * 10,000) + Minimum field**.

The totalizing is done at the minute change (eg, every minute) and the totalizer does not reset at midnight. Zeros may be entered (in the Minimum and Maximum fields) to clear out the totalizer at any time.

CAUTION	Do not change any values in the TimeOfMx (Col K), TimeOfMn (Col J) or MINVAL (Col H) columns as they contain internal numbers used in the calculations.

The INVERT field is used to control positive and negative rates, if the field is set to NO-INVRT (normal setting) only positive rates will be totalized. If the field is set to INVERT then only negative flows will be totalized.

If you wish to totalize the sum of several rates, or if the rate you want to totalize is already in a row in Table 1, the following method can be used:
HW TYPE (P) to CALC
PT TYPE (Q) to TOTALIZE
CALC TYPE (S) to ADD
and then IN PT 1, IN PT 2 and IN PT 3 can reference the rows that have the rates to totalize.

6.3.6. PWI 3-15 (Pulse width digital input)

This is designed to measure the ON duration of digital inputs that are used in pulse width duration equipment. Although a digital point is being monitored, the addressing of that point will look like an analog point to allow for an analog value (the total ON time).

The MOD ADDR, REG/PT and BIT POS must be set to monitor a digital input point, however, the BIT POS field must be set to 0 (zero) and the REG/PT field will be the actual bit position within the digital input module for that digital point. The CURVALUE field will contain the "ON" time in tenths of seconds. Maximum measurement is 25.5 seconds (will be displayed as 255).

6.3.7. AI w/DBA (Analog input with moving alarm limits)

This is similar to an analog input field except the range is used to calculate a dead band for alarming the point. The dead band is 2.3% of the range, if no range is specified then the dead band will be 5 counts.

When the input changes by more than the dead band the alarm will toggle for one scan and then reset until the value again changes by more than the dead band. This is a convenient way to set an alarm point to trigger a report by exception transmission.

6.3.8. Other Point Related Parameters-

After the main parameters have been entered, which determine the point type, etc., there are several additional parameters which affect the display appearance, alarming actions and sampling criteria.

Parameters which affect the display appearance include:

- Label Selection
- Decimal Point
- Point Name
- Invert

6.4. Calculated Points

Calculated points are defined by setting the HW TYPE parameter (Column P) to CALC.PT. When this is done the adjacent columns become the parameters for the Calculation Type. The Header line will reflect this change if the display is updated by pressing the "END" key. The PT TYPE parameter (Column Q) is set to the proper point type and the CALCTYPE parameter (Column S) is used to select the particular calculation. Columns T, U and V are used for three arguments to the calculation, IN PT 1, IN PT 2 and IN PT 3. The CURSTATE (Column C) is also used in some of the calculations.

The calculation type is a list type entry and selection can be made using the up/down arrow keys until the desired calculation type is displayed. The three arguments (IN PT 1, IN PT 2 and IN PT3) are numeric entries and, in most cases, are point numbers of other Table 1 points which serve as either an input or as a destination. In some cases, the argument entry may serve as a constant.

In general then, a calculated point tends to involve a single destination point and up to three source points. Note that a calculated point can be defined as either an "input" or an "output" point. Generally, this affects whether the calculated point is a source or the destination for the calculation result.

If the calculated point is an "input" type (ie, DIGITAL IN), then the 3rd parameter is a third input and the result (output of calculation) is stored as the "current value" of the calculated point.

If the calculated point is an "output" type (ie, DIGITAL OUT), then the third parameter becomes the destination point (output of calculation) and the "current value" of the calculated point is used as the "3rd input".

Example:	A Digital Input boolean AND calculation will calculate a digital point value whose state is the logical AND of the current states of the defined Point1, Point2 and Point3. The result will be the current value of the calculated point. For an equivalent Digital Output calculation, the inputs are Point1, Point2, and the current state of the calculated point, with the result being stored as the current value for Point3.

The following is a list of the calculation types:

ADD
BAND
BMUX
BOR
BXOR
CHDET1
CHDET8
COPY
CTDWN
CTRLR
CYCTMR
DE-MUX
DIV
LATCH
MULT
SUB
TOD-OS

6.4.1. Calculation Type Operations

Caution	should be exercised on all "output" calculated points to direct output results to the desired destination point. If multiple results are stored in a single destination point, the result will not be predictable.

6.4.1.1. Boolean Operators (BAND, BOR, BXOR)

The boolean calculated points operate with digital points and calculate a result based on the states of the input points and stores that result in the destination point.

Parameters which are equal to 0 indicate "no point selected" for that term. BXOR generates a true (ON) result if one and only one of the inputs is true (ON).

If the PT TYPE is DIG IN then CURSTATE will hold the result of the calculation. If the PT TYPE is DIG OUT then the CURSTATE column is used as a third input and the IN PT 3 column (V) will hold the result of the calculation.

6.4.1.2. Logical Multiplexer (BMUX)

The multiplexor calculation allows selection of one of two inputs (Source #1 & Source #2) based on the state of the control signal (Input #3). The Off (0) state of the selector point will result in selection of the point associated with Input 1. This calculation type is unique in that it can be used with a point type of either digital or analog. The <u>selector input</u> will always be linked to a digital point (On/Off).

6.4.1.3. Logical DeMultiplexer (DE-MUX)

This is a digital point calculation. The de-multiplexer allows routing of a digital point to two destination digital points. Input #1 (Source) is the source point to route, and Inputs #2 & #3 (Destination #1 & #2) are the destination points. The CURSTATE column will show the status of the Source point.

The result (state of source point) will be placed in the destination points regardless of whether the calculation point is defined as a digital input or digital output.

6.4.1.4. Controller (CTRLR)

The controller calculation can be used in four basic modes: Pump-In, Pump-Out, Single Set-point On/Off, and Single Set-point Off/On. (Pump-In implies turn on when less than the low threshold and turn off when above the high threshold) The "mode" is determined by whether both input parameter #1 (Low Limit) and input parameter #2 (High Limit) are non-zero (indicating the use of both thresholds) or if only one of those parameters is linked. The entries in Input columns are references to other points in the table and those points must have the alarms set to generate the HI and LOW thresholds that this controller uses for control.

The INVERT selection for the calculated point is used to select whether the operation is "pump-in" or "pump-out". NO_INVERT is for pump out and INVERT is for pump in.

If both parameter 1 and parameter 2 are non-zero, <u>the controller calculation latches based on exceeding the associated high/low limit thresholds of the source point</u>. The Set and Reset inputs can be set to the same or different source input points. This can be used for simple tank control operations.

Greater than/Less than function:
If <u>only</u> the set or reset input is used (leaving the other input as 0), the controller will be set only while the associated limit is exceeded, providing a Greater than or Less than function.

Note:	The CTRLR function has been specifically designed for use with analog points, if the controlling inputs are digital, such as float control, then the LATCH function is the best function to use.

6.4.1.5. Latch (LATCH)

This calculation type is useful for On/Off control based on limit switch inputs. The result will set on the leading edge of input 1, and will reset on the leading edge of input 2. The calculation is enabled when parameter #3 is set to zero, or if set to a line number, then that line becomes the enabling point. When disabled, the result is forced to the reset state. Invert has no effect on the result.

The LATCH may be used as a "one-shot" point. If input 2 is set to the same line number as the LATCH itself, then the LATCH will turn itself OFF after one scan cycle. When the enabling point turn OFF it will automatically reset itself. This is the simplest way to set up a point that will only be ON for one scan cycle.

6.4.1.6. ChangeDetect1 (CHDET1)

This calculation results in a set output if an input change of state occurs. Input 2 is used with a constant (does not refer to a line number) to specify the output as latching (1) or momentary (0). Invert has no effect on the result. The CONST column controls the three modes of operation.

If CONST is:

0 The output will set on the "leading" and "trailing" edge.
1 The output will set on the "leading" edge only.
2 The output will set on the "trailing" edge only.

6.4.1.7. ChangeDetect8 (CHDET8)

This calculation results in a set output if any bit (0-7) of an input register (point) changes state. It is convenient when determining a common alarm response to multiple input bits. Input 2 is used to specify the output as latching (1) or momentary (0). Invert has no effect on the result. The CONST column controls the three modes of operation.

If CONST is:

0 The output will set on the "leading" and "trailing" edge.
1 The output will set on the "leading" edge only.
2 The output will set on the "trailing" edge only.

6.4.1.8. Arithmetic (ADD, SUB, MULT, DIV)

These calculation types will perform the indicated arithmetic operations on the source operands indicated by the calculation parameters. A simple "MOVE" of an analog value can be accomplished by ADD'ing a single source point (other parameters equal 0).

> Note: The registers are signed 16 bit integers, so the range of possible values is -32767 to + 32767. Use caution that your calculations will remain within these limits. BASIC can be used for floating point calculations and large numbers.

ADD = (source1 + source2 + source3)
SUB = (source1 - source 2 - source3)
MULT= (source1 * source2 * source3)
DIV= (source1 / source2) * source3)

The DIV type uses source3 (IN PT 3) for a multiply factor,
0=X1,
1=X10,
2=X100,
3=X1000,
4=fractional value of 4096, for outputting directly to analog output.

6.4.1.9. Cycle Timer (CYCTMR)

The Cycle Timer momentarily sets the output every time the "timer" reaches the cycle time. Calculation parameters 1 and 2 (Inputs 1 & 2) are multiplied to determine the total cycle time. Input 1 & Input 2 are CONSTANTS, they do not refer to line numbers in Table 1. The third input is used as an enable/disable function. Both Input and Output calculation types use "current state" to show status. Invert has no effect on the result.

The total cycle time is the product of Input 1 and Input 2 (Input 1 * Input 2 = total cycle time). The CONST column controls several aspects of the timer.

If CONST is:

0 Inputs 1 & 2 are seconds. Thus, if either parameter is set to 60, the other parameter becomes, in effect, the number of minutes.
1 Inputs 1 & 2 are tenths of a second (0.1 seconds each).
2 Inputs 1 & 2 are seconds and the output functionality changes from a momentary to a square wave. The square wave has the same ON and OFF time as the total of inputs 1 & 2.
3 This is the same as #2 except the input times 1 & 2 are in tenths of a second.

6.4.1.10. Count Down (CTDWN)

This calculation has several options that control its functionality as a count down controller. This calculation is useful for measuring out a particular volume of product or providing timer control capabilities. Invert has no effect on the output.

The first input (Input 1) points to another point that is used as a trigger to start counting down; if a zero is entered for Input 1 the count will decrease by one each time the function is evaluated, which is every 0.1 seconds.

The second input (Input 2) points to another point that will be used as the starting value to to decrement (once per Input 1 changing state). If a constant value is desired, link to a calculated point, ADD, with the CONST field set to the desired value and the other fields set to zero. The starting value will only be read at the beginning of each cycle.

The third input (Input 3) points to another point that is the enable point for the countdown. Each time the enable point is set the counter will reset and start counting down and the output will stay set until the enable point is reset. If Input 3 is set to <u>zero</u> the counter will repeat continously setting the counter output for one cycle every time the counter reaches zero.

If configured as an output, the CURVAL field is used as the enable and Input 3 is the destination field.

6.4.1.11. Time of Day - One Shot (TOD-OS)

There are three modes of operations for the TOD function. The normal calculation (CONST=0) will **SET** (for approximately 1 minute) the "current value" column at a particular time of day. The start/stop type calculations (CONST=1or2) will **SET** the output between the start and stop times. Invert has no effect on the result. The CONST parameter controls the functions as follows:

If CONST is:

- 0 Input 1 is the hour setting, if over 24 then the timer ignores hours. Input 2 is the minute setting.
- 1 Input 1 is the start minute and Input 2 is the stop minute.
- 2 Input 1 is the start hour and Input 2 is the stop hour.

Input 3 is a value to set the day-of-week parameter. The day-of-week value is based on setting bits for each day that is active, with bit 0 for Sunday, bit 1 for Tuesday, etc. (active every day would be 127). For example, if the timer is to be active on Monday and Friday the bit mask for the third parameter would be as follows:

Day	Bit value	Bit Position value	Total value
Sunday	0	0	0
Monday	1	2	2
Tuesday	0	4	0
Wednesday	0	8	0
Thursday	0	16	0
Friday	1	32	32
Saturday	0	64	0
Input 3 value			34

Figure 6.9
Time-of-Day weekday masking

6.4.1.12. Copy (COPY)

The copy function will move data from one place to another, it is designed primarily to route analog data to and from other analog points. The copy function is the only way to route data directly to the MIN, MAX, HI LIMIT and LO LIMIT fields of an analog point.

PT TYPE is output:
The first parameter (IN PT 1) is used to select the line number to read data from, if the a zero is used then the data in the CURVALUE column of this point will be used.

The second parameter (IN PT 2) is used to select various field types to send the data to:

0=CURVALUE,
1=MAX,
2=MIN,
3=HI LIMIT,
4=LO LIMIT.

The third parameter (IN PT 3) is the point (line number) to send the data to, using the second parameter to determine which field to update.

PT TYPE is input:
The first parameter (IN PT 1) is used to select the line number to read data from, the field that will be read is determined by IN PT 2.

The second parameter (IN PT 2) is used to select various field types to read the data from:

0=CURVALUE,
1=MAX,
2=MIN,
3=HI LIMIT,
4=LO LIMIT.

The IN PT 3 can be used as an offset index from the number in the IN PT 1 column. The CURVALUE column will contain the data.

6.4.2. Input Function tables

The next figure is an overview of calculation types where the PT TYPE is set as an **input.**

Column S FUNCTION	Column C CURSTATE	Column T IN PT 1	Column U IN PT 2	Column V IN PT 3	Column W CONST
BAND	Result	Source 1	Source 2	Source 3	N.U.
BOR	Result	Source 1	Source 2	Source 3	N.U.
BXOR	Result	Source 1	Source 2	Source 3	N.U.
BMUX	Result	Source 1	Source 2	Select 1 or 2 Digital only	N.U.
LATCH	Result	Set input	Reset input	Enable	N.U.
CTRLR	Result	Point for High trigger	Point for Low trigger	Enable	N.U.
CTDWN	Result	Trigger point	Base Value	Enable	N.U.
ADD	Result	Source 1 +	Source 2 +	Source 3	N.U.
SUB	Result	Source 1 -	Source 2 -	Source 3	N.U.
MULT	Result	Source 1 *	Source 2 *	Source 3	N.U.
DIV	Result	Source 1 /	Source 2 *	Multiply codes 1-3	N.U.
CYCTMR	Result	Const time 1	Const time 2	Enable	Control codes 0-3
TOD-OS	Result	Const HOUR	Const MINUTE	Const code Day-of-week	0=normal, 1=minutes, 2=hours
CHDET1	Result	Source 1	Control code 0-1	Enable	N.U.
CHDET2	Result	Source 1	Control code 0-1	Enable	N.U.
DE-MUX	Result	Source	Destination 1	Destination 2	N.U.
COPY	Result	Source point	Field type 0-4	Offset from Input 1	N.U.

Figure 6.10
INPUT Point Types

6.4.3. Output Function tables

The next figure is an overview of calculation types where the PT TYPE is set as an **output.**

Column S FUNCTION	Column C CURSTATE	Column T IN PT 1	Column U IN PT 2	Column V IN PT 3	Column W CONST
BAND	Source 3	Source 1	Source 2	Destination	N.U.
BOR	Source 3	Source 1	Source 2	Destination	N.U.
BXOR	Source 3	Source 1	Source 2	Destination	N.U.
BMUX	Result	Source 1	Source 2	Select 1 or 2 Digital only	N.U.
LATCH	Enable	Set input	Reset input	Destination	N.U.
CTRLR	Result	Point for High trigger	Point for Low trigger	Destination	N.U.
CTDWN	Enable	Trigger point	Base Value	Destination	N.U.
ADD	Source 3 +	Source 1 +	Source 2	Destination	N.U.
SUB	Source 3 -	Source 1 -	Source 2	Destination	N.U.
MULT	Source 3 *	Source 1 *	Source 2	Destination	N.U.
DIV	Result	Source 1 /	Source 2	Multiply codes 1 - 3	N.U.
CYCTMR	Enable	Const time 1	Const time 2	Destination	Control codes 0 - 3
TOD-OS	Result	Const HOUR	Const MINUTE	Const code Day-of-week	0=normal, 1=minutes, 2=hours
CHDET1	Enable	Source 1	Control code 0 - 1	Destination	N.U.
CHDET2	Enable	Source 1	Control code 0 - 1	Destination	N.U.
DE-MUX	Result	Source	Destination 1	Destination 2	N.U.
COPY	N.U.	Source point	Field type 0 - 4	Destination	N.U.

Figure 6.11
OUTPUT Point Types

6.5. Scaling and Calibration

Table 1 analog points have individual full scale and offset parameters.

If the Full Scale parameter is left at 0, then the analog value will not be converted, but will show the raw value as presented by the hardware. This is also used when displaying a value retrieved from another station which has already been converted to engineering units.

The resolution of the I/O hardware may be specified in the Resol/LZ column of the display.

Resolution options are:

0	10 bit bipolar	HWFS 512
1	10 bit unipolar,	HWFS 1023
2	12 bit bipolar and	HWFS 2047
3	12 bit unipolar.	HWFS 4095

The default is 10 bit, bipolar A/D configuration (0).

6.5.1. Inputs

Depending on the hardware used, a rough calibration of the sensor may be required. For Sensor Modem expansion I/O modules, the points are referenced to a precision reference and there is no calibration required. (there is a full scale trim which should not require field adjustment)

The basic formula for analog conversions is:

converted value= (raw value/HWFS * (Range - Offset)) + Offset

Note that the HWFS (Hardware Full Scale) term is the full scale for the A/D, refer to the above list for actual HWFS values. The Resol/LZ column ("W") must bet set to the proper value.

The RANGE/FS value is the maximum value that you want to display when the instrument is producing full scale for the analog input (i.e. 5 volts or 20 mA).

To quickly calculate the OFFSET, determine the percentage of the range that will be suppressed for the raw offset and multiply that by the range of the finished values.

A standard 4 - 20 mA (or 1 - 5 volt) input has a 25% range suppression (20 - 4 = range of 16, 4 / 16 = .25). Take 25% of the full scale RANGE value for the OFFSET.

As an example, for 4-20 ma signals with a desired display of 0 to 100, set the offset value to -25 and set the Range to 100.

Examples (4-20 ma input)

Scaling			OFFSET	RANGE/FS
0	to	100	-25	100
0	to	300	-75	300
0	to	500	-125	500
0	to	2000	-500	2000
-100 to +100			-150	100

Scaling to match field data.

The first step in scaling analog values to match the field data, is to take readings at two points so that a linear equation can be determined.

One reading should be at the low end and one at the high end of the scale(or somewhere close to each end). Set the analog scaling parameters, RANGE/FS and OFFSET both to zero so that the raw analog values can be observed. The terms Maximum and Minimum values are the actual readings that you want displayed and the Raw minimum and Raw maximum are the readings directly from the A-D converter, i.e. the value in the CURVALUE column ("C").

The fundamental equation is, **y = m*x + b**, and the first step is to calculate the terms "m" and "b":

m = (Maximum value - Minimum value) / (Raw maximum - Raw minimum)

b = Minimum value - (m * Raw minimum)

Note that you must solve for "m" first because it is used to determine "b".

The term HWFS means HardWare Full Scale and there are four possibilities determined by the type of hardware for the analog input. The four values are 512, 1023, 2047 and 4095. These correspond to the four choices for hardware type in Resol/LZ column ("W") 0,1,2,3.

After solving for "m" and "b", the RANGE/FS value can be determined by the following formula:

RANGE/FS = (m * HWFS) + b

The OFFSET value is equal to "b" and needs no further calculation, therefore.

OFFSET = b

Note: An EXCEL spreadsheet with the above calculations is available at no charge.

Example 1. An elevated tank with a bowl of 30 feet and a total height or 50 feet is being measured (at ground level) by a pressure transmitter with a range of 0 to 30 PSI. It is desired to only show the level in the bowl (0-30 feet) and suppress the riser pipe level. The transmitter is installed, the analog value read into the internal analog (10 bit unipolor, HWFS = 512) and is set in Table 1 with zero values in the RANGE/FS & OFFSET columns.

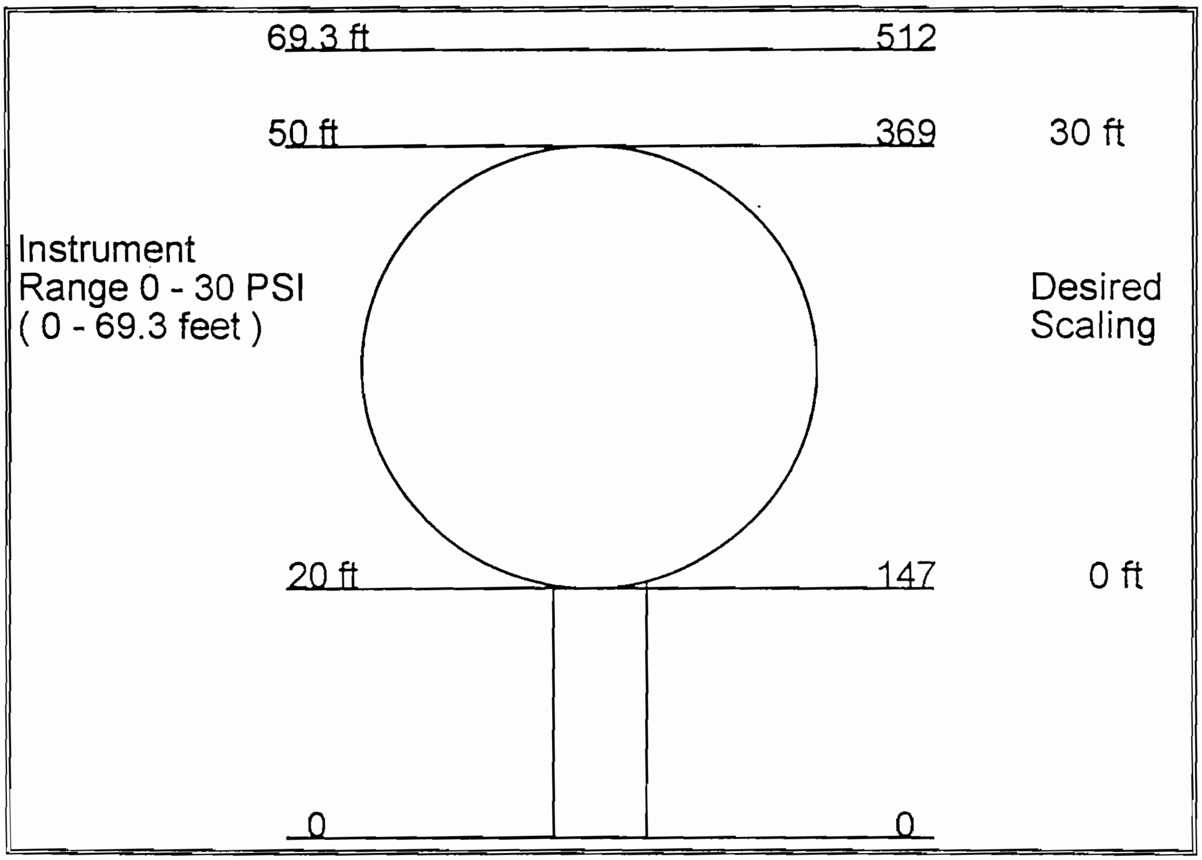

Figure 6.12
Sample Tank Calibration

To establish the high values it is observed that when the tank is overflowing (known overflow at 50 feet) the value shown is 369. We now have a maximum desired value of 30 feet with a maximum raw count of 369.

The tank is drained to the bottom of the bowl and the raw count is noted at 147. The low values are then minimum desired is 0 feet and miminum raw count is 147.

1)	m	= (30 - 0) / (369 - 147)	=	0.135
2)	b	= 0 - (0.135 * 147)	=	-19.845
3)	RANGE/FS	= (0.135 * 512) + (-19.845)	=	49.3
4)	OFFSET	(same as b)	=	-19.8

Example 2. A level transmiter has been factory calibrated so that a range of 0 - 12 feet will produce a 4 - 20mA output. This will be read into an analog-expansion module with 12 bit resolution (i.e. HWFS = 4095).

Since the maximum value desired is at the full scale output, the 12 feet can be entered directly into the RANGE/FS column and the standard 25% (4-20 mA loop) range offset would be, 25% of 12 = 3.0, and this can be entered into the OFFSET column.

For the sake of example we can do the full calculation. The high raw will be 4095 and the low raw value will be 819 (20% of full scale).

1)	m	= (12 - 0) / (4095 - 819)	=	0.003663
2)	b	= 0 - (0.003663 * 4095)	=	-3.0
3)	RANGE/FS	= (0.003663 * 4095) + (-3.0)	=	12.0
4)	OFFSET	(same as b)	=	-3.0

6.5.2. Outputs

Analog outputs will convert an engineering unit value to a 12 bit binary value suitable for a 12 bit D/A. Clamping at 0 and Max scale (4095) prevent undesirable "overflow" wrap-around from causing unwanted excursions of the output signal.

The conversion is as follows:

output value = 4095 * (EUvalue-Offset)/Range)

As an example, to convert a 0-100% value to a 4-20 ma output, the Range and Offset would be 125 & -25.

The Resol/LZ column has no effect on the conversion.

Invert will reverse the output range.

6.5.3. Engineering Unit Labels Analog Points

A list of standard Engineering unit labels is available for analog points. They can be selected by using the up/down arrow keys to edit the label field. (Use the HOME key to return to the first entry) The available labels are:

MV	INCH	DEG C
MA	PSI	R HUM
VOLT	GAL.	WndSp
AMP	KGal	InH20
KV	GPM	MB
KW	MGal	RPM
KVAR	GPM	%
KWHR	MGD	x10
WATT	SEC	x100
'blank'	DEG	x1K
FEET	DEG F	x10k

6.5.4. Engineering Unit Labels Digital Points

The default label pair for digital points is ON/OFF. Several other label pairs are available, which make the display information more relevant to the use of the point.

These label pairs are selected by entering the number of the pair as shown below in the LabelSelect column.

SEL:	POINT STATE 0	1	
0	OFF	ON	(default)
1	OPEN	CLOSE	
2	STOP	RUN	
3	ManOFF	Man ON	
4	MANUAL	AUTO	
5	Normal	High	
6	Normal	Low	
7	UP	DOWN	
8	DisArm	Armed	

Figure 6.13
Engineering Unit Labels

6.6. Point Alarming Functions

All points in Table 1 can indicate an alarm condition (or alarm state). The display as an alarm can be suppressed by setting the **ALM ENBL** field to Disabled.

If the alarm is Enabled for a point, the Alarm Acknowledge field will set (UNACK) on any change in alarm state. It will remain set, even after the alarm condition disappears, until manually reset (Acknowledged) by an operator.

6.6.1. Digital Alarming

Digital points that have alarming enabled, will create an alarm on change of state. If the alarm delay value is set to a non-zero number of seconds, alarming will occur only after the delay period if the alarm condition still exists. The reset delay will be a <u>maximum of 6 seconds</u> regardless of the delay value.

The '**Invert**' parameter may be used to reverse the actual status as needed to assure the correct "alarm" and "normal" states for a digital point.

Digital outputs on the expansion bus have special characteristics that can be used with the alarm functions. If the AlmAct'n field (AE) is set to 4 the output will flash on alarm and return to alarm, if set to 6 it will flash on alarm but not on return to normal. Acknowledge will stop the flashing.

6.6.2. Analog Alarming

Analog points that have alarming enabled, will create a high/low alarm if the corresponding limit is exceeded. If the alarm delay value is set to a non-zero number of seconds, alarming will occur only after the delay period if the alarm condition still exists.

6.6.3. Common Alarms-

Alarms can be classified as Major or Minor or Both (or neither). The **AlmType** field is used to set the parameters.

- 0 = Do not include as part of Major or Minor alarm set.
- 1 = Major alarm.
- 2 = Minor alarm.
- 3 = Both Minor and Major.

Alarm actions can be altered by setting the AlarmAction field to the desired mode. The **AlmAct'n** types are:

- 0 = Normal Alarming
- 1 = Suppress Unacknowledge on Set or Return
- 2 = Suppress Unack on Return to Normal.
- 4 = Flash expansion DO on alarm and Return to Normal.
- 6 = Flash expansion DO on alarm but not return.

All alarming on a particular point may be disabled by setting the Alarm Enable field (Column "N") to "Disabled".

An Internal DI point (Reg 0, Bit 4) is set active upon the occurrence of any new "major" alarm. It can be accessed for output to an audible alarm or other actions. This point can be reset by an external input or manual toggling of the common alarm reset by the operator.

An Internal DI point (Reg 0, Bit 5) is set active upon the occurrence of any new "minor" alarm. It can be accessed for output to an audible alarm or other actions. This point can be reset by an external input or manual toggling of the common alarm reset by the operator.

To reset minor and major alarms the reset point is Internal DO Reg 0, Bit 2 and to acknowledge all alarms the reset point is Internal DO Reg 0, Bit 3.

Note:	The Controller type calculated point uses the "alarm" thresholds as the Set/Reset inputs. To use a Controller calculated point without nuisance alarms, leave alarms enabled on the analog point and set the **AlmAct'n** field to 1.

6.7. Data Storage Functions

6.7.1. Summary Data

Summary data is captured at midnight for all points in Table 1. There are two previous days of summary data available. There is no point specific setup required for this feature.

Display of summary data can be selected from the line. Select Main menu, then select Display, then Summanry and then the data that you want.

6.7.2. Historical Data Points

A Table 1 point may be selected for recording on a periodic or event based trigger for Historical sample storage. The sampling parameter, **SMPLTYPE** (column AG), will set the conditions for sampling. A value of 0 (default) disables sampling for this point.

If the sampling parameter is set to a point number (between 1 and the maximum Table 1 point number), then recording will occur CONTINUOUSLY while that enabling point is ON (Current State = 1). If for example, the enabling point is a calculated cycle timer point. Then samples would be recorded during the time that the timer is in the ON state.

Enabling point	**Description**
1 - 180	A trigger can be specified by entering the enabling point number of another point.
250	will enable "event" (alarm) recording for this point, i.e., record a sample when this point exceeds the alarm limit or changes state.
251	enables recording of a sample every minute
252	enables recording of samples every day
253	a sample of the MAXIMUM and MINIMUM will be recorded once each HOUR.

Figure 6.14
Historical Sample Triggering

NOTE:	For PT TYP set to AVERAGE or TOTALIZE and SMPLTYPE set to 253, the MAX and MIN cells will be recorded once each HOUR. Those cells hold hourly average and the hourly totalized readings, respectively. The recorded data type flag will still be displayed as MAX and MIN.

6.7.3. Historical Data Controls

The Historical Data display can be accessed from the Menu Line of the Current/Summary display by selecting DISPLAY & then HISTORY. Begin viewing data by pressing the HOME key. The up/down arrow keys, up/down page keys and Menu Line access key (/) operate similar to the Current/Summary display.

```
    STATION      15   Sta Name   HISTORICAL DATA   Wednesday 14:43:27  06/23/93
RTN-EXIT  PointSel   Control    JumpTo     SetMarker   WrtCrtMrkr
RECORDING:       CURRENT POS    MAX POSITION     MARK POSITION    OVERWR:   ON
ON                 5854            12415                0         AUT/MN:   MANUAL
    DISP_CRIT>   PT1:      0    PT2:       0    STA:      0         TRIG PT:
SAMPLE#    DAY   TIME       STATION / POINT#      TYPE      NAME        VALUE

  5853      23    14:43:00       15         16      DG                       0
  5852      23    14:43:00       15         15      DG                       0
  5851      23    14:43:00       15         14      DG                       0
  5850      23    14:43:00       15         13      DG                       1
  5849      23    14:43:00       15         12      DG                       0
  5848      23    14:43:00       15         11      DG                       0
  5847      23    14:43:00       15         10      DG                       0
  5846      23    14:43:00       15          9      DG                       0
  5845      23    14:43:00       15          8      DG                       0
  5844      23    14:43:00       15          7      DG                       1


                  Enbl/Dis   Auto/Man     AutoPnt     OverWrEnb   Clear


          Point #1    Point #2    StationSel
```

The Header area of the Historical Data display contains several parameters. These parameters control the content of the displayed data, or are used to control the actual historical recording process.

NOTE:	A memory cartridge must be present for historical recording to be effective. If the Maximum Available Index parameter displayed in the Header lines is equal to 0, it means that no cartridge is present or that no sampling has occurred (either no points requesting sampling or historical recording is not enabled).

PointSel Allows the selection of two different point numbers, and/or a stations address, and the display will only show those points or station logs. This only controls the display of data, all of the data still remains on in the historical file. If the values are zero all points will be displayed.

Point #1	
Point #2	values are 1 through 180
StationSel	values are 0 through 240.

Control The main functions under control are:

Enbl/Dis	command which turns the historical recording OFF and ON.
Auto/Man	is not presently used.
AutoPnt	is not presently used.
OverWrEnb	determines if the recording process will stop or continue when the data storage is full, if ENABLED then recording will continue from index zero.
Clear	Resets the pointer position to zero.

JumpTo This allows jumping to any index in the historical file.

SetMarker This marker keeps track of the last position that was sent during the last XMODEM transfer. The XMODEM file transfer will automatically reset this after each transmission but it can be manually set to the current position with this command.

WrtCrtMrkr is not presently used.

6.8. Station Parameters

There are several parameters which define the current Station. They include:

- Station name,
- Master/Slave role,
- Auxiliary port baud rate,
- Dialup access phone numbers
- Station number (address),
- Scan protocol,
- Passwords,
- Time and Date settings

6.8.1. Station Name and Number

Station name (8 character string) and station number entries are accessed via the Menu Line. The Station number is the "station address" for use in Master station communications. There are special station addresses that should not be used for station address, 245 and 250 are reserved for global addressing. See section 7.1.1 for details.

6.8.2. Password Entries

Password entries are accessed through the Menu Line (select Station). New password entries are then used to validate future logon operations. **The initial default password is "QWERTY".**

Passwords may be any 6 character entry. There are 6 indexes available for passwords. They are identified as passwords 1 through 6.

The passwords have different levels of access and authority.

Password 1	User 1	Display only in the RTSYS area, no changes allowed, cannot access the BASIC programs or other areas.
Password 2	User 2	Same as password 1
Password 3	User 3	Editing in RTSYS allowed but no access to Time / Date change Xmodem transfers DBload and DBdump commands.
Password 4	User 4	Same as password 3
Password 5	User 5	Unrestricted access, all areas and commands are available.
Password 6	User 6	Same as password 5

Figure 6.15
Password Table

6.8.3. Time / Date Functions

Time and date entries can be made from the Menu Line under "Time" parameters. Provisions include manual reading and writing of the displayed time to the Real Time Clock chip.

The current time is used to time stamp alarms and events and analog minimum and maximums. It is also used for Time of Day calculations.

Note: If changes are made to the time they must be written to the "real-time-clock" or the changes will be lost when power is removed. After all changes are made to the time/date settings be sure to select the function "Wrt_RTC" which will make the changes to the actual read-time-clock.

Chapter 7
Table 2 Setup

7. Table 2 - Communications

Table 2 consists of a large contiguous block of 900 Holding registers, and an associated table of STATION INDEX parameters.

There are 60 station index positions as indicated by the line number at the left side of the display. The station index parameters are used to define scan (read/write) operations that gather data from remote slave stations or from this station (local I/O or Table 1 data).

In addition to actively reading or writing data into or from the holding registers (according to the station index parmeters), the holding registers can be accessed passively from other areas of the system.

For example, a station index might be setup to read a group of registers from a remote slave station into a set of Table 2 registers. The contents of those registers could then be used by a BASIC program, read into Table 1 points, or accessed by a PC via a serial port.

Typically Table 2 registers are blocks of registers read from or written to a remote station. There are several methods for sending and receiving data from remote stations that are described in detail in this section.

The other major source of data used in Table 2 is this station's physical I/O and the Table 1 register data. This type of data is frequently consolidated in Table 2 for retrieval by another site.

7.1. Special Addresses and Registers

There are special addresses and registers in the Sensor Modem to handle unique communication and special functions.

7.1.1. Global addresses 250 & 245

Address 250 is used for broadcasting data to multiple RTUs. Every RTU will receive data when it is addressed by its own address <u>or address 250</u>. When an RTU receives data via address 250 there is no acknowledgment from the RTU. This address can be used to transmit the time and date registers to multiple RTUs to syncronize the "real-time-clocks" in each RTU with the time in the master.

Address 245 is also a special purpose address that every RTU will respond to, including an acknowledgment, however, <u>this special address only works with the "rear" ports</u> on the Sensor Modem. This is most commonly used with computer based master software during system checkout, or when in the field, so that mulitple RTU can be quickly checked without having to set different addresses (in the master software) for each one.

7.1.2. Special function "900" series registers

Registers 901 through 907 are time and date registers. These registers are automatically updated from the "real-time-clock" (it may not appear to be updating when viewed in Table 2 due to the relatively slow table scan rate but the registers are up to the second). A master unit may transmit these registers to another RTU (using the same address at the remote) and the remote unit will automatically be updated with the time from the master (the remote unit will syncronize its real-time-clock to the new time).

901	Seconds
902	Minutes
903	Hour
904	Day
905	Month
906	Year
907	Weekday

The are two special registers to provide control over both Table 1 and Table 2 execution. Table 1 & 2 lines are executed in a linear fashion from lowest to highest line number and registers 908 and 909 allow the disabling of any line or all lines in either table. Register 908 controls Table 2 and register 909 controls Table 1.

908 Table 2 disable
  1 - 60 will disable that particular line
  255 will disable all lines.

909 Table 1 disable
  1 - 180 will disable that particular line (or point)
  255 will disable all lines (or points).

There are three registers for tracking communications. Every time there is a communication transmission on a port, a counter is incremented for that port. The counter will wrap when full. This is commonly used in diagnosing communication problems or tracking of communication transmissions.

911	Comm port transmissions (internal modem, front port)
912	Port 0 transmissions (external rear port)
913	Port 1 transmissions (external rear port)

7.2. Accessing Table 2 from Table1 & BASIC

When Table 2 data is being used by Table 1 the ENABLE column (B) may be set ON or OFF, however, regardless of the ENABLE setting, the

STATUS column (C) must show Comm. OK or the data will not be read into Table 1.

When setting up an index line in Table 2 for use by Table 1, or if you just wish to view the data in the registers, the STA ADDR may be set to 0 or the actual station address. If the actual address is used and the ENABLE is set to ON then the data can be viewed but not changed, if ENABEL is OFF then the data will not be updated. If address 0 is used, the data can be changed and it will reflect the current state.

When linking a Table 1 point to a Table 2 register, that it is the station index (or line number) that is used in the MOD ADDR field. The register specified in the REG/PT field is then the offset into the registers assigned to that station index.

Note:	The access of remote station data by Table 1 points uses the remote station index, not the actual remote station address. (The station index is the position of the station (line #) shown in the Station display.)

7.3. Accessing Table 1 from Table 2

In many instances, particularly when this station is a slave being polled by a computer (or a Sensor Modem master station), much of the attached Expansion I/O data is not utilized for any local display or alarming functions, but only needs to be reported back to the master station. In those cases it is convenient to simply do block transfers of local I/O data directly into Table 2 for subsequent access by the master station.

There are 4 significant types of data that can be setup for direct transfer into Table 2.

These special cases are defined by setting the Station Address field to the address of THIS station (station number). By setting the station address to the current station address, a block of registers can be defined to receive and hold:

1. The current **raw I/O** data registers of this station,
2. The **MAX / MIN** and time registers for Table 1 points,
3. **Summary** registers (same as above) from yesterday's file,
4. The **communications status and enable flag** for each individual station defined in Table 2.

Note	Table 1 current data registers and current day summary registers are also selectable for storage in Table 2 "holding" registers.

In data concentrator applications, the status of each individual sub-RTU can be made available in Table 2 registers for use by an "up-stream" master station.

For SCADA applications, where the unit is acting as a "dumb" RTU, a complete image of the local INPUT raw data can be captured in Table 2 registers and be made available for interrogation from an external master station. This is usually used where data is to be concentrated and/or scaled to provide data to the master station that is ready to use.

Data from remote slave stations can be read and/or written to specified destination registers. Selection can be made for Table 1 or Table 2 registers from the remote station.

Note	If the remote station has defined a Table 2 entry so that its raw data is present in its Table 2 registers, it can then be read into this station and processed as any local I/O might.

Reading of blocks of Table 2 registers provides an easy means of "concentrating" data from a number of sub-RTU's into only a few requests from an up-stream master station.

In fact, in many instances of a hierarchical SCADA configuration, much of this data would "flow through" in a transparent fashion.

7.4. Serial Port Baud Setting

The baud rate for serial port 1 (right 9 pin D connector when looking from the rear) is shown on the REMOTE STATION display, and is settable via menu selection.

Serial port 0 (left 9 pin D connector when looking from the rear) is set according to the settings of the front panel DIP switches SW 4&5.

7.5. Master/Slave & Protocol

The protocol which is used for RTU communications is defined by the firmware sub-set installed at the factory. The protocol type is indicated on the REMOTE STATION display.

The role of this station as either a master or slave for RTU communications via the internal modem option (Comm. Port), is defined by the settings of SW 3 of the front panel DIP switch. The selection made is displayed on the REMOTE STATION display.

7.6. Standard Polling Communications

A slave station is one which is scanned by this station (which implies this station is set up as a Master). Each line in the Remote Station display (Table 2) defines a station index. The stations specified in the station index list are scanned in a round robin fashion – each being polled in the order of the station index in Table 2.

The station index numbers are shown on the extreme left hand side of the Remote station display. They are equivalent to line numbers on this display. Paging down will show the next group of station indices and their associated station parameters, etc.

The address of the remote station is a field **(STA ADDR)** within each station index (or line). That address is the actual address that is transmitted to the slave station during the polling of that station.

Each individual station index can be Enabled/Disabled to include/exclude it from the active scanning rotation.

The entry of First Register and Number of Registers parameters in a station index indicates which and how many registers of data to read (or write) from the indicated slave station. The FUNCTION entry indicates the type of registers that are to be accessed (ie, Table 1, Table 2, Expansion Registers, etc.).

The data read from the remote slave station will be "plugged into" the Table 2 registers beginning with the absolute Table 2 register number indicated by the register offset parameter, and successive registers up to the total number read in.

Additionally, a very powerful feature is provided to allow the automatic allocation of space in Table 2 for the registers specified for a station, or the user can "assign" the registers for that station.

For example, assume that it is desired to read 20 registers from station 1 and to then send those same 20 registers to station 2. This can be accomplished very simply by specifying the "allocate" mode for station 1 (thereby letting the system allocate the register location and space for station 1's data in Table 2), and then specifying "assign" mode for station 2.

When the "assign" mode is selected, the user is responsible to set the "register" number which points to the registers in Table 2 for that station. By setting the number of output registers to 20 and setting the "register" number to the same value as station 1's input registers, the data from station 1 will be transmitted to station 2.

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```
STATION        1 Master  TABLE2_DATA-REM.STA Sunday     21:13:21  01/10/93

Ph#1:................ Ph#2:................ Ph#3:................
Ph#4:................ Ph#5:................ Ph#6:................
 MASTER MODE     Use MENU For PWs.  P1BAUD= 9600        Scan is  Enabled
      A        ^B        ^C        ^D        E         F         G
 STA ADDR  ENABLE    STATUS     ERR CTR   FUNCTION  1ST IN     NBR IN
01    2      ON      Comm. OK      28     TBL2/RAW   3000         9
02    2      ON      Comm. OK      30     TBL2/RAW      0         0
03    0      OFF     Comm. OK       0     TBL1 REG      0         0
04    0      OFF     Comm. OK       0     TBL1 REG      0         0
```

Figure 7.1
Remote Station Parameters

7.6.1. Remote Station Direct I/O

A master station can, in addition to reading a slave station's Table 1 and Table 2 registers, directly read the physical I/O modules connected to the slave station. This allows remote access to that data without any configuation or setup at the remote slave station.

Note:	In this mode data retrieved is in raw data form (no scaling, etc.).

Remote stations may be polled for data without setting up any information in table 2 (at the remote site) <u>if the remote hardware is scanned</u>. The normal entry in table 2 to request data from a remote site is a request for data from table 2 starting at the register given in 1ST IN column. Special codes allow reading and writing of data directly to the hardware addresses in the remote unit. The special codes are as follows:

3000	request analog and digital data starting with the internal data registers.
2000	request analog data only stating with the internal data registers.
1000	request digital data only starting with the internal data registers.

The first digit determines the request type (digital, analog or both) and the next three digits are the staring address of the hardware to scan. If the remote unit has expansion hardware at address 1, 2, 3 and 4, with 1 and 2 being digital input modules and 3 and 4 analog inputs modules the following would recall the information direct from the modules.

3001 for the 1ST IN and 18 for NBR IN column. The 3001 starts obtaining data at the first address and the 018 is to reserve enough registers for the data. Each analog input module needs 8 registers and each digital unit needs 1 register.

7.6.2. Communication Status

A local I/O function is provided in a "master" unit so that the communication status and enable status is available in Table 2 registers. Each register contains two bits per station, Bit 0=Comm Status &

Bit1=Enable/Disable, so each register holds information about 4 stations (8 bits/register).

7.6.3. Table 2 Menu Listing

	A	^B	^C	^D	E	F	G
	STA ADDR	ENABLE	STATUS	ERR CTR	FUNCTION	1ST IN	NBR IN
01	1	ON	Comm. OK	0	TBL2/RAW	0	4
02	2	OFF	Comm. OK	0	TBL2/RAW	0	0
03	0	OFF	Comm. OK	0	TBL2/RAW	0	1
04	2	OFF	Comm. OK	0	TBL1 REG	10	3
05	2	OFF	Comm. OK	0	TBL2/RAW	0	0
06	3	ON	Comm. OK	0	TBL1 REG	9	1

	H	I	^J	K	L	M	N
	1ST OUT	NBR OUT	REG.TYPE	R-OFFSET	REG 00	REG 01	REG 02
01	0	0	Allocate	0	0	0	2
02	10	7	Allocate	4	350	620	300
03	0	0	Allocate	11	0		
04	0	0	Allocate	12	1	1	0
05	16	1	Allocate	15	0	0	0
06	0	0	Allocate	144	806		

Figure 7.2
Polling Unit Menu Line

7.6.3.1. Menu listing ordered by name

1ST IN	F	This specifies the first register (starting register) that should be read in. The register referred to is at the other (remote) unit. This field and the next field are used for requesting data from another source.
1ST OUT	H	This specifies the first register (starting register) in this row that should be sent out. If this field is set to zero then the first register will be the "R-OFFSET" register. This field and the next field are used for sending data to another remoter unit.
ENABLE	B	Activates polling of respective remote unit specified in this line when set to ON. Data may be read/written from Table 1 with ENABLE set to OFF but the STATUS must be Comm. OK.
ERR CTR	D	Counts the number of times that atempts were made to communicate with the specified remote unit and a communications error occurred.

FUNCTION	E	There are five types of registers that can be setup: TBL1 REG – Table 1, CURVALUE column TBL2/RAW – data in Table 2 from slave or local direct I/O EXP REG – Table 1, MAXVAL, MINVAL, TimeOfMx,TimeofMn SUM1 REG – Same as above for yesterday COMM STS – Communication status and enable flag for each station in Table 2. (see section 7.1.3)
NBR IN	G	This specifies the total number of registers to be read in, using the previous column for the starting position.
NBR OUT	I	This specifies the total number of registers to be sent out, using the previous column for the starting position.
R-OFFSET	K	This specifies which register, of the 900 Table 2 registers, that this row should start with.
REG 00	L	This is the first register in this row and the R-OFFSET field determines the starting position of the 900 registers. For example, if the R-OFFSET field is set to 80 then REG 00 for this row would be register 80 of the 900 registers.
REG 01	M	This is the second register for this row, starting with the R-OFFSET field. (As per example above this would be register 81 of the 900 registers.)
REG 02	N	This is the third register for this row, starting with the R-OFFSET field.
REG xx	N	There are thirty registers displayed per row.
REG.TYPE	J	The two options are Allocate and Assign. Allocate is the normal operation and it will automatically increment the register offset to accommodate the number of registers that are needed. The Assign is used when you want to specifically set the starting register for the offset.
STA ADDR	A	This is the address of the remote station that data is to be sent to or received from. If the <u>address of this station</u> is entered special internal data can be placed into the Table 2 registers making the data available for other uses. (See 7.1.2)
STATUS	C	Shows communication status for this line. If the STATUS is "Failed" Table 1 will not be updated with data from this line. "Comm Failed" will occur if four successive communication attempts fail.

7.6.3.2. Menu listing ordered by column

STA ADDR	A	This is the address of the remote station that data is to be sent to or received from. If the address of this station is entered special internal data can be placed into the Table 2 registers making the data available for other uses. (See 7.1.2)
ENABLE	B	Activates polling of respective remote unit specified in this line when set to ON. Data may be read/written from Table 1 with ENABLE set to OFF but the STATUS must be Comm. OK.
STATUS	C	Shows communication status for this line. If the STATUS is "Failed" Table 1 will not be updated with data from this line. "Comm Failed" will occur if four successive communication attempts fail.
ERR CTR	D	Counts the number of times that atempts were made to communicate with the specified remote unit and a communications error occurred.
FUNCTION	E	There are five types of registers that can be setup: TBL1 REG – Table 1, CURVALUE column TBL2/RAW – data in Table 2 from slave or local direct I/O EXP REG – Table 1, MAXVAL, MINVAL, TimeOfMx,TimeofMn SUM1 REG – Same as above for yesterday COMM STS – Communication status and enable flag for each station in Table 2. (see section 7.1.3)
1ST IN	F	This specifies the first register (starting register) that should be read in. The register referred to is at the other (remote) unit. This field and the next field are used for requesting data from another source.
NBR IN	G	This specifies the total number of registers to be read in, using the previous column for the starting position.
1ST OUT	H	This specifies the first register (starting register) in this row that should be sent out. If this field is set to zero then the first register will be the "R-OFFSET" register. This field and the next field are used for sending data to another remoter unit.
NBR OUT	I	This specifies the total number of registers to be sent out, using the previous column for the starting position.

REG.TYPE	J	The two options are Allocate and Assign. Allocate is the normal operation and it will automatically increment the register offset to accommodate the number of registers that are needed. The Assign is used when you want to specifically set the starting register for the offset.
R-OFFSET	K	This specifies which register, of the 900 Table 2 registers, that this row should start with.
REG 00	L	This is the first register in this row and the R-OFFSET field determines the starting position of the 900 registers. For example, if the R-OFFSET field is set to 80 then REG 00 for this row would be register 80 of the 900 registers.
REG 01	M	This is the second register for this row, starting with the R-OFFSET field. (As per example above this would be register 81 of the 900 registers.)
REG 02	N	This is the third register for this row, starting with the R-OFFSET field.
REG xx	N	There are thirty registers displayed per row.

7.7. Report by Exception Communications

The SM601 series has additional communication capabilities that are described in this section.

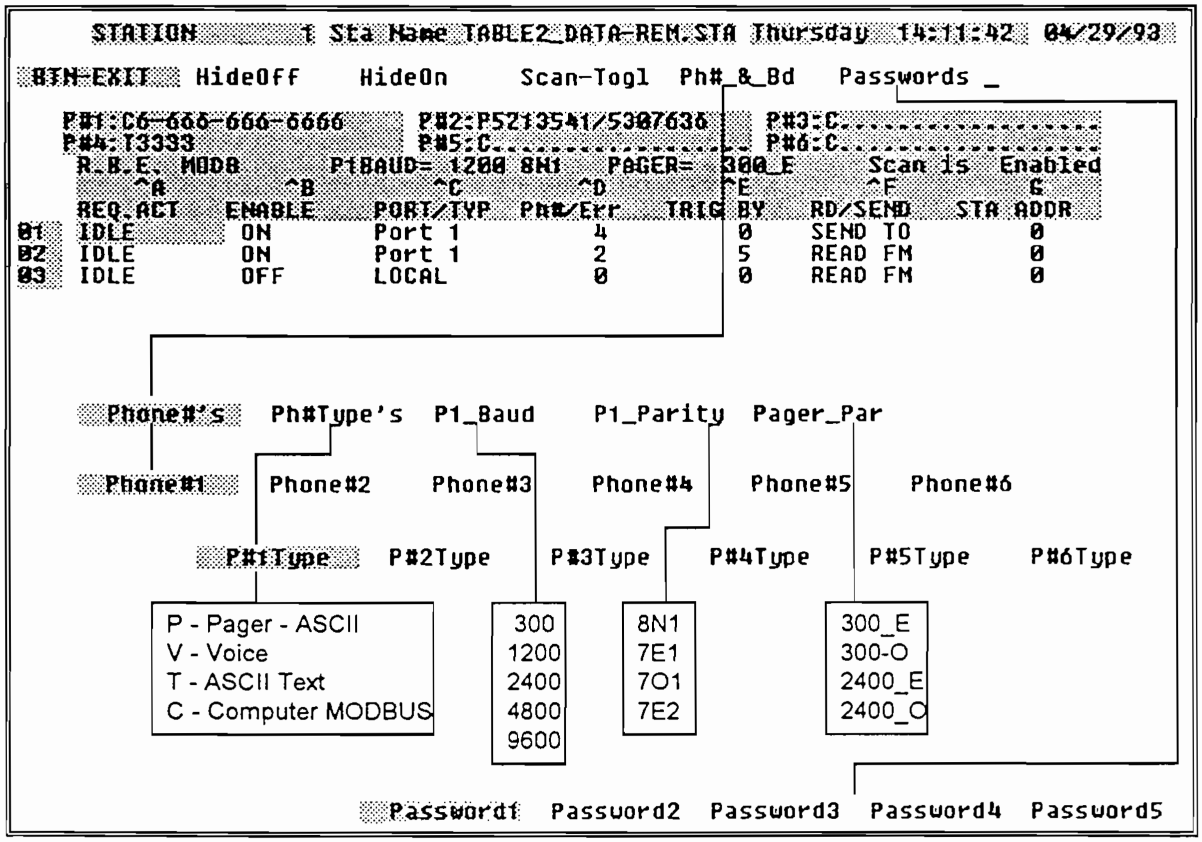


Figure 7.3
Table 2 Menu Listing

The menu listing is mostly self-explanatory but there are a few points to consider.

1. The "Voice" option under the phone number is only available using the internal NBT dial-up modem.

2. The "Pager" option requires two phone numbers, the number of the paging service and the number of the actual pager unit that the message is sent to. The two numbers are separated by a slash ("/").

3. Also note that the Pagers require their own baud rate settings, the port baud rate will return to normal after the call to the pager service.

7.7.4. Table 2 Parameter Listing

	^A	^B	^C	^D	^E	^F	G
	REQ.ACT	ENABLE	PORT/TYP	Ph#/Err	TRIG BY	RD/SEND	STA ADDR
01	IDLE	ON	LOCAL	4	0	SEND TO	0
02	IDLE	ON	Port 1	2	5	READ FM	0
03	IDLE	OFF	Port 0	0	0	READ FM	0
04	IDLE	OFF	COMM	0	0	READ FM	0

	^H	^I	^J	^K	^L	^M	N
	DATA TYP	FWA I/O	LENGTH	SRC/EPIB	STORAGE	REGISTER	STATUS
01	BLK-SMEX	0	0	53	Allocate	0	Comm. OK
02	BLK-TB1	20	2	0	Allocate	0	Comm. OK
03	EVENTS	0	0	0	Allocate	2	Comm. OK
04	EVENTS	0	0	0	Allocate	2	Comm. OK

	O	P	Q	R
	REG 00	REG 01	REG 02	REG 03
01				
02	92	0		
03				
04				

Figure 7.4
Report by Exception Parameter Menu

7.7.4.1. Parameter listing ordered by column name

DATA TYP H — The type of data that is being transmitted, the data types are:

EVENTS	Event messages (history file data)
BLK-TB1	Register data from Table 1
BLK-TB2	Register data from Table 2
BLK-DIO	Direct access to digital I/O modules
BLK-AIO	Direct access to analog I/O modules
BLK-D&A	Direct access to analog & digital mod.
COMM-STS	Maps communication status bits
BLK-T1EX	Table 1 Min, Max and times registers
BLK-SMEX	Table 1 summary data (yesterday)

ENABLE B — Activates polling of respective remote unit specified in this line when set to ON. Data may be read/written from Table 1 with ENABLE set to OFF but the STATUS must be "Comm. OK".

FWA I/O	I	REGISTER DATA: This specifies the first register (starting register) that should be read/written based on the above type of data. EVENT READ: point range qualifier, first point number of range (point number in remote unit). EVENT WRITE: *If column J=0;* Delayed transmission criteria, three digit number, DHH (D=weekday, HH= hour). If Day = 0 or 8 everyday, and if hour = 24, every hour. *If column J <> 0:* Point range qualifier, first point number of range (point number in remote unit).
LENGTH	J	REGISTER DATA: This specifies the total number of registers to be read in, using the previous column for the starting position. EVENT READ: Point range, number of points included in read processing. EVENT WRITE: set to zero and all events will transferred using DHH criteria in column I. If set to non-zero, columns I & J become range qualifiers and events transmit at time of occurance.
Ph#/Err	D	Enter the list number (top of Table 2) where the phone number is for this communication link. If there is no phone number in the list (1-6) item then communication is assumed to be a direct connection. If set to COMM then this is the number of times that there was a communication failure.
PORT/TYP	C	This is used to specify the communication port to use, the choices are: LOCAL Accessing registers in this unit COMM Use the front communication port PORT 0 Use port 0 (rear inside DB9) PORT 1 Use port 1 (rear outside DB9)
RD/SEND	F	Specifies direction of data flow, either reading data from another unit or sending data to another unit.
REG 00	O	This is the first register in this row and the R-OFFSET field determines the starting position of the 900 registers. For example, if the R-OFFSET field is set to 80 then REG 00 for this row would be register 80 of the 900 registers.
REG 01	P	This is the second register for this row, starting with the R-OFFSET field. (As per example above this would be register 81 of the 900 registers.)

REG.02	Q	This is the third register for this row, starting with the R-OFFSET field.
REG xx		There are thirty registers displayed per row.
REGISTER	M	This specifies which register, of the 900 Table 2 registers, that this row should start with.
REQ.ACT	A	Indicates the current activity status for this line .
SRC/EPTR	K	If the DATA TYP is set to EVENTS this shows the local pointer position for the history file, the unit will continue trying to send events until this pointer advances to match the pointer in the history file.
STA ADDR	G	The address of the station refered to in RD/SEND column (F).
STATUS	N	Shows communication status for this line. If the STATUS is "Failed" Table 1 will not be updated with data from this line. "Comm Failed" will occur if four successive communication attempts fail.
STORAGE	L	The two options are Allocate and Assign. Allocate is the normal operation and it will automatically increment the register offset to accommodate the number of registers that are needed. The Assign is used when you want to specifically set the starting register for the offset.
TRIG BY	E	REGISTER DATA: Point number in Table 1 that will cause a data transmission, if zero (0), then continous data transfer. EVENT READ: This is station qualifier, only events origination from this station will be processed to Table 2 registers. EVENT WRITE: Station qualifier, only events originating in this station number will be sent.

7.7.4.2. Parameter listing ordered by column letter

REQ.ACT	A	Indicates the current activity status for this line .
ENABLE	B	Activates polling of respective remote unit specified in this line when set to ON. Data may be read/written from Table 1 with ENABLE set to OFF but the STATUS must be "Comm. OK".
PORT/TYP	C	This is used to specify the communication port to use, the choices are: LOCAL Accessing registers in this unit COMM Use the front communication port PORT 0 Use port 0 (rear inside DB9) PORT 1 Use port 1 (rear outside DB9)
Ph#/Err	D	Enter the list number (top of Table 2) where the phone number is for this communication link. If there is no phone number in the list (1-6) item then communication is assumed to be a direct connection. If set to COMM then this is the number of times that there was a communication failure.
TRIG BY	E	REGISTER DATA: Point number in Table 1 that will cause a data transmission, if zero (0); then continous data transfer. EVENT READ: This is station qualifier, only events origination from this station will be processed to Table 2 registers. EVENT WRITE: Station qualifier, only events originating in this station number will be sent.
RD/SEND	F	Specifies direction of data flow, either reading data from another unit or sending data to another unit.
STA ADDR	G	The address of the station refered to in RD/SEND column (F).
DATA TYP	H	The type of data that is being transmitted, the data types are: EVENTS Event messages (history file data) BLK-TB1 Register data from Table 1 BLK-TB2 Register data from Table 2 BLK-DIO Direct access to digital I/O modules BLK-AIO Direct access to analog I/O modules BLK-D&A Direct access to analog & digital mod. COMM-STS Maps communication status bits BLK-T1EX Table 1 Min, Max and times registers BLK-SMEX Table 1 summary data (yesterday)

FWA I/O	I	REGISTER DATA: This specifies the first register (starting register) that should be read/written based on the above type of data. EVENT READ: point range qualifier, first point number of range (point number in remote unit). EVENT WRITE: *If column J=0;* Delayed transmission criteria, three digit number, DHH (D=weekday, HH= hour). If Day = 0 or 8 everyday, and if hour = 24, every hour. *If column J <> 0:* Point range qualifier, first point number of range (point number in remote unit).
LENGTH	J	REGISTER DATA: This specifies the total number of registers to be read in, using the previous column for the starting position. EVENT READ: Point range, number of points included in read processing. EVENT WRITE: set to zero and all events will transferred using DHH criteria in column I. If set to non-zero, columns I & J become range qualifiers and events transmit at time of occurance.
SRC/EPTR	K	If the DATA TYP is set to EVENTS this shows the local pointer position for the history file, the unit will continue trying to send events until this pointer advances to match the pointer in the history file.
STORAGE	L	The two options are Allocate and Assign. Allocate is the normal operation and it will automatically increment the register offset to accommodate the number of registers that are needed. The Assign is used when you want to specifically set the starting register for the offset.
REGISTER	M	This specifies which register, of the 900 Table 2 registers, that this row should start with.
STATUS	N	Shows communication status for this line. If the STATUS is "Failed" Table 1 will not be updated with data from this line. "Comm Failed" will occur if four successive communication attempts fail.
REG 00	O	This is the first register in this row and the R-OFFSET field determines the starting position of the 900 registers. For example, if the R-OFFSET field is set to 80 then REG 00 for this row would be register 80 of the 900 registers.
REG 01	P	This is the second register for this row, starting with the R-OFFSET field. (As per example above this would be register 81 of the 900 registers.)

REG 02	Q	This is the third register for this row, starting with the R-OFFSET field.
REG xx		There are thirty registers displayed per row.

Chapter 8
Utility Information

8. Utility Information

This chapter has general information about the technical characteristics of the Sensor Modem (Remote Access PLC) product.

8.1. Hardware Specifications

Processor:	64180
Storage Capacity:	Up to 32KB EEPROM 256 KB EPROM 64 KB SRAM 512 KB RAM Cartridge
I/O Connectors:	RS485 port Extended I/O modules Expansion port I/O Expansion boards RS232 port Local operator port RJ11 Communications
Local Point Maximums:	800 Digital Points 100 Analog Points or combination of above.
Remote Registers:	900
Remote Stations:	20 (SCADA Extension: 60)
Point Types:	Over 100 types of sensor interface, including: All std. voltage, current, RTD, bridge ranges
Base Unit Points:	2 Optically Isolated Digital Inputs 2 Open Collector Relay Drivers 4 (+/-2.5V or +/-5V) Analog Inputs
Base I/O Termination	Terminal Strip Connections for 2DI, 2DO(w/relays), 4AI 12VDC output

Indicators:	4 User Assignable LED outputs. RS485 polling Modem Rx and Tx Low (missing) AC power Low (missing) Battery power
Setup:	Built-in configuration displays Password Access

Modem:	1200 Baud Half Duplex
	    2 Wire
	    4 Wire
	    Radio
	    Packet Radio Option
	1200 Full Duplex Dial

Power:	10 - 24 VDC 200ma

Optional full Battery backed operation.
Internal trickle charger.

Environmental:	Temperature Range
	    0 – 55 Deg C
	Humidity
	    0 – 95% non-condensing

Physical:	8.5 x 5.5 x 1.5 inches PC Board Mount Wall or Cabinet Mount Desk-top Enclosure

8.2. Base Unit Installation and Setup

8.2.1. Mounting

The Sensor Modem Model 300 Remote Terminal Unit (RTU) comes with a steel and aluminum enclosure of its own. An optional panel mounting bracket may also be specified.

For units ordered without an enclosure, the board is mounted in a extruded aluminum base plate, similar to the enclosure base. Key-hole cutouts provide easy mounting to a panel or wall. See Figure 1 for the mounting hole pattern.

The unit with enclosure is suitable for wall mounting or desktop use.

8.2.2. Power

Power connection is made via the 5 pin DIN connector on the rear panel (see Figure 2.). This connector supports the primary power input of 12 VDC or 12 VAC, and an external backup battery (12 VDC).

A wall transformer is the standard power source. If 12VDC power is already available, a DIN plug can be wired directly to that source.

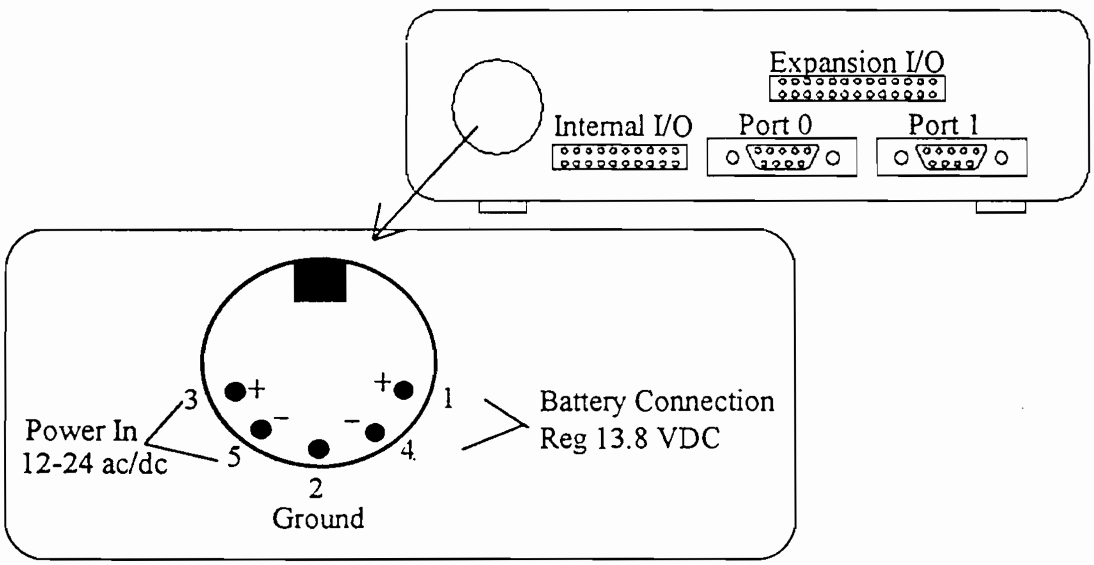


Figure 8.1
Facing Rear Panel

8.2.3. Battery Backup

The power connector also provides connection to an external re-chargeable battery. This battery can be sized to provide the required amount of battery operation. The base unit contains trickle charge circuitry and a battery voltage adjustment.

8.2.4. Expansion I/O Board Connector

The base unit provides a 26 pin ribbon connector for connection of up to 31 expansion I/O cards, which are described in the following sections. This local I/O contingent will provide up to 240 digital or analog points, or a combination of these quantities.

8.2.5. RS232 Serial Ports

There are two 9 pin male connectors for serial port connection. The first is used for connection to a PC or terminal for setup and operation of the unit. The port is normally configured as DCE equipment (uses standard modem cable to PC). The port is jumper configurable to DTE or other non-standard interfaces.

The second connector provides an additional an RS232 interface or, using an RS232 to RS422 converter, extended serial I/O port. It also is jumper configurable for DCE or DTE configurations. If the port is not used for RS485 extended I/O, it can be used for local connection to instruments or output devices.

8.2.6. Communications Connectors

Modem options include Bell 202 (radio/leased line), Bell 212 (dial), and RS485/RS422 wire line modules. See the modem descriptions for additional detail on setup and configuration.

An RJ11 (6 pos.) connector provides connection to either wire lines., a radio, or dial up lines for communications with the master station or remotes. Local twisted pair connection is also supported by the RS422 / RS485 option.

8.2.6.1. RJ11 Pin Assignments:

Bell 202 Radio Connection		
2 wire/ 4 wire TX	3,4	(center pins)
4 wire RX	2,5	
PTT/GND	1,6	(open collector)
Dial Modem		
Line Tip/Ring (RX / TX)	3,4	

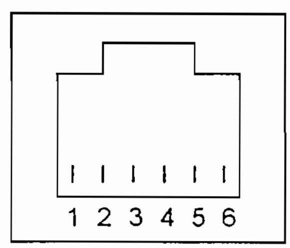
8.2.6.2. RS485

RX / TX	3,4	(+,-)

8.2.6.3. RS422

RX	3,4	(+,-)
TX	2,5	(+,-)

RJ 11 Connector



8.3. Switches and Jumpers

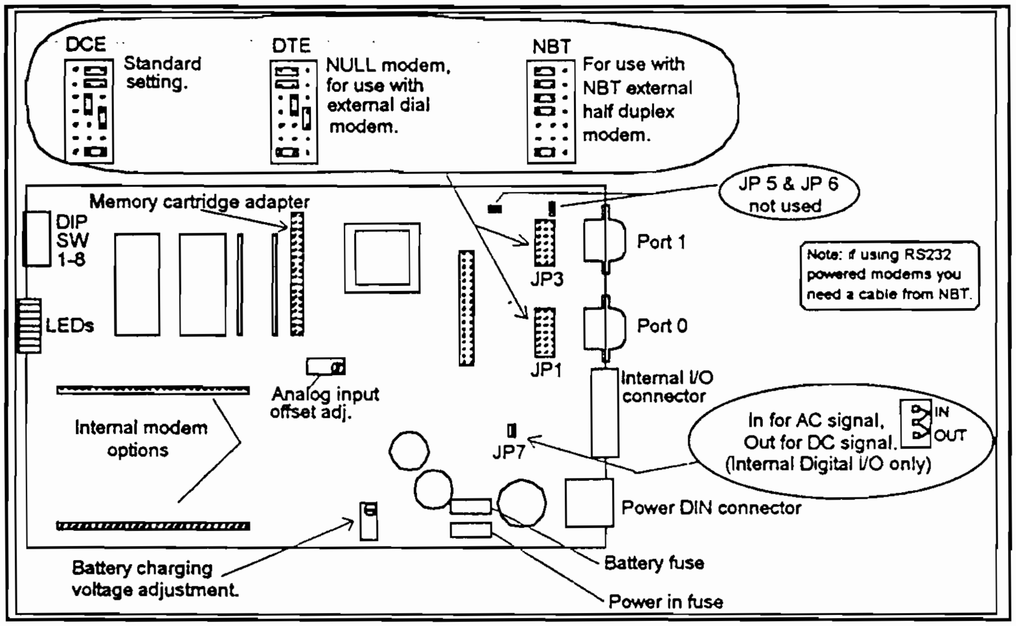


Figure 8.2
DIP Switch Settings

8.3.1. DIP Switches- Front Panel

The front panel Dip Switches affect startup conditions. They generally are not used after power on startup. Normally all switches should be UP, except Sw 3 which must be down for remote (slave) units. Switch 7 will clear memory if there is no Memory Card.

	Up (Normal)	Down
Sw 1	Online Mode	Maintenance Monitor
Sw 2	BASIC Autoexec OFF	BASIC Autoexec ON
Sw 3	Master Unit	Slave Unit
Sw 4	9600 Baud	2400Baud (Port 0)
Sw 5	9600 Baud	1200Baud (Port 0)
Sw 6	Default Password	Assigned Password
Sw 7	Use internal configuration	Clear memory & use memory card configuration
Sw 8	Not Used	Not Used

Figure 8.3
DIP Switch Settings

8.3.2. Internal Jumpers (See Board Layout)

JP1 - Local Serial Port Configuration

JP3 - Extended I/O Port Configuration (RS232 mode)

8.4. LED Indicators (Front Panel)

Left to Right

1. Green #1 - User Assignable
2. Green #2 - User Assignable
3. Green #3 - User Assignable
4. Green #4 - User Assignable
5. Red #1 - I/O Scan Indicator
6. Red #2 - Low AC Voltage
7. Red #3 - not used
8. Red #4 - not used

Modem Indicators- (4 LED's)

Dial Telephone Modem (Left to Right)

1. Off-Hook
2. Carrier Detect
3. Tx Active
4. Voice Mode (n.u.)

Radio/Wire Line Modems (Left to Right)

1. Request to Send (PTT)
2. Carrier Detect (Rx Mode)
3. Tx Data
4. Rx Data

8.5. I/O Termination Board

The I/O termination board provides screw terminals for the internal I/O points and external access to ground and +12VDC. It connects to the base card via a 20 pin ribbon cable.

The I/O termination card has mounting holes in the corners or fits a standard piece of 3 inch wide Snap-Track, 6 inches in length.

The termination board provides mounting for various scaling resistors for the four internal analog input points.

The termination board provides two 10 Amp / 240 VAC SPDT relays for driving external loads. Space is provided for optional contact arc suppression components.

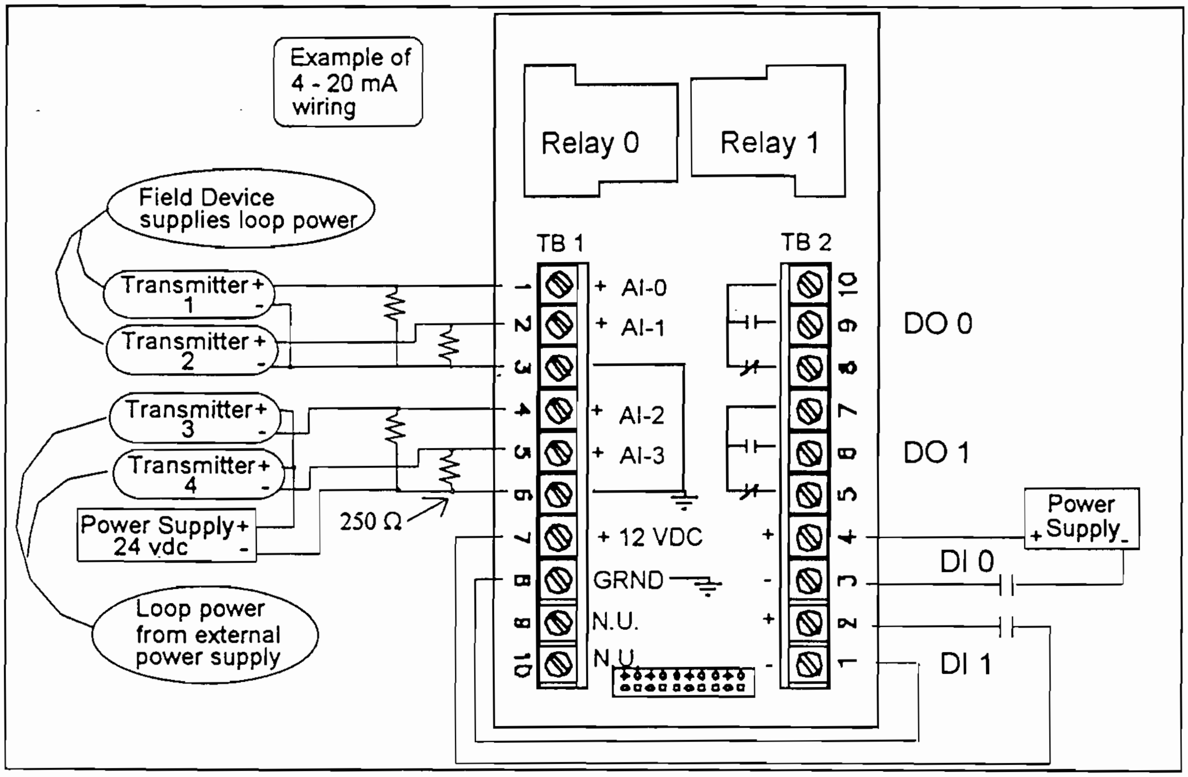


Figure 8.4
Internal I/O Termination Card

Note 1:	The 12VDC available on TB1-7&8 is intended for light loads associated with the analog or digital inputs.
Note 2:	The digital inputs require an externally powered contact input. Polarity is not critical.
Note 3:	250 Ω resistors are available from the factory.

The nominal scaling for analog inputs is set at 0-5V. The scaling may be changed by changing the scaling resistors as required. The A/D uses a 2.5 V reference. Scaling dividers should provide 2.5 V across the lower leg for a full scale reading. Resistors are listed high leg first.

AI1	R1 - R5
AI2	R2 - R6
AI3	R3 - R7
AI4	R4 - R8

8.6. Bell 202 Modem Adjustments

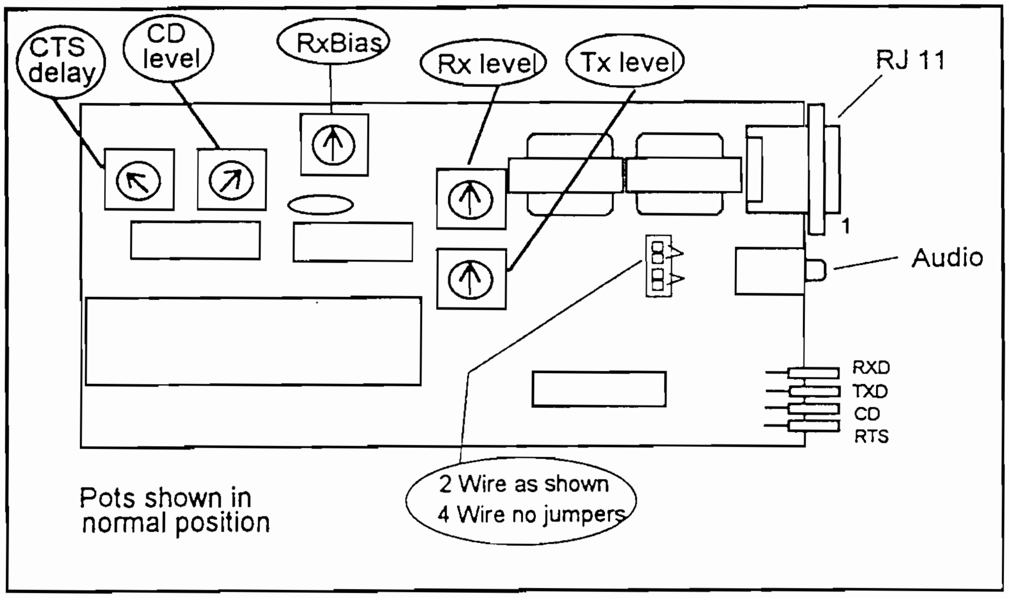


Figure 8.5
Bell 202 Modem Jumper Selection

Settings as shown provide for nominal leased line operation. (e.g., 50 ms CTS, -8 dbm Tx Level)

CTS - Radio operation may require a longer CTS delay. The CTS delay can be lengthened by turning the CTS pot clockwise. The maximum CTS delay is about 500 ms.

The RxBias adjustment should not deviate very much from the setting shown in the figure. This adjustment may require minor adjustment if there are intermittent errors which are not attributable to noise, low Rx signal level, or other common communications line distortions. Proper adjustment should provide symmetrical bit widths for mark and space bits.

The PTT output will pull to ground when RTS is active. The audio jack (J1) can be used for connections to a radio. If JP2 is IN, the tip side of Tx data is pulled down by a 1K resistor.

Both telephone coupling transformers must be present and both jumpers must be removed from JP1 for 4 wire communications via J2. Install jumpers in JP1 for 2 wire operation via J2.

8.7. RS-485 / RS-422 Modem Option

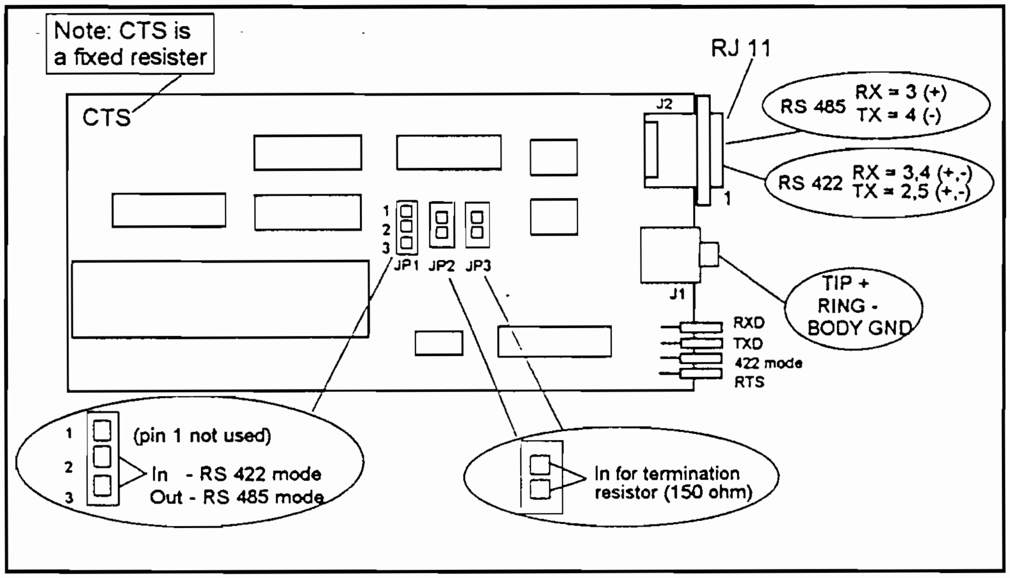


Figure 8.6
RS-485 / RS-422 Jumper Selection

8.8. Expansion I/O Installation

8.8.1. Logic Power

The expansion modules operate on power from the base unit via the expansion bus ribbon cable. All expansion points utilize optical isolators for total isolation. The LED indicators on the digital input and output boards are driven by the bus ribbon and represent the status as seen by the opto isolator.

The "field side" of the digital inputs require power (they may be internall jumpered to common power). The digital outputs will switch a live load and can be internally jumped to a common source.

The analog boards require an isolated power source for operation independant of the actual "loop" power. The required power can be connected to the same power supply as the base unit, or the same power supply as the instruments, if galvanic isolation is not required.

8.8.2. Mounting Expansion I/O Boards

There are optional I/O Expansion boards for increasing the point configuration of the unit. The size of these modules is 3.5" x 5.5" x 1.5". These modules are suitable for desktop or panel mount. The panel mounting bracket has two 0.187 inch holes spaced at 6.4 ".

8.8.3. Expansion I/O Hardware Addressing

Each I/O expansion card has a jumper selection (J1) for card address. Each card must be set for a unique address between 1 and 31. This address is used in the parameter setup of points (Module Addr) to indicate the associated board.

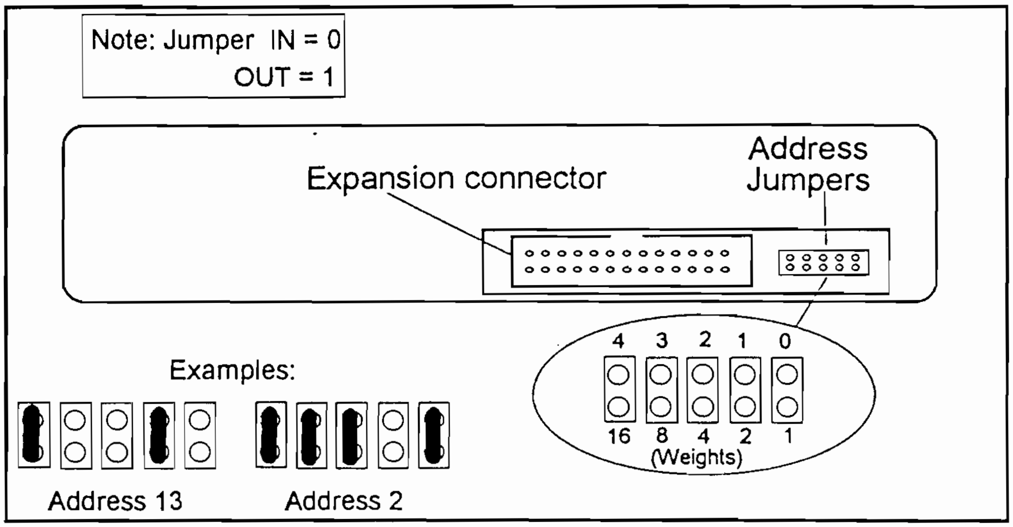


Figure 8.7
Expansion Module Addressing

The expansion cards provide "pluggable" terminal strip connections to field wiring. Wire sizes up to size 14 AWG can be accommodated.

The expansion I/O cards connect to the base unit via a 26 conductor ribbon cable. Up to 31 cards can be connected on a single cable.

8.9. Digital Input Expansion Modules-

There are no internal jumpers or adjustments on the digital modules intended for field configuration. The Digital Input module comes with each point occupying 2 terminal strip positions and both legs isolated from power or ground.

Digital points can be configured to use an internally bused voltage, an externally supplied voltage, or "live" contacts. The modules operate with 8 - 100 VDC and 16 - 35 VAC.

DIGITAL INPUT, No internal jumpers

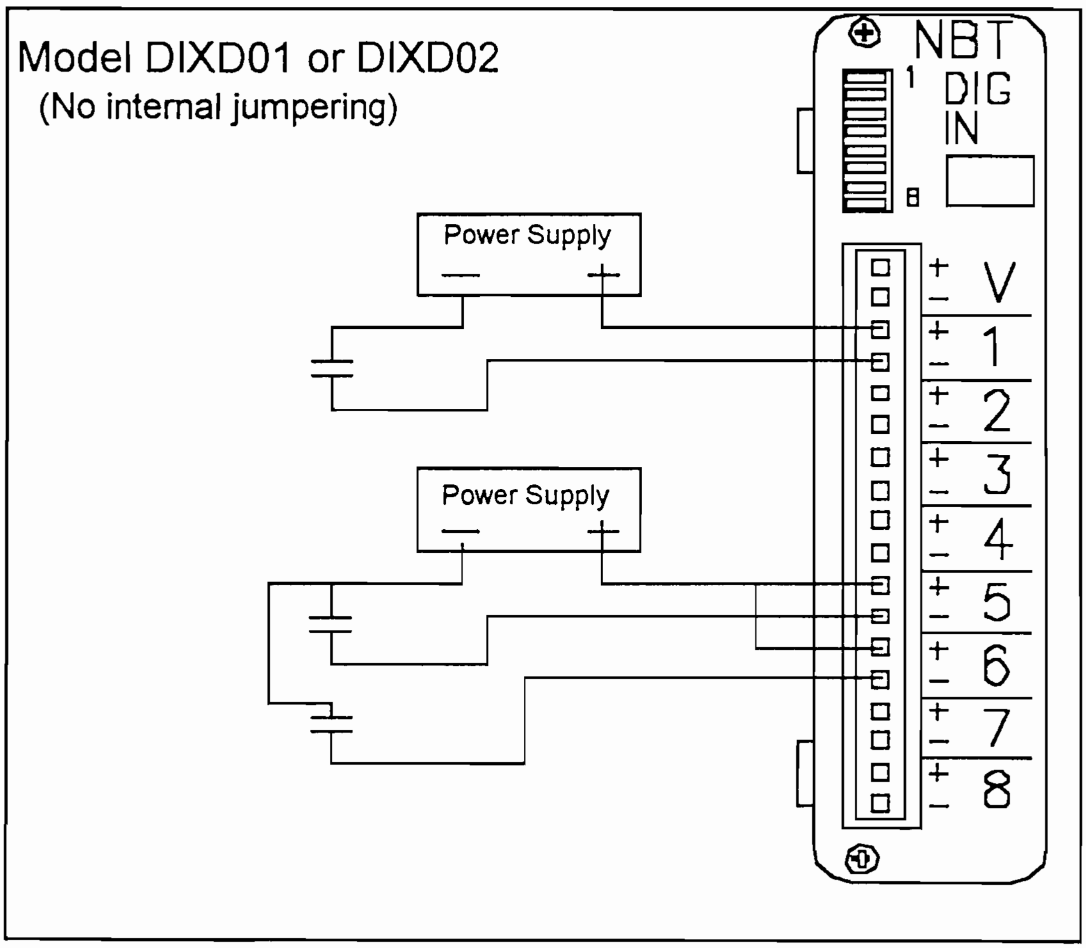


Figure 8.8
Digital Input, no internal jumpers.

DIGITAL INPUT, with internal jumpers

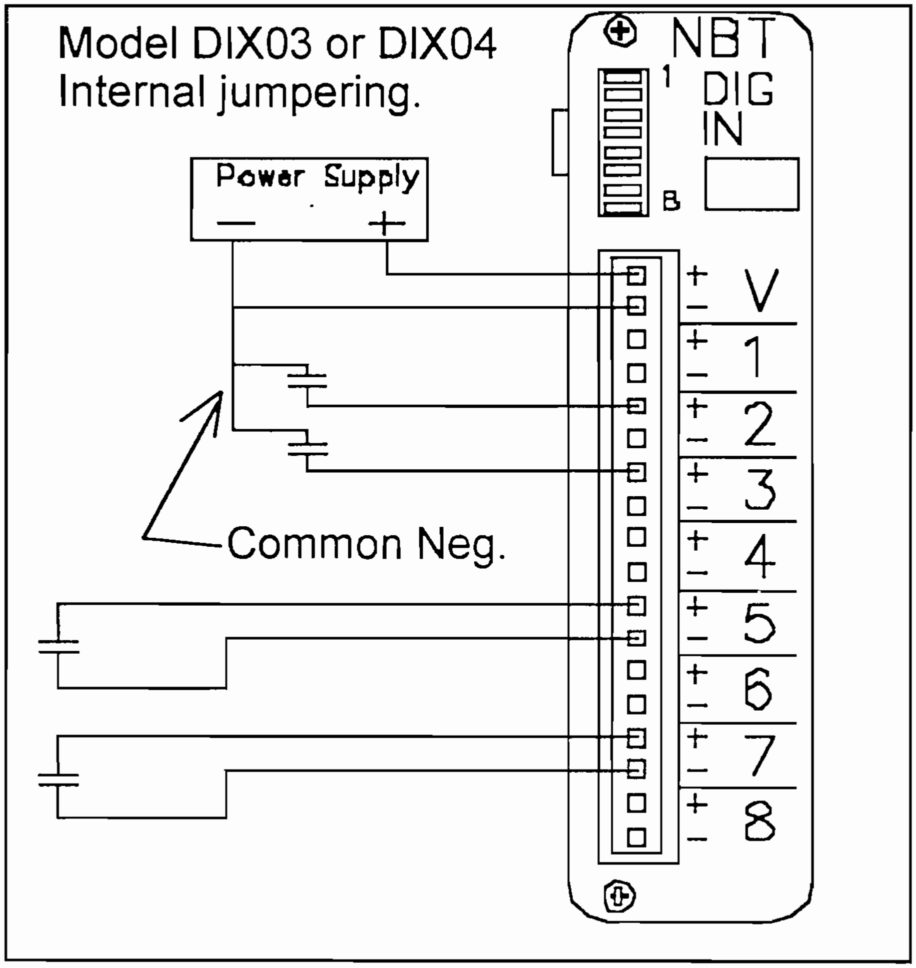


Figure 8.9
Digital input with internal jumpers.

8.10. Digital Output Expansion Modules

There are no internal jumpers or adjustments on the digital modules intended for field configuration. The Digital Output module comes with each point occupying 2 terminal strip positions and both legs isolated from power or ground. Optional configurations can be ordered which bus either the high side or the lo side to the +V or -V terminals respectively. This provides a switched live lead for direct connection to un-powered loads.

DIGITAL OUTPUT, No internal jumpers

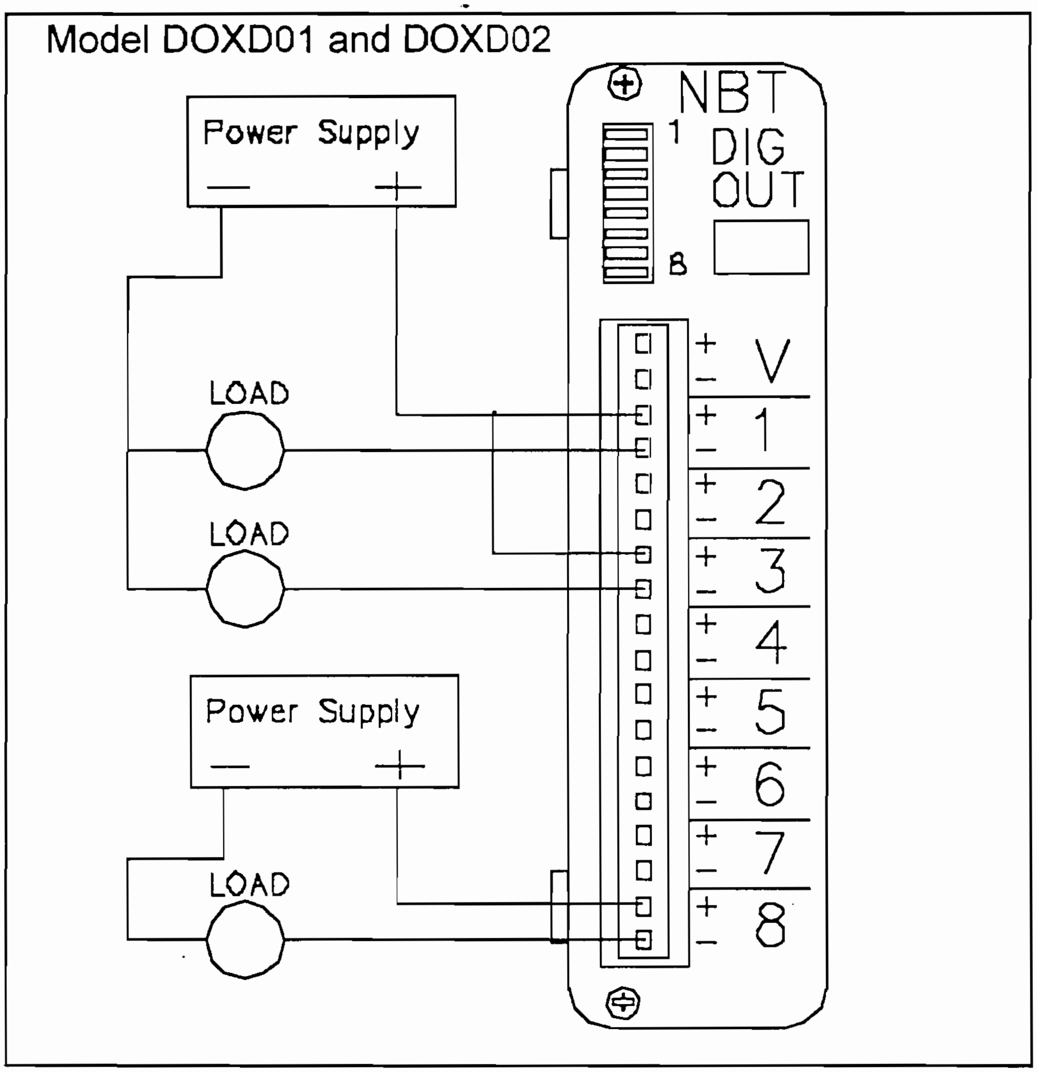


Figure 8.10
Digital Output, without internal jumpers.

DC Digital Output points utilize medium or high power FET relay drivers, suitable for connection to external relay coils or small indication loads (24VDC 1.0 amp or 5.0 amp max). Transient clamping is provided. Note: the field side Expansion I/O power source must be sized to support the maximum load current.

AC Digital Outputs use an optically isolated triac output (solid state relay) capable of handling up to 5 amps at 120VAC.

DIGITAL OUTPUT, with internal jumpers

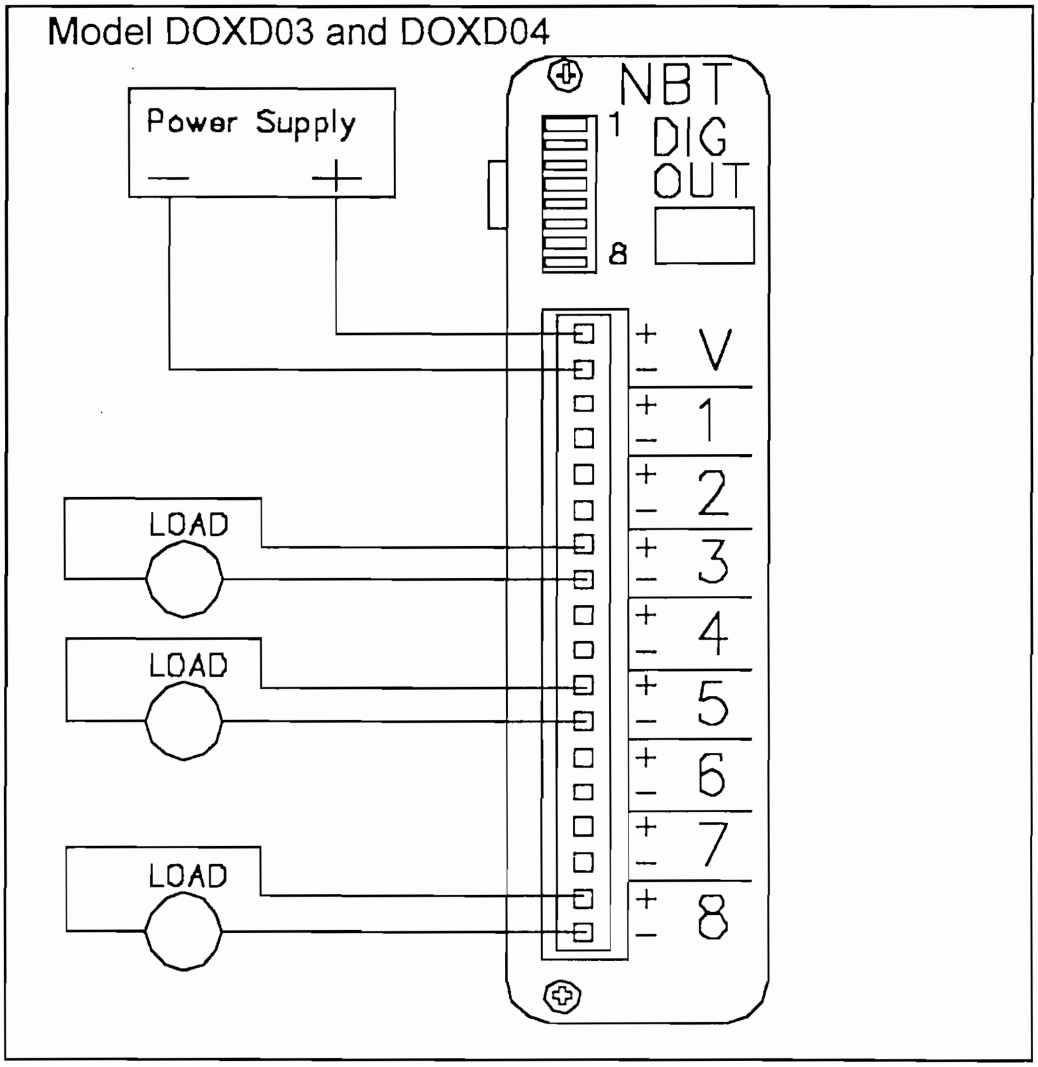


Figure 8.11
Digital Output, with internal jumpers.

8.10. Analog Input Expansion Modules-

There is a Full Scale trim pot (R8) located in the AI module. It is adjusted at the factory for correct calibrated value. Over a long term there may be minor trim adjustments required. The analog input value will go high with an open circuit.

Jumper JP2 is a 3 pin jumper located in the AI module.

JP2	1-2	selects bipolar operation of the A/D
	2-3	selects unipolar operation

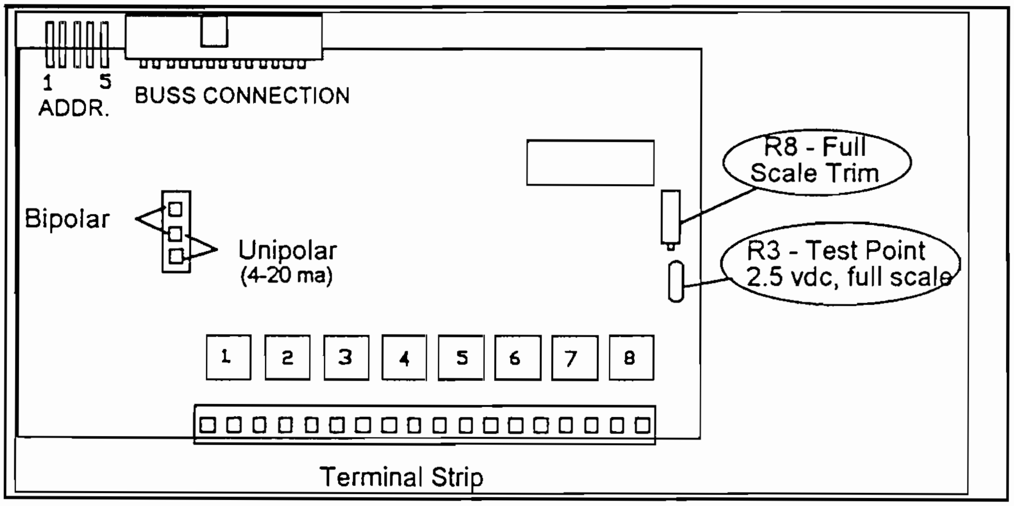


Figure 8.12
Analog Input, jumper selection.

The AIXA01, AIXA02, AIXA03 and AIXA04 analog input modules require + 12 & - 12 VDC (or 24 VDC) for full range operation. Load current for a XAI module is approx. 30 ma.

Each expansion module uses an independent A/D converter with 10 or 12 bit resolution. Note that the points within a single expansion module are not optically isolated from each other. They each, however, can withstand continuous common mode voltages of +/- 200 VDC and momentary (10 sec) common mode voltages of +/- 500 VDC (SWC - Surge Withstand Capabiltiy). Optical Isolation allows the entire field side of the module to float to voltages of 500 volts.

Surge protectors are typically set at about 75 V. Contact the factory for other options.

ANALOG INPUT, with internal jumpers

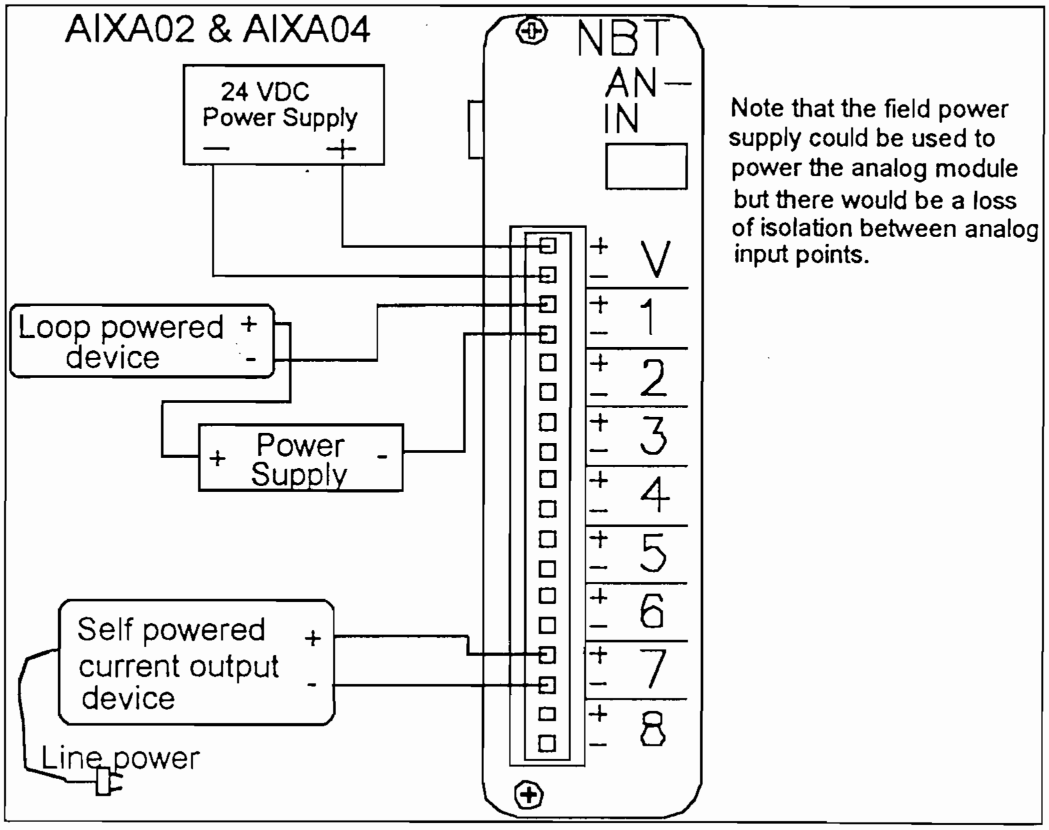


Figure 8.13
Analog Input with internal jumpers

8.11. Analog Output Module-

Wiring connections are shown in Figure 8.11

There is a Full Scale trim pot (R8) located in the AO module. It is adjusted at the factory for correct value. Over a long term there may be minor adjustments required.

Jumpers are available on each point to select range and voltage or current mode.

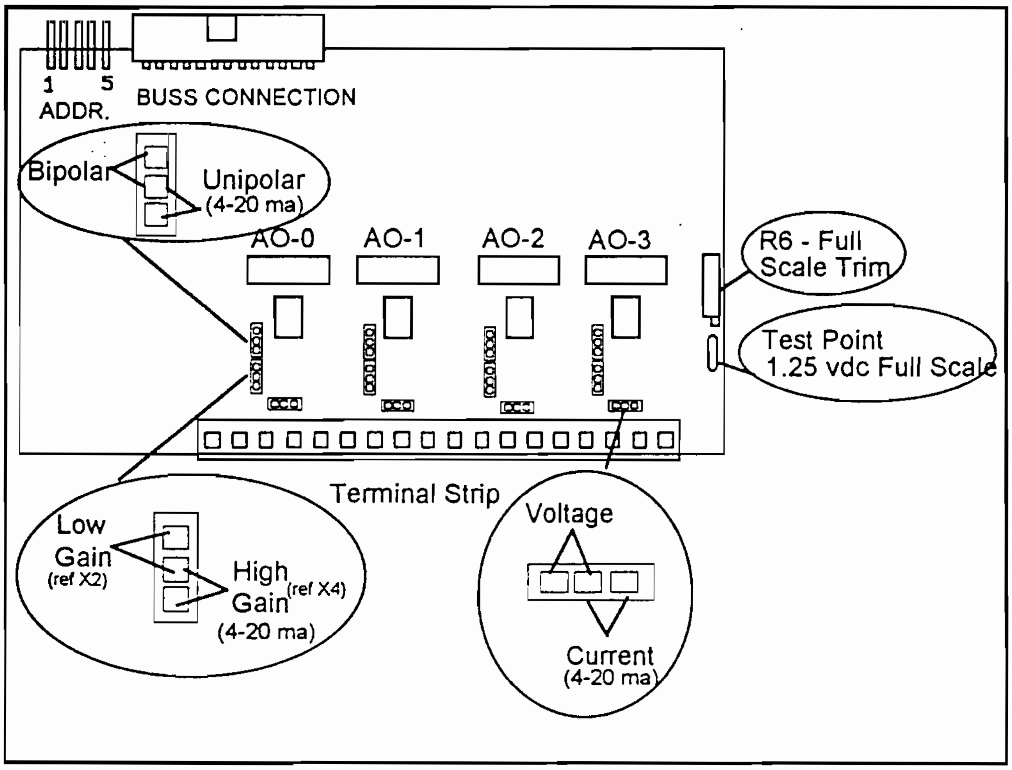


Figure 8.14
Analog Output jumper selection.

ANALOG OUTPUT

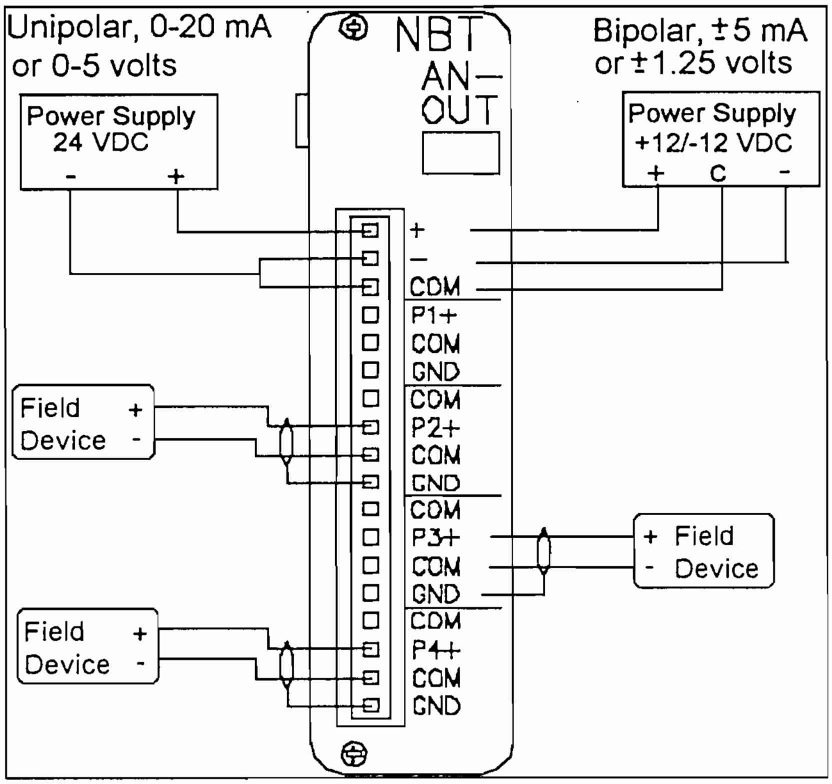


Figure 8.15
Analog output wiring

The XAO analog output module requires a minimum of 16 VDC for unipolar operation. For bipolar operation, the power supply should be + 12 & - 12 VDC.

Analog Outputs can be ordered for most standard voltage and current ranges. Optional scaling can be configured on a per point basis. Resolutions are available in 10 or 12 bits. The field side of the Analog Output Module is optically isolated

8.12. Internal I/O and System Monitoring Points

8.12.1. Internal I/O Points

The Base unit includes 2 (or 10) Digital Inputs, 2 Digital Outputs, and 4 Analog Inputs for connection to external I/O devices.

Additionally, there are 4 user assignable front panel LED's and 4 system power monitoring analog signals:

1. Main power monitor,
2. backup battery monitor,
3. Memory cartridge battery monitor,
4. ground,

and several internally generated "common" alarm signals.

The following parameters are used to configure Table 1 points to access these standard internal points.

Note:	The Module address parameter (MOD ADDR) is not used for linking internal I/O to Table 1 points.

Description	Register		Bit
Digital Input Registers			
Int. Phys I/O 0 (TB2-3,4)	DI	0	0
Int. Phys.I/O 1 (TB2-1,2)	DI	0	1
Slave Communications Alm	DI	0	2
Master Communications Alm	DI	0	3
Common Major Alarm	DI	0	4
Common Minor Alarm	DI	0	5
Int. Phys.Inp 2 (Min. I/O Option)	DI	1	0
Int. Phys.Inp 3 (Min. I/O Option)	DI	1	1
Int. Phys.Inp 4 (Min. I/O Option)	DI	1	2
Int. Phys.Inp 5 (Min. I/O Option)	DI	1	3
Int. Phys.Inp 6 (Min. I/O Option)	DI	1	4
Int. Phys.Inp 7 (Min. I/O Option)	DI	1	5
Int. Phys.Inp 8 (Min. I/O Option)	DI	1	6
Int. Phys.Inp 9 (Min. I/O Option)	DI	1	7
Digital Output Registers			
Int. Phys Out 0 (K1)	DO	0	0
Int. Phys Out 1 (K2)	DO	0	1
COMMON Reset Major & Minor Alarms	DO	0	2
COMMON Acknowledge All Points	DO	0	3
COMMON Reset Minor Alarms	DO	0	4
User LED 1 (Front panel)	DO	1	0
User LED 2 (Front panel)	DO	1	1
User LED 3 (Front panel)	DO	1	2
User LED 4 (Front panel)	DO	1	3
Int. Phys. Out 3 (Opto I/F)	DO	2	0
Int. Phys. Out 4 (Opto I/F)	DO	2	1
Int. Phys. Out 5 (Opto I/F)	DO	2	2
Int. Phys. Out 6 (Opto I/F)	DO	2	3
Int. Phys. Out 7 (Opto I/F)	DO	2	4
Int. Phys. Out 8 (Opto I/F)	DO	2	5
Int. Phys. Out 9 (Opto I/F)	DO	2	6
Int. Phys. Out 10 (Opto I/F)	DO	2	7
Analog Input Registers			
Int. Phys I/O 0	AI	0	
Int. Phys I/O 1	AI	1	
Int. Phys I/O 2	AI	2	
Int. Phys I/O 3	AI	3	
Mem.Cart.Bat.Volts	AI	4	
Main Power Voltage	AI	5	
Backup Bat Voltage	AI	6	
GND (offset adj)	AI	7	

Figure 8.16
Internal register data

The local I/O data registers (inputs only) described in the previous table can be directly mapped into assigned Table 2 data registers and they will be in the following order:

Register	(see previous table for details of each register)
0=	Internal DI Reg 0
1=	Internal DI Reg 1
2=	Internal AI Reg 0
3=	Internal AI Reg 1
4=	Internal AI Reg 2
5=	Internal AI Reg 3
6=	Internal AI Reg 4
7=	Internal AI Reg 5
8=	Internal AI Reg 6
9=	Internal AI Reg 7
10=	1st Expansion I/O Module Input Regs
10+n	2nd Expansion I/O Module Input Regs
	(Last register, as specified in # of registers parameter)

Figure 8.17
Register mapping

The above table is only true if Register 0 is the offset, otherwise, if a different 1st Reg offset is specified, transfer of the local input data into Table 2 begins at the specified offset into the above data map.

8.12.2. Special (Alarm) Point Functions

8.12.2.1. Common Alarm Points

Major and Minor common alarm points are available. They are set by any Table 1 point having the Alarm Type field set so as to be included in either the major or minor alarm groups. A point may be configured to be a member of both groups. (See previous tables for Register and Bit assignments for these points.)

8.12.2.2. Common Slave Communication Fail Point

This point will set any time a slave station's communication status goes to "Down" (or "Failed"). It is accessed via Internal DI point, Reg 0, Bit 2 and it can be reset by setting the Alarm Reset Point (Internal DO point, Reg 0, Bit 2).

8.12.2.3. Superior Master Communication Failure

This point will set any time that communication with the "master" station fails (goes to "Down"). It is accessed via Internal DI point, Reg 0, Bit 3.

8.12.2.4. COMMON Reset Major & Minor Alarms

By setting the COMMON Alarm Reset Point (Internal DO point, Reg 0, Bit 2) both Major and Minor alarms and the RTU communication alarms will be reset.

8.12.2.5. COMMON Acknowledge All Points

All alarm points will be acknowledged by setting this bit. This point is Internal DO point, Reg 0, Bit 3.

8.12.2.6. COMMON Reset Minor Alarms

All minor alarms will be acknowledged by setting this bit. This point is Internal DO point, Reg 0, Bit 4.

8.13. Saving a Customized Setup File

Configuration information is stored in nonvolatile memory so that it is never lost.

After a customized point configuration has been created, it can be saved for permanent reference by selecting the "Transfer" menu option and doing a "Save to CD" function to transfer the data to a memory cartridge.

Uploading and downloading of point configuration files to a PC is supported using the XMODEM transfer.

BASIC programs can also be saved as files, see section 9.4.14 for details.

8.14. Loading Alternate Configurations

Configuration files that have been saved to the memory cartridge can be loaded by selection from the menu line under the TRANSFER selection. Generally, however, once a configuration has been entered, it will remain as the active configuration indefinitely.

Under certain circumstances the user may elect to load in an alternate configuration from the RAM cartridge. There is provision for saving one configuration file on the memory cartridge. Loading the configuration from the memory cartridge is a convenient means of loading several similar Sensor Modems. The memory cartridge is also a convenient way to save a "backup" or master copy of the configuration for off-site storage.

DIP switch settings (SW7) can be used to force clearing of the configuration file to a default condition and can be used to specify the preferred configuration to load if none is currently active. This is relevant during startup (powerup).

8.15. XMODEM Transfers

A new or revised configuration can be saved to, or uploaded from, a connected computer file. Access to XMODEM transfer options is available from the TRANSFER selection in the Menu Line.

Options that are selectable for XMODEM transfer are:

```
  1.  SEND DATA BASE <TO COMPUTER>
  2.  SEND CURRENT & SUMMARY DATA
  3.  LOAD DATA BASE <FROM COMPUTER>
  4.  OFFLOAD HISTORY <TO COMPUTER>
  5.  EXIT TO RT-DISPLAY
SELECT:
```

Figure 8.18
XMODEM Transfer Options

After selecting one of the above options there is a 15 second wait for the computer to start the file transfer. If the file transfer is not started in time the RTU will return to its normal mode automatically.

If you are using PROCOMM, the PageUp and PageDown keys are programmed to start the file transfer, <u>PageUp if sending from the computer</u> and <u>PageDown if sending to the computer</u>. PROCOMM can be pre-set to the XMODEM protocol and then you need only select the file to send or the name of the file to receive. See the PROCOMM manual for details on the file transfer functions.

Note:	After a file transfer to the RTU the "scan" is disabled. Restart the scan from the main menu under the STATION command. The unit will restart automatically if it is reset.

8.16. BASIC Program Transfers

Basic programs may be saved to the computer using the ASCII file transfer protocol in PROCOMM. In the BASIC program area type "LIST" but <u>do not press the <ENTER> key</u>. After setting up PROCOMM for a file recieve, switch back to the RTU and hit the <ENTER> key and the file will be captured on the computer.

Note:	The newer versions of PROCOMM will automatically send the <ENTER> key when setting up the file receive.

A file on the computer can be sent to the RTU by first clearing the program in the unit, type "NEW" <ENTER>, and then use the ASCII file transfer from the computer to the RTU. The text file will be sent directly to the BASIC area. The file must then be saved to a local file for automatic startup, etc. See section 9.4.14 for details.

8.16. BASIC Applications / Calculations

Simple BASIC programs have complete access to Table 1 and Table 2 registers, as well as historical and summary data.

In some cases, it is more convenient to write a BASIC program to perform complex mathematical conversions, or to perform a specialized control algorithm.

This flexibility is optionally available in each Sensor Modem unit. This powerful capability allows a complete range of application specific functions to be added on an as needed basis or customized on a per job basis.

Mathematic functions include Trigonometric, Exponential and Logarithmic functions. Integer and single precision floating point types are supported. Bitwise Boolean functions allow easy manipulation of digital points.

See Sections 9.0 for detailed BASIC programming information and for information on available "standard application" programs available.

8.17. Autoexec Startup of a BASIC Program

Setting DIP SW2 to the down position will cause BASIC program file 11 (first file in file device 10) to automatically load and execute at startup.

If battery backed operation is not provided, this is important if a BASIC program is to be utilized for online control purposes.

Autoexec loads the program file and executes it in the NOERROR mode. It is important that this program be error free before using it for Autoexec purposes.

8.18. Dial-Up Modem Functions

Dial modem access can be via the internal dial modem option or via an external modem connected to one of the serial ports.

The internal dial modem is patterned after most smart modems and has a subset of the "Hayes" modem commands. Commands include both dial and auto-answer functions.

The user may manually initiate a dial connection or the modem can be controlled by a BASIC program.

A BASIC program can access the station name and the alarm dialout phone number strings by using FILE 9 to read these strings. The selection of string to read is made by writing a single ASCII digit to FILE 9, followed by a read from FILE 9 until a 'cr' terminating character is read.

Selection of Station Name is made by writing a '0' to FILE 9. Selection of phone #'s (1-6) is made by writing the number of the phone number string desired- '1' through '6'.

8.19. BASIC Application Programs

The following application programs are available as a standard library of functions. They are generic and may require minor customization for specific installations.

8.21.1. Local Keypad Display - Operating Data

8.21.2. Dial-Up Retrieval of Historical Data

8.21.3. Graphic Presentation of Analog Points

8.21.4. KW and KVAR Calculations

8.21.5. Flow Rate Calculations

8.21.6. Pump Alternation Control

8.21.7. Chemical Feeder Control

8.20. Maintenance Monitor / Diagnostics

An offline maintenance monitor is included in the unit. It provides a number of offline maintenance type functions. It is intended only for experienced service personnel.

The monitor can be entered by setting the left most DIP switch to the down position and resetting the unit by disconnecting power momentarily. Any power-up start with DIP SW1 down will take you to he monitor instead of to the normal ON-line system.

The monitor will automatically output an initial identification message to serial port 0 at 9600 baud. A list of available commands can be displayed by entering a '?' and CR (carriage return or Enter).

8.20.1. Verifying Micro-processor Running

If a unit has failed and shows no signs of life, a quick verification of power present is to reset the unit by momentarily removing power and then restoring it. When power is restored, the front panel LEDS should all (1 thru 8) light up briefly before being shut off and then proceeding to their on-line functions. If there is no indication of the LED's lighting momentarily, either there is no power being supplied to the unit, or the internal fuse has blown, or the internal power supply has failed.

If the unit does not start-up normally, or appear to be running, the monitor can be used to verify if the unit is basically functional (e.g., the processor and memory are operational).

If the unit will not start up in monitor mode and interact via port 0, then the unit must be returned to the factory for repair.

The monitor can run simple memory tests on selected portions of memory and can exercise basic I/O functions (to the LED's for example) as a means of isolating a failure.

8.20.2. Manually Keying Transmit

Occasionally, it is desirable to manually key the transmitter to test levels or otherwise verify a communications path. This can be accomplished for the Bell 202 modem option by entering the following commandS:

For manual "ON" OE004,2 cr

For manual "OFF" OE004,0 cr

8.21. Configuration Examples

The following configuration examples are intended to serve as a pattern for functions which are commonly required.

8.22.1. Two Station, Two Pump Control

Problem: Retrieve tank level from remote station to control local pumps for start/stop operation.

REMOTE TANK STATION CONFIGURATION

Read local analog input for Tank level and scale the 4 - 20 mA signal to 0 -100 feet with one decimal place.

```
     Station         2 Sta Name TABLE1_DATA-CUR/SUM Tuesday   15:38:40  06/22/93


    File =     TODAY'S    06/22/93     Scan is  Enabled  ALLPoints NoAlmQual NoAlmQual
        A          E          P         Q          S          T          U         V
    PT.NAME    CURVALUE   HW TYPE    PT TYPE    MOD ADDR   REG/PT     RANGE/FS    OFFSET
01  Tank Lvl      73.8    INTERNAL   ANL IN          0          0       100.0   -  25.0
```

Figure 8.19
Sample Remote Station Setup

MASTER PUMP STATION CONFIGURATION

Scan for remote station and retrieve Tank level register and set up pump control for two pumps based on the Tank level. Each pump will have its own start and stop set points and the tank level will have seperate high and low alarm limits. Set up a fail circuit for each pump.

```
     STATION         1 Pmp Stat TABLE2_DATA-REM.STA Tuesday   15:55:14  06/22/93


   Ph#1:...................  Ph#2:...................  Ph#3:...................
   Ph#4:...................  Ph#5:...................  Ph#6:...................
    MASTER MODB      Use MENU for PWs.   P1BAUD= 9600        Scan is   Enabled
        A          ^B          ^C          ^D          E          F          G
    STA ADDR   ENABLE      STATUS      ERR CTR    FUNCTION   1ST IN     NBR IN
01         2    OFF        Comm. OK          0    TBL1 REG        1          1

     Scan RTU #2 and retrieve level data from line 1 of table 1.  Level is already scaled to proper units.
```

Figure 8.20
Sample Master Station Polling Setup

Station 1 Pmp Stat TABLE1_DATA-CUR/SUM Tuesday 16:22:56 06/22/93

File = TODAY'S 06/22/93 Scan is Enabled AllPoints NoAlmQual

	A	C	P	Q	S	T	U
	PT NAME	CURSTATE	HW TYPE	PT TYPE	CALCTYPE	IN PT 1	IN PT 2
01	Tank Lvl	42.1	TABL2/RS	ANL IN	1	0	.0
02	P_1 Lvl	42.1	TABL2/RS	ANL IN	1	0	.0
03	P_2 Lvl	42.1	TABL2/RS	ANL IN	1	0	.0
04	P_1 ctrl	ON	CALC-PT	DIG IN	CTRLR	2	2
05	P_2 ctrl	OFF	CALC-PT	DIG IN	CTRLR	3	3
06	P1_REQ	ON	INTERNAL	DIG OUT	0	0	0
07	P2_REQ	OFF	INTERNAL	DIG OUT	0	0	0
08	P1_RUN	ON	INTERNAL	DIG IN	0	0	0
09	P2_RUN	OFF	INTERNAL	DIG IN	0	0	1
10	P1_FAIL	OFF	CALC-PT	DIG IN	BXOR	6	8
11	P2_FAIL	OFF	CALC-PT	DIG IN	BXOR	7	9

Figure 8.21
Sample Master Station Pump Control

	L	M
	HI LIMIT	LO LIMIT
Tank level alarm limits	80.0	20.0
Pump 1 control limits	75.0	45.0
Pump 2 control limits	60.0	30.0

Figure 8.22
Control Level Settings for Sample

Line #	Functional description for pump control
1	Alarm limits on the level.
2	Control limits on the level for pump 1.
3	Control limits on the level for pump 2.
4	Control block for pump 1, INVERT field is set to INVERT.
5	Control block for pump 2, INVERT field is set to INVERT.
6	Digital output for pump 1, Lint PT field set to line 4.
7	Digital output for pump 2, Lint PT field set to line 5.
8	Digital input for pump 1 status.
9	Digital input for pump 2 status.
10	Fail calculation for pump 1, XOR the RUN & REQ fields to calculate a "fail", set AlmDelay column for desired fail delay time.
11	Fail calculation for pump 2, XOR the RUN & REQ fields to calculate a "fail", set AlmDelay column for desired fail delay time.

Figure 8.23
Level Control Explanation

8.22.2. HOA Switch Implementation

An HOA switch will force the manual output to off when the Auto mode is selected. When Auto is OFF, the Manual mode allows operator selection of manual OFF or manual ON. Automatic mode generates an ON condition based on an external request condition (level control, etc.)

To implement a logical HOA switch in Table 1:

	File =	TODAY'S	06/23/93	Scan is	Enabled	ALLPoints	NoAlmQual	ALLPoints
	A	C	P	Q	S	T	U	V
	PT.NAME	CURSTATE	HW TYPE	PT TYPE	CALCTYPE	IN PT 1	IN PT 2	IN PT 3
30	Auto	OFF	CALC-PT	DIG OUT	BMUX	31	29	32
31	Manual	OFF	CALC-PT	DIG IN	BXOR	30	30	31

Figure 8.24
Two Pump Altemator Sample

Line #	Functional description for HOA switch control
30	Controls AUTO mode, IN PT 2 is linked to the point to control the AUTO mode request and IN PT 3 is the output link.
31	Controls the manual mode.

8.22.3. TWO PUMP ALTERNATOR

Problem: Alternate the two pumps that are set up in the configuration problem above (8.22.1). The Lead/Lag switch should occur after the Lead pump has stopped so the Lead pump will continously alternate every time both pumps are OFF.

	A	C	P	Q	S	T	U	V	W	X	Y
	PT.NAME	CURSTATE	HW TYPE	PT TYPE	CALCTYPE	IN PT 1	IN PT 2	IN PT 3	CONST.	N.U.	INVERT
13	both OFF	ON	CALC-PT	DIG IN	BAND	20	21	0	0		NO-INVRT
14	one shot	OFF	CALC-PT	DIG IN	LATCH	13	14	0	0		NO-INVRT
15	Lead/Lag	OFF	CALC-PT	DIG IN	LATCH	16	17	0	0		NO-INVRT
16	(set ON)	OFF	CALC-PT	DIG IN	BXOR	14	15	0	0		NO-INVRT
17	(set OFF	OFF	CALC-PT	DIG IN	BAND	14	15	0	0		NO-INVRT
18	Lead REQ	OFF	CALC-PT	DIG IN	BMUX	4	5	15	0		NO-INVRT
19	Lag REQ	OFF	CALC-PT	DIG IN	BMUX	5	4	15	0		NO-INVRT
20	Lead OFF	ON	CALC-PT	DIG IN	BAND	18	18	0	0		INVERT
21	Lag OFF	ON	CALC-PT	DIG IN	BAND	19	19	0	0		INVERT

Figure 8.25
Two Pump Altemator Sample

Line #	Functional description for pump alternation control
13	Check that both pumps are OFF, using lines 20 & 21 which are the INVERSE of the pump statuses.
14	One-shot triggered off of both pumps OFF, resets itself.
15	Lead/Lag latch, set and cleared by 16 & 17
16	latch ON by line 14 "OR"15
17	latch OFF by lines 14 "AND" 15.
18	Lead REQ, this line is linked to the actual outputs, look at lines 4 & 5 for REQ, and switch according to line 15
19	Lag REQ, this line is linked to the actual outputs, look at lines 5 & 4 for REQ, and switch according to line 15.
20	Invert of Lead REQ, used by line 13 for Lead/Lag trigger.
21	Invert of Lag REQ, used by line 13 for Lead/Lag trigger.

Figure 8.26
Alternator Control Explanation

8.22. Cross Reference for Register Addressing

NBT Remote Access PLC SM 501 series	**MODBUS PROTOCOL**	**Wonderware & FIX DMACS** Memory Type	**Wonderware① & FIX DMACS** Address Method	**SKYHAWK** Memory Type	**SKYHAWK** Address	**SKYHAWK** Address Method
Table 1 Bits Rows 1-180	Input Status **(Read Only)**	10,009 thru 11,441	10,001 + (Row * 8)	IS	0016 thru 1141	(Row + 1) * 8
Table 1 Registers Rows 1-180	Input Registers **(Read Only)**	30,002 thru 30,182	30,001 + Row	IR	0002 thru 0182	Row + 1
Table 2 Bits Registers 0-900	Coils **(Read/Write)**	0009 thru 7208	(Register * 8) + 1 + bit	C	0009 thru 7208	(Register * 8) + 1 + bit
Table 2 (Integers) Registers 0-900	Holding Registers **(Read/Write)**	40,001 thru 40,901	40,001 + Register ②	HR	0001 thru 0901	Register + 1

① Wonderware register address must be followed by a space and the letter "S" to indicate signed register or the registers will be full 16 bit unsigned values.

② Wonderware allows bit addressing using a register and offset (ie 40001:3) for Table 2 but this is a read-only function.

8.23. PC Based Utility Programs

8.24.1. SLIST - DataBase List Program

SLIST is a PC based program to list the contents of a Sensor Modem DataBase which has been downloaded to the PC via an XMODEM transfer.

Command Line Format:

```
Usage:  SLIST [-Type C|R] src_file [>dest_file]
        -TC=Table1(Default)  -TR=Table 2
        (if dest not present, send output to screen)
```

8.24.2. HCOM - Historical File Conversion

HCOM is a PC based program which will translate a Historical data dump file which has been downloaded to the PC to either MIS2 or LOTUS or TEXT format.

Command Line Format:

```
C:\NBT\SM>HCON
Usage:  HCON  src_file [dest_file [-<format>]]
        (if dest not present, send output to screen)
 Format options: T: text, M: MIS2, L: Lotus, C: comma sep.
        (format can include list of qualifying points)
        (ie,  1, 2, 3h, 3l, 4t, ... ) (20 pts max)

C:\NBT\SM>
```

Chapter 9
BASIC Programming

9. BASIC Statements and Commands

9.1. BASIC Programs / Displays

The BASIC compiler, as well as any BASIC programs, run in the background concurrently with the on-line real time scan functions of the Sensor Modem.

BASIC can be accessed by linking directly from the command mode. ("LINK,BASIC", "ONLINE")

If you are currently in the Real-time Data Displays, or other linked functions other than BASIC, you must use the ESCAPE SEQUENCE (three ^X's) to return to the command level and then LINK to basic.

By going "ONLINE" linked to BASIC, any BASIC user program display output is presented on your terminal, and any keyboard inputs are available for the user program to read.

BASIC programs are very convenient to create custom summary displays or other unique operator interface requirements.

Details of accessing real-time registers from BASIC programs is discussed in section 9.6.33

Programs that are SAVED for permanent use and set for AutoStart, are suitable for continuous background operation without any further operator access or attention. Programs of this type allow complex control algorithms to be implemented in a "high level" language and the outputs passed directly to the real-time registers.

Programs may also be set up which are operator interactive and provide specialized operator displays. This type of program is useful in replacing dedicated hardware panel meters and other "panel mounted" indicators.

Specific operator interactions with BASIC display programs is determined by the system implementor and the particular BASIC program installed.

9.2. BASIC Compiler

9.2.1. Overview

The optional BASIC compiler (BASIC180) is a multitasking programming environment completely available to the user. It provides all programming capabilities. Editing or running programs can be done concurrently with on-line operation of the real-time system.

BASIC runs in a background mode to the real-time scanning, data processing and communications functions of the Sensor Modem. It can freely read (or write) real-time data from the register tables. The serial ports can be utilized by BASIC programs. (when not assigned for active use by the real-time system)

Programs can be interactively edited and run through either local or remote inter-active links.

Floating point and integer functions are supported, as well as, numerous advanced mathematical functions.

Windowing display support is provided for Heath 19 CRT terminals.

LOAD and SAVE functions will retrieve or store programs to the optional memory cartridge.

Note:	You must use the LOAD and SAVE functions or the BASIC program will be lost upon loss of power. Unlike the run time part of the system the BASIC program is not automatically saved. See section 9.4.9 for automatic load & run.

9.2.2. Access to BASIC (Inter-Active)

Access to BASIC from the terminal display and keyboard is accomplished from the command level by entering the following:

```
LINK,BASIC
ONLINE
```

Return to Command Mode while linked to BASIC can be accomplished by entering three ^X's within one second.

Note:	Exiting to command mode does not necessarily end execution of a BASIC program which can continue to run in background.

If a BASIC program is currently running, it can be stopped by entering ^C (Control C).

If a BASIC program is not running, the compiler is waiting for commands or input of statements. Entry of non-numbered statements or commands are referred to as Immediate Commands. Immediate commands include LIST, COMPILE, RUN, SAVE, LOAD, NEW, GO.

While a BASIC program is running, the program determines what keyboard inputs are allowed and what responses are generated.

9.2.3. BASIC Access to Real-Time Registers

Registers in TABLE 1, TABLE 2, Summary Registers and Historical Data can be accessed from a BASIC program.

Access to real-time data registers is accomplished with two BASIC statements: TBLRD and TBLWRT.

TBLRD is a function which returns the specified register or parameter. The syntax is I=TBLRD(J) , where J specifies the register or parameter, and I receives the value. The syntax of TBLWRT is TBLWRT J,K , where J specifies the destination register or parameter and K is the value to be written to the destination.

The J variable is an integer value. The usage of this function allows access to several different parameters. See section 7 for syntax and specific request information.

9.2.4. BASIC Access to Historical Data

Historical data (recorded samples) can easily be accessed by a BASIC program by using the HST function. The variable associated with this function request can be set so that all necessary information can easily be retrieved for use in the BASIC program. Each sample consists of time stamp, point #, station #, point type (digital or analog), timed or event flag, and the actual data value.

Additional information available include the current sample index, the most recent sample number (top), the oldest sample number (end), maximum sample number (size) and current word index. The parameter also permits selection of the same word in the previous sample. This facilitates searching by specific time, point or station criteria.

See section 9.6.33 for specific command syntax.

9.2.5. Access from BASIC program to Auxiliary Ports

A BASIC program can access the external world through two paths to the physical and logical ports in the Sensor Modem. The BASIC program can LINK to ports similarly to the way you would manually LINK to a desired port.

Inside BASIC, these redirections of keyboard and display data (via GET and PRINT statements) are accomplished by the FILE statement. FILE 5 and FILE 7 are the two paths for redirected I/O. (see 9.6.7)

9.2.6. Report Printing

Printer output can be routed to a serial port and then print output will be routed to the assigned port.

9.2.7. Non-Standard Instrument Interfaces/Secondary Port

Within a BASIC program, character I/O can be routed to either the "console" port, or an auxiliary port. The normal console port is the one which is typically used to manually enter BASIC commands, list programs, and other operator interactions. The connection from the user to this port is via the "LINK, BASIC" entry while at the command level.

The secondary BASIC port is the HOST port (LINK,HOST). These ports are the outside connections to a BASIC program. They are logical ports within the Sensor Modem. Like any of the Sensor Modem's logical ports, they can be "linked" to other logical ports or, physical serial ports.

Within a BASIC program (or task), Serial I/O can be directed to a selected output by using the FILE statement. (not to be confused with the File device files for program storage) The BASIC FILE statement parameter can be: 0- Console I/O, or 5 for the secondary (HOST) port I/O. By using BASIC's FILE 5 statement, data is diverted from the console device to the secondary port.

By logically linking the HOST port to a physical serial port, character I/O can be routed from a BASIC program to the serial port. Using this technique, a task can be set up within the program to exchange data of virtually any format.

9.2.8. Specialized Calculations

Basic programs may access real-time data and utilize log, trigonometric, and other floating point functions for specialized calculation requirements.

Common control algorithms used for pumping and other applications are available in the form of a library of example routines. These may be integrated into a customized program to facilitate the program development.

9.2.9. Multiple Tasks

The BASIC statements include statements to support multiple time-shared BASIC tasks. Up to 10 independent task programs may be concurrently active.

This feature allows the programming to be modular and to minimize problems of timing and undesirable task inter-actions.

As an example, one task may be performing a control calculation while another is displaying data or accepting keyboard commands. Each task can continue to execute independently of the other. Common variables can be accessed by either task. This allows easy communications and coordination between tasks.

However, caution should be exercised when programming multiple-task programs, since improper priority conflicts can prevent expected operation.

Also, there are some restrictions on multiple tasks performing I/O to a single device.

9.3. BASIC Utility Functions

There are several utility type operations that are provided for use in BASIC programs.

These utility functions are accessed through the BASIC "SYSTEM UTIL array(0)" statement. The "SYSTEM" statement is essentially a call to assembly language subroutines built into the Sensor Modem firmware. (The UTIL variable must be defined and explicitly set to $7520) Parameters are passed to and from the SYSTEM utility functions via an integer array with at least 4 integer elements (0-3).

Functions available via the **SYSTEM UTIL,R(0)** statement are:

- CONVERT HI BYTE TO HEX ASCII.
  (AND SWAP BYTES IN INTEGER VALUE)
- CONVERT LO BYTE TO ASCII DECIMAL.
- CONVERT INTERNAL PACKED TIME TO SS, MM, HH. (Integers)
- GET STATION NUMBER. (Integer)
- GET CURRENT TIME AS SS, MM, HH. (Integers)
- GET CURRENT DATE AS DD, MM, YY. (Integers)

(See "SYSTEM" statement in section 9.6.32 for details.

9.4. Direct Commands

Direct commands are those commands given to BASIC-180 to control its operation. Direct commands are not part of BASIC-180 programs, but are entered via a keyboard by the user. These are the BASIC-180 direct commands:

CLS	LOAD
COMPILE	NEW
CONSOLE	NOERR
END	PRINTER
ERROR	RUN
FILEFORMAT	SAVE
GO	STATUS
LIST	

Figure 9.1
Direct Commands

9.4.1. CLS

CLS clears the CRT screen to blanks and places the cursor in the upper-right corner of the screen. BASIC-180 must be properly installed for the terminal being used for CLS to work correctly.

9.4.2. COMPILE

COMPILE causes BASIC-180 to convert the program currently in memory to machine language. COMPILE is identical to the RUN direct command except that the compiled program is not executed. The COMPILEd program may be executed using the GO command. Example:

```
>LOAD 11
>COMPILE
COMPILED
>
```

9.4.3. CONSOLE

CONSOLE causes output previously directed to the printer by the PRINTER command to be directed back to the system console. CONSOLE is the default setting.

```
10 PRINT"HI"
>RUN
COMPILED
HI
```

PRINT statement sent "HI" to the console

```
>PRINTER
RUN
>
```

Nothing happens on the screen because the program sent "HI" to the printer. To redirect output to the screen, type:

```
>CONSOLE
```

9.4.4. END

END is a direct command used only in files containing BASIC-180 source programs. During the LOAD command, "END" indicates to the compiler the end of the file containing BASIC-180 statements. Whenever the SAVE command is used to store a program on disk, BASIC-180 inserts an END as the last item in the file.

The only time the user has to use the END command is when a BASIC-180 program is created off-line with a text editor or word processor. In this case, an END with no line number should be the last line in the file. For example:

```
10 PRINT "This program was created using an editor."
END
```

9.4.5. ERROR

ERROR turns on the compiler's runtime error checking software. It is the converse of NOERR. When BASIC-180 is first started, all runtime error checking is on and stays on until explicitly disabled by NOERR.

Runtime error checking is essential in most programs to insure that mistakes don't "blow up" the compiler. For example, if a "SUBSCRIPT OUT OF RANGE" error was not detected, a program could write over itself, or even over the compiler, causing unpredictable and undesirable results.

Like NOERR, ERROR modifies how the code is generated during compilation of the program, so it must be specified before the program is RUN or COMPILEd (if you have used NOERR in the BASIC-180 session before RUN or COMPILE). ERROR will then remain in effect unless disabled by NOERR.

CAUTION:	Whatever debugging work is needed should be done with ERROR on (the default setting). When checkout is complete, compile using NOERR for faster code:

```
>NOERR
>COMPILE
```

9.4.6. FILEFORMAT x0

where x specifies the File Device to be initialized.

There are two BASIC file storage areas available for user programs. The first is in internal nonvolatile RAM and the second is in the removeable RAM memory cartridge.

The first area, in internal RAM, is known as file device 1. The area in the removable memory cartridge is known as file device 2. Either of these "RAM disks" may be formatted using the FORMATFILE command. Formatting initializes the storage area and erases any existing files in the file device.

See LOAD (9.4.9) and SAVE (9.4.14) commands for details of storing and retrieving program files.

9.4.7. GO

The GO command starts execution of the most-recently COMPILED (or RUN) program. If the source code has been modified, a NEW command has been executed, or there was an error in the last compile, then the NO COMPILED CODE error results.

GO is typically used to run a program previously compiled using the RUN or COMPILE commands. If the program is very long, then GO is faster than using RUN repeatedly (since RUN must first recompile the program).

```
>LOAD 11
>COMPILE      !to check for errors
>GO           !program executed
```

9.4.8. LIST <line1, line2>

LIST displays the program currently in memory on the system's console. If a PRINTER command has been issued, the program will also be listed on the printer.

If LIST is typed with no arguments, the entire program is listed. If only one line number is specified, just that line, if it exists, will be listed. If two arguments are given, then the set of program lines between and including the two line numbers will be listed.

Examples:

```
>LIST
>LIST 100
>LIST 100, 200
```

9.4.9. LOAD xy

LOAD xy   where x is the file device and y is the file number

LOAD retrieves the specified BASIC program file from either of 2 File Devices. File Device 1 is internal non volatile memory. File Device 2 is in the removeable memory cartridge. The first digit of the parameter specifies the file device and the second digit specifies the file number (1 through 9), the second digit is always zero.

An "autoload" can be set up by saving the program to FILE 11 and then setting dip switch #2 to the down position. The unit will automatically load and run the program in FILE 11 on startup. (A mini autoexec.bat function).

Also see the FILEFORMAT (9.5.6) command for discussion of initialization of the File Device.

9.4.10. NEW

NEW erases the program currently in memory.

```
>LOAD 11
>RUN
```

program executes

```
>NEW
>LOAD 12
```

NOTE:	If you did not use the NEW command, FILE 11 and FILE 12 would be merged (in order by line number). This may not be the desired effect, but is sometimes useful.

9.4.11. NOERR

NOERR turns off much of the runtime error checking of BASIC-180, resulting in a program that runs much faster.

CAUTION:	When using the automatic file load by setting dip switch #2 down the unit will start in NOERR mode.

To insure that a program doesn't run wild and destroy itself or the compiler, BASIC-180 inserts quite a lot of error-checking code into the compiled program. For example, tests are made for "SUBSCRIPT OUT OF RANGE," "NEXT WITHOUT FOR," and so on. NOERR also removes the test for Ctrl-C. (Ctrl-C aborts a running program, so a program compiled under NOERR can't be stopped.) Most of these tests are removed by specifying NOERR. Some error-checking routines remain since, in some cases, the error-checking code does not greatly affect execution speed.

An increase in execution speed of several-hundred percent can often be realized by using NOERR. The compiled program will also be significantly shorter. Be warned, though. NOERR permits the user's program to execute erroneously, possibly trashing BASIC-180 or the operating system. Only fully-debugged programs should be compiled under NOERR.

When the compiler starts, all error checking is enabled and remains on until NOERR is specified. NOERR affects the way a program is compiled, so it must be specified before the program is COMPILEd or RUN.

CAUTION:	Whatever debugging work is needed should be done with ERROR on (the default setting). When completed, compile using NOERR for faster code.

```
>NOERR
>COMPILE
```

9.4.12. PRINTER

The PRINTER command causes all output normally sent to the console to be sent to the printer as well. This includes output generated by the program (using PRINT and FPRINT statements) as well as output generated by direct commands (such as LIST).

CONSOLE disables PRINTER. (redirects output to the screen):

9.4.13. RUN

RUN compiles and executes a program. The program is not executed if any compilation errors are found.

```
>LOAD 11
>RUN
>COMPILED
```

program executes

```
>LOAD 12
>RUN
STRING LENGTH EXCEEDED 110
>Compilation error detected, program not executed.
```

9.4.14. SAVE xy

SAVE stores the current BASIC program on either of 2 File Devices. File Device 1 is internal non volatile memory. File Device 2 is in the removeable memory cartridge.

The first digit of the parameter specifies the file device and the second digit specifies the file number (1 through 9).

Also see the FILEFORMAT command for discussion of initialization of the File Device.

9.4.15. STATUS

STATUS displays the start and end address of the compiled program, along with the amount of free memory and the starting address of the variables used in the program. The space between the end of the program and the start of the variable storage may be used for assembly language routines.

```
>LOAD 12
>COMPILE
COMPILED
>STATUS
Start: A56F
End: A619
Variable: FBFC
```

Starting address	6EOF
Ending address	794C
Variable start	F619

9.5. Components of Statements

A statement is composed of the name of the statement itself (for example, GOTO) along with optional parameters. These parameters may consist of variables, constants, functions, operators, or combinations of all of the above.

9.5.1. Variables

BASIC-180 variables are formed by a letter followed by up to six letters or digits. For example, A is a legal variable, as well as AO, A1, HI92, and JUMP. However, 9AB is not a legal variable, nor is A1234567899.

String variables are formed the same way, but are followed by a dollar sign. HIYA$, A1$. and A9$ are all legal string variables.

A maximum of 255 different variables may exist in any given program. These variables may be in any form within the rules given above. Note that integer or real variables may not have the same name as string variables. For example, the variable A may not be used in the same program that uses the variable A$. BASIC-180 will try to use A and A$ as the same variable and a string variable error will result. Similarly, a dimensioned variable must not have the same name as an undimensioned variable (for example, you cannot use B and B(n) in the same program).

All variables must be declared at the beginning of the program before any executable code is encountered. In practice, this means that the variable declaration statement (INTEGER, REAL, and STRING) should be the first statements in the program. If undeclared variables are found during the compilation, the compiler will display an error message.

For strings, the string length is specified in the STRING statement (for example, B$(80)). If no string length is specified, a string length of 20 will be assigned. The maximum allowable string length is 127.

String arrays are defined by specifying the length of each element, followed by the number of elements in the array. STRING A$ (10,20) specifies 20 strings, each of length 10. Any element can be accessed just like a single-dimension array. A$(3)="123" assigns a value to the third element of the string array.

Subscripted variables are specified within the INTEGER and REAL statements. Note that subscripted variables start with the zero dimension and extend to the maximum dimension specified. Therefore, the statement INTEGER A(10), defines a variable with eleven members, A(0) through A(10).

9.5.2. Numbers

Integer variables are stored using s sixteen-bit two's complement representation. An integer value can range from +32,767 to -32,768. Positive values which exceed +32,767 will appear as negative numbers.

Real values are four-byte (32-bit) IEEE-compatible single-precision real numbers. This means that approximately 6.5 digits of precision are maintained for real numbers. Many BASIC interpreters and compilers use BCD mathematics or 64-bit representations resulting in high-accuracy numbers that require lots of memory. BASIC-180 does not support either of these in the interest of maximizing speed.

The user must be aware that a real number may not be exactly the number anticipated. For example, since real numbers are constructed by using powers of two, the value 0.1 cannot be exactly represented. It can be represented very closely (within 2 -23), but it will not be exact. Therefore, it is very dangerous to perform a direct equality operation on a real number. The statement "IF A= 0.123" (assuming A is real) will only pass the test if the two values are exactly equal, a case which rarely occurs. This is true for all real relational operators including, for example, the statement "IF a>B" if values very close to the condition being measured are being used. Be aware that the number you expect may not be exactly represented by the compiler. If necessary, use a slight tolerance around variables with relational operators.

9.5.3. Constants

Constants are formed by combining decimal digits with an optional decimal point. Whenever a decimal point is included in a constant, the compiler assumes this constant is a real number. If the constant is expressed without a decimal point, the compiler assumes that the value is an integer. This has significance when combining real and integer values within an expression (see Chapter 7). Even though BASIC-180 is smart enough to convert constants between integer and real as required, programs will run more efficiently if modes are not mixed.

When expressing constants between -1 and 0, a zero should be used between the negative sign and the decimal point. For example, "-0.25" should be used and <u>not</u> "-.25".

BASIC-180 provides a facility for using hexadecimal constants. Hexadecimal constants are specified with a leading dollar sign..$1AB represents the hexadecimal constant 1AB.

9.5.4. Mode Conversions

BASIC-180 is unlike many BASICs in that it forces the user to declare the mode of each variable, thereby optimizing the compiler's speed. With all variables predeclared, the compiler is not forced to evaluate all expressions in floating point at run time (which is a very slow procedure). and then convert to integer as the need arises. Instead, the algorithms used in BASIC-180 attempt to evaluate all expressions in the output mode (the mode of the variable to which the expression is being assigned).

To make it easier to write programs, BASIC-180 provides automatic mixed-mode expression evaluation. This means that an expression may consist of a combination of real and integer values. BASIC-180 will automatically convert the components of the expression to the proper mode of the variable to which the expression is being assigned. This is very convenient for programmers; however, there are some important implications arising from it.

Whenever an expression is to be assigned to a real variable, every component of that expression is evaluated in real mode. Components of the expression which are integer (for example, integer variables) are automatically converted to real before any arithmetic is performed. This conversion takes place entirely within temporary values in the compiler; the integer values themselves are not changed. Whenever a constant is specified with no decimal point, the compiler assumes that it is an integer value. Any constant designated with a decimal point will be assumed to be real. Since the process of converting an integer to a real is relatively slow, faster code will result with real operations when all real operands are specified.

Expressions are defined in terms of parenthesis. Whenever an expression in parenthesis is encountered, it is treated as a new expression although it may be part of a larger expression. This has significance when expressions are being evaluated which will be assigned to integer arguments. When the compiler encounters a new expression (one with parentheses). it attempts to evaluate that expression in the mode of the variable to which it will be assigned. In the case of a real operator this is not important since all values are converted to real before any operation takes place. With integer variables, however, if any component of an expression is real, the rest of that expression will be converted to real before the operation takes place. A few examples will make this clear.

```
10   INTEGER A
20   A=(1/2)*2
```

In this case, the expression will evaluate to the value zero. All operations specified are integer. Integer operations take place by truncating the result, so one divided by two evaluated to zero.

```
10   INTEGER A
20   A= (1.0/2)*2
```

This expression also evaluates to zero, but for a different reason. The inner 1.0/2 evaluates to 0.5, but after the value is calculated, the compiler attempts to convert this back to integer to be in the proper mode for variable A. The integer version of 0.5 is 0.

```
10   REAL A
20   A=(1.0/2)*2.0
```

In this case, the expression will evaluate to 1. Each of the operations is real, so all operations take place in real mode.

9.5.5. Operators

Operators are connections within expressions that perform logical or mathamatical computations.

9.5.5.1. Integer and Real numbers

These operators work with both integer and real numbers:

+	addition
-	subtraction
*	multiplication
/	division

Figure 9.2
Mathematical Operators

Note: see 9.7.11 for exponential math functions.

9.5.5.2. Relational

Some operators are relational. They generate a nonzero result if their condition is met. These operators may be used in mathematical expressions, but they are more frequently used with IF/THEN statements. A variable may hold the result of a relational comparison. For example, A = R > 0.

>	greater than
<	less than
<> **or** ><	not equal to
=	relational equality test
>=	greater than or equal (integers and reals)
<=	less than or equal (integers and reals)
AND	logical AND (integer, reals automatically converted)
OR	logical OR (integer, reals automatically converted).

Figure 9.3
Relational Operators

Note: Strings are not supported by >= or <= and for concatenation you must use CONCATS instead of + .

9.5.5.3. Precedence

All operators are in a hierarchy that defines what operators will be evaluated first. The following is a list, from the highest to lowest priority.

***, /**
+, -
unary -, >, <, <>, ><
AND, OR.

Figure 9.4
Precedence Operators

9.6. Statements

A statement is an instruction in a program which specifies what action the program will take. These are the BASIC-180 statements:

CANCEL	INPUT	STOP
CLS	INPUT$	STRING
CURSOR	INTEGER	SYSTEM
DATA	NEXT	TASK
DEF	ON GOSUB	TBLWRT
DEFMAP	ON GOTO	TRACE OFF
ERASE	POKE	TRACE ON
EXIT	PRINT	WAIT
FILE	PRIORITY	WCLEAR
FNEND	RANDOMIZE	WFRAME
FOR/NEXT	READ	WINDOW
FPRINT	REAL	WPOKE
GOSUB	REM	WSAVE
GOTO	RETURN	WSELECT
IF/THEN	RUN	WUPDATE

Figure 9.5
Statements

All statements must be preceded by a line number. This line number determines the position of the statement within the program. For example, if a statement is entered with a line number of 10, and later on a statement is entered with a line number of 1, the statement numbered 1 will appear in the program before the statement numbered 10. This is BASIC-180's primary editing facility. To delete a statement, simply type its line number followed by a return. To replace a statement, type the statement's line number followed by the new statement. These procedures are the same as those used on many interpreters.

Multiple statements may be on the same line. Each statement must be separated by a colon. For example:

```
10   PRINT "HELLO"; : PRINT "BOB" : ! OUTPUT IS HELLO, BOB
```

9.6.1. CANCEL <task>

CANCEL stops the specified task from being started again when the schedule interval given in the RUN statement elapses. CANCEL does not immediately abort the task--only EXIT or STOP can stop the execution of a task. When a RUN statement is entered, a schedule interval is specified. CANCEL causes the scheduling of the task to cease. When the CANCEL is executed, the task continues executing normally until it EXITs or its current time slice expires. The task will not run again until it is specifically invoked using another RUN statement.

CANCEL is useful when a task needs to only run once. The task CANCELs itself.

9.6.2. CLS

CLS is the same as ERASE. It erases the contents of the CRT. BASIC-180 must be configured before using CLS.

9.6.3. CURSOR

CURSOR <row coordinate>, <column coordinate>

CURSOR is used to position the cursor within a window on the screen. Like all window-related commands, it will function properly only if BASIC-180 has been configured.

CURSOR's arguments are the logical row and column coordinates of the desired window position. These are logical values, meaning that they are referenced to the current window's upper-left-hand corner. CURSOR 0,0, therefore, positions the cursor to the current window's upper-left-hand corner.

9.6.4. DATA <data list>

DATA statements are used to define a block of constants which will be read by READ statements. All DATA statements must be in your program before the first READ statement.

9.6.5. DEF <function name> {<arguments>}

The DEF statement marks the beginning of a user-defined function. The function name must follow the rules for variable names. Arguments for the function are optional. Also see FNEND for more information.

9.6.6. DEFMAP <address>

The DEFMAP statement is used to provide access to memory outside of the current logical address space. See Chapter 6 for more detail on logical/physical addresses.

DEFMAP causes the PEEK, POKE, WPEEK, and WPOKE statements and functions to operate on memory anywhere in the physical address space of the HD64180. When BASIC-180 is started, DEFMAP defaults to a -1, which has the effect of accessing only the current logical map.

If a DEFMAP is issued with an argument other than -1, all PEEK, POKE, WPEEK, and WPOKE statements form their physical addresses as follows:

Physical address = (DEFMAP address) * 4096+ (PEEK address) AND $OFFF

9.6.7. FILE <file number>

FILE causes all subsequent I/O from PRINT, FPRINT, INPUT, and INPUT$ statements to be sent to the device specified by <file number>. The file number definitions are:

0	= console
5	= alternate device 1 (Linked as HOST)
6	= (associated control with file 5)
7	= alternate device 2 (Linked as HOST)
8	= (associated control with file 7)
9	= read phone numbers, station name

Figure 9.6
FILE types & values

The FILE statement sets the file number for the task that issues the statement. Each task may have a different active file number, but only a total of four files may be active at one time. (see 9.2.5)

9.6.8. FNEND

The FNEND statement marks the end of a user-defined function. Also see DEF.

9.6.9. FOR

FOR <variable> = <expr1> TO <expr2> {STEP <expr3>}

This statement will start execution of all statements between itself and the first NEXT it finds. Initially, <variable> is set to <expr1>. During each iteration of the loop, <variable> (which must be a nonsubscripted variable) is incremented by 1 (the default value) or by <expr3>. The statements within the loop will be executed until <variable> is equal to or greater than <expr2>. *Loops may be nested.*

9.6.10. FPRINT <format>, <expr list>

FPRINT allows formatted printing on the screen. Using the <format> string, the list of expressions, <expr list>, is printed. FPRINT is a much more sophisticated version of the PRINT statement since FPRINT allows the programmer to precisely control the format of data output by the program.

If the width specified for a field is not wide enough to contain the item printed, then asterisks are printed. For example, if a format of H2 is specified, and the number output is $3344, then "**" will be printed. Whenever a field overflow of this sort occurs, the field width specified in the format statement sort occurs, the field width specified in the format statement (in this case 2) will be filled with asterisks.

In the <format> string the following symbols are valid:

Hn	Prints n hexadecimal digits, truncating if needed. Leading zeros are printed.
In	Prints n integer digits. Leading zeros are converted to blanks before being printed.
Sn	Prints n characters of a string.
Xn	Prints n spaces.
Fm.n	Prints m digits before the decimal point and n digits following it. Leading zeros are converted to spaces and trailing zeros are left as zeros. No more than 6 positions after the decimal point are allowed.
Z	Suppresses the carriage return at the end of the line. This is only legal at the end of the format string.

Figure 9.7
FPRINT formats

Examples:

```
10   FPRINT "H3, X1, F3.4",X,Y
```

If X=$2AB and Y=123.123456, then the output will be:

2 AB 123.1234

```
20   FPRINT "S5, X1, S4",A$,B$
```

If A$="Hello" and B$="John Doe", then the output will be:

Hello John

```
30   FPRINT A$,B,C
```

If A$="I1,X1,I1", B=3, and C=9, then the output will be:

9.6.11. GOSUB <line number>

This is BASIC-180's subroutine call technique. GOSUB is a shortened form of GO to SUBroutine. When a GOSUB is encountered, program execution continues at <line number> until a RETURN is executed.

9.6.12. GOTO <line number>

GOTO transfers control to the line number given as its argument.

9.6.13. IF <rexpr> THEN

IF <rexpr> THEN <statement> or <line number>

This statement allows branches to <line number> if the relational expression <rexpr> evaluates to be <u>true</u>. If a statement follows the THEN, it will be executed if <rexpr> is true. If <rexpr> evaluates to be false, program execution continues at the next line in the program. For integers and real number, the relational operators are: =, <>, ><, <, >, >=, <=, **AND** and **OR**. For strings, only =, >, <, <>, and ><, may be used.

Note	The IF statement actually tests the result of an expression. Transfer to the indicated line number or execution of the given statement takes place if the expression is nonzero. Therefore, statements of the form "IF A THEN 100" are legal.

9.6.14. INPUT <var> {,<var>...}

The INPUT statement stops the program until the user types a value for the variable <var> and ends it with a carriage return. If <var> is an integer or a real variable and a string is typed, an error message will be displayed and the request for input will be made again.

Multitasking operations are not affected by INPUT. An INPUT statement stops only the task that issues the INPUT, not any other task.

INPUT statements cannot read commas when string variables are given. The commas delimit input items to the program. By the same token, control characters cannot be read by INPUT. INPUT$ will, however, accept commas and place them in string variables.

9.6.15. INPUT$ <var> {,<var>}

INPUT$ is identical to INPUT with one exception. If a string variable is specified, INPUT$ will read whatever is entered, including commas and most control characters.

9.6.16. INTEGER <var> {,<var>,...}

INTEGER allows the user to specify that a variable or group of variables is to be handled as a 16-bit two's complement integer (useful range is -32768, to 32,767). BASIC-180 requires that all variables be declared as INTEGER, REAL, or STRING.

The INTEGER statement must occur before any executable statement in the program. Generally, all INTEGER, REAL and STRING statements are the first statements in a program.

Integer arrays are also specified using this statement. In the case of an array, the variable name must be followed by the maximum dimensions expected. Arrays may not include more than two dimensions. Array dimension 0 is always present. If an array is dimensioned as A(10), then A(0) thru A(10) may be referenced.

9.6.17. NEXT <variable>

The NEXT statement terminates FOR loops. A NEXT must appear for every FOR.

9.6.18. ON <expression>, GOSUB line#, line#,...

ON GOSUB is a computed transfer statement. It causes the program to branch, via GOSUB, to a line number based on the value of the <expression>. The expression must evaluate to a number from 1 to the number of line numbers given in the command. If the expression evaluates to 1, then the program branches to the first line number; if it is 2, the program branches to the second line number; and so on. If the expression evaluates to a number larger or smaller than the number of line numbers given, then the error message "Line number does not exist" will appear.

9.6.19. ON <expression>, GOTO line#, line#,...

ON GOTO is a computed transfer statement. It causes the program to branch, via GOTO, to a line number based on the value of the <expression>. The expression must evaluate to a number from 1 to the number of line numbers given in the command. If the expression evaluates to 1, then the program branches to the first line number; if it is 2, the program branches to the second line number; and so on. If the expression evaluates to a number larger or smaller than the number of line numbers given, then the error message "Line number does not exist" will appear.

9.6.20. POKE <expr1>,<expr2>

POKE places the value of <expr2>, which must be from 0 to 255, into memory location <expr1>.

USE WITH CAUTION!

The following program places $C9 at $8700:

```
10   INTEGER K
20   POKE $8700,$C9
40   STOP
```

On HD64180 systems, POKE places the data in the segment specified by the DEFMAP statement. The physical address is formed as follows:

Physical address = (POKE address) AND 0FFF= (DEFMAP address) * 2 12

The address supplied to POKE <u>must</u> be less than $1000 (2**12) or BASIC-180 will AND it with $0FFF. Careful selection of a DEFMAP value will let you access anywhere in physical memory.

If DEFMAP is set to -1, no address translation takes place. The 16-bit address supplied to POKE will be used as a logical address in the HD64180's current map.

9.6.21. PRINT <expr>, {expr>...}

PRINT sends output to the currently-active device or file based on the setting of the last FILE statement. The console is the default device.

Commas or semicolons may separate print items. Commas cause each item to be separated into columns, while semicolons cause the items to be run together. If the last thing on the PRINT line is a semicolon, no carriage return or line feed will be printed.

A question mark (?) is equivalent to using PRINT.

9.6.22. PRIORITY <priority number>

The priority statement assigns a priority level to a task. It is used to alter the manner in which tasks are executed. It allows the user to assign a priority, or degree of importance, to a task. PRIORITY is useful only in multitasking programs. The PRIORITY statement must be issued from within the task whose priority level is to be altered.

PRIORITY takes one argument, which is the relative priority level for that task. The larger the number, the more important the task is. These numbers may range from 0 to 127. Therefore, 0 is least important and 127 is most important. Note that BASIC-180 assumes all tasks run at priority level 0 if no PRIORITY statement is issued.

In a multitasking program with no PRIORITY statements, each task is executed in a "round-robin" fashion. Upon receipt of a tic, BASIC-180 stops running the current task and starts running the next sequential task if it is ready to be run.

PRIORITY can be used to alter this sequence.

BASIC-180 re-evaluates the priorities on each tic, so tasks can dynamically change their level and the compiler will alter the scheduling as demanded.

Whenever a CANCEL statement is encountered, the priority level for that task is dropped to 0. This yields faster context switching.

If the task with highest priority level does not EXIT or WAIT, then it will use all of the computer time, effectively disabling multitasking, until it EXITs, goes into WAIT, or reduces its priority level.

9.6.23. RANDOMIZE

The RANDOMIZER statement reseeds the random number generator. It extracts this seed from the HD64180 refresh register. To make sure the numbers generated by RND are truly pseudo-random, it is best to use this statement before RND is used.

9.6.24. READ <variable list>

READ loads the variables in its argument list with values from a DATA statement. As successive READs are executed, data is taken from each DATA statement in the program.

9.6.25. REAL

REAL allows the user to specify that a variable or group of variables is to be handled as a 4-byte floating-point number (one with a decimal point). BASIC-180 requires that all variables be declared as INTEGER, REAL, or STRING.

The REAL statement must occur before any executable statement in the program. Generally, all INTEGER, REAL, and STRING statements are the first statements in a program.

Real arrays may also be specified using this statement. For arrays, the variable name must be followed by the maximum dimensions expected. Arrays may not include more than two dimensions. Array dimension 0 is always present. If an array is dimensioned as A(10), then A(0) thru A(10) may be referenced.

9.6.26. REM <text>

or ! <text>

or ' <text>

REM or ! or ' precede comments. The ! or ' can be anywhere on a line as a statement separator but REM must be used at the beginning of a line or after a ":". Nothing is done with comments during compilation; they are for the user's benefit.

```
10   REM This is a remark.
20   ! This is another remark.
30   ' This is also a remark.
40   INTEGER X,Y :REM this is also a remark
```

9.6.27. RETURN

RETURN ends a subroutine started by a GOSUB. After the RETURN, execution of the program continues at the line number following the GOSUB statement.

9.6.28. RUN <task number>,<schedule interval>

RUN, not to be confused with the direct command of the same name, is used within a multitasking program to start execution of a task. The specified task in <task number> starts execution one tic after the RUN statement is executed. If the specified task EXITs, then it is automatically restarted after the number of tics in <schedule interval> has elapsed. This provides a convenient method of making something happen periodically. The schedule interval must be in the range of 1 to 32,767.

For example:

```
10   RUN 1,100
30   GOTO 30
40   TASK 1
50   PRINT "Task running"
60   EXIT
```

In the above example, task 1 is started by line 20. Since task 1 EXITs (line 60), the schedule interval on line 20 causes task 1 to restart every time 100 tics elapse after task 1 EXITs.

In the following example, the schedule interval has no effect since task 1 never EXITs.

```
20   RUN 1,20
30   GOTO 30
40   TASK 1
50   PRINT "TASK": GOTO 50
```

9.6.29. STOP

This statement stops execution of the program.

9.6.30. STRING <var>{,<var>...}

STRING allows the user to specify that a variable or group of variables is to be handled as a string. BASIC-180 requires that all variables be declared as INTEGER, REAL, or STRING.

The STRING statement must occur before any executable statement in the program. Generally, all INTEGER, REAL, and STRING statements are the first statements in a program.

Variables in the STRING statement may have a maximum string length specified by enclosing the maximum length in parentheses. If no maximum is given, a maximum length of 20 characters is assumed. No more than 127 may be specified.

A string array may be specified by giving two parameters after the string's name. The first is the length of each string element. The second argument is the number of elements in the array. For example:

```
10    STRING A$(10,20)
```

defines a string array A$ containing 20 strings, each of length 10.

9.6.31. TASK <task number>

This statement marks the beginning of a task. All tasks, other than the lead task (main program), must begin with a TASK statement. The TASK statement must be on a line by itself. The task number is a unique digit from 1 to 31 used to identify the task.

The task numbers in a program must include all numbers between 1 and the highest task used. For example, it is OK to specify tasks 1, 2, and 3, but specifying tasks 2, 4, and 5 will not work; tasks 1 and 3 must be used. If any gaps exist, tasks numbered after the gap will never be executed. In the previous example, tasks 4 and 5 would never be executed.

9.6.32. SYSTEM <mem address>,<var array>

A variable, usually named UTIL, should be defined and set to $7520 for use as the "mem address" for the following utility functions.

The "var array" is an array of integers with at least 4 members. Element 0 of this array is entered as the "var array". The first four elements of this array are used to pass values to and from the UTILITY functions.

Assume that the integer array is defined as: INTEGER R(4).

R(0) would be set to the utility function desired. R(1) through R(3) would contain the values input to and/or output from the UTIL fuction.

9.6.32.1. Utility function types

0	=	Convert upper half of integer (R(1)) to HEX ASCII and swap upper and lower HEX bytes of integer. RETURNS: R(2) = HI Nibble ASCII HEX R(3) = LO Nibble ASCII HEX
256	=	Convert byte (LO R(1)) to ASCII decimal (R(1)-R(3))
512	=	Convert internal packed time (R(1)) to HH,MM,SS RETURNS: R(1). =secs R(2) =minutes R(3) =hours
768	=	Get station number in R(1)
1024	=	Get current time RETURNS: R(1) =secs (in hundredths) R(2). =minutes R(3) =hours
1280	=	Get current date in DD, MM, YY RETURNS: R(1) = Day R(2). = Month R(3) = YR

Figure 9.8
Utility Function Types

Example: Get station number.

```
R(0)= 768: SYSTEM UTIL, R(0): STA=R(1)
```

9.6.33. TBLWRT <var1>,<var2>

Allows access to Real Time System Data Tables. (Also see function TBLRD in section 9.7.23)

The first variable (var1) is the destination register in Table 1 or Table 2. See following figures for information on determining the address. The second variable (var 2) is the value to be written to the destination.

Note: If the destination is in Table 1 and is designated as a digital point then only the lower byte will be written to the destination.

9.6.33.1. Calculating the address "WORD".

Chosing Table 1 or Table 2

```
BIT   15=1        TABLE 2        (Bit 15=$8000)
      BIT 14 = 0 and 13 = 0 - Station/Register Data
           BITS 8 - 12 = Station index (Line number ) (Line * $100)
           BITS 0 - 7  = Register (offset from first data column "L")
      BIT 14 = 1 and 13 = 0 - Index parameters (Bits 15,14=$C000)
           BITS 8-12 = offset into table for this index (line)
           BITS 0 - 7 = Index (line) number
      BIT 14 =1 and 13 = 1 - Absolute register 0 - 899 (Bits 15,14,13=$E000)
           BITS  0 - 12= Register number to read

BIT   15=0        TABLE 1
      BITS 13 = 0 and 14= 0 - Current Day
      BITS 13 = 1 and 14= 1 - Yesterday (Bits 14,13 =$6000)
           BITS 8 - 12 - Parameter ID to read (Column) (ID*$100)
                          (see next table for Paramater ID values)
           BITS 0 - 7 Index (line) number
```

Figure 9.9
Register Table Addressing

Calculating Parameter ID values for Table 1

Parmeter ID values (bits 8 - 12) to access the following columns/data:

ID value	Column	Description (digital/analog)	
0	C	CURSTATE/CURVALUE	
1	G	CYCLES/MAXVAL	
2	H	DURATION/MINVAL	
3	I/J	LAST ON/TimeOfMx	
4	J/K	LAST OFF/TimeOfMn	
5	Q/O	TYPE & ModulSTS	(same for digital & analog)
		To decode results see tables on next page for **PT TYPE values & STATUS values**	
6	L	NU/HI LIMIT	
7	M	NU/LO LIMIT	
8	U	BIT POS/RANGE FS	(BIT POS not available)
9	V	NU/OFFSET	
10	X	Link Pt./N.U.	
11	W/Z	Resol/UNITS	(same for digital & analog)
		To decode results see tables on next page for **Resol/UNITS**	
12	A	PT.NAME	(returns characters 1 & 2 of name)
13	A	PT.NAME	(returns characters 3 & 4 of name)
14	A	PT.NAME	(returns characters 5 & 6 of name)
15	A	PT.NAME	(returns characters 7 & 8 of name)

(See 6.2 for full description of field names)

Figure 9.10
Parameter ID values

Decoding Table 1 PT TYPE values

Bits 11 - 8 = PT TYPE
0 = DI
1 = DIG OUT
2 = ANL IN
3 = ANL OUT
4 = TOTALIZE
5 = AVERAGE
6 = PWI 3-15
7 = AI w/DBA

Figure 9.11
PT TYPE values

Decoding Table 1 STATUS values

Bits 7 - 0 = PT TYPE
BIT 7 = New Alarm Flag
BIT 6 = Alarm/Ack
BIT 5 = HI/LOW
BIT 4 = Alarm
BIT 3 = N.U.
BIT 2 = Comm Status
BIT 1 = N.U.
BIT 0 = N.U.

Figure 9.12
STATUS values

Decoding Table 1 Resol/UNITS values

BITS 7 - 6 = Decimal place

BITS 5 - 0= UNITS, with following values

0 = MV	12 = PSI	24 = InH2O
1 = MA	13 = GAL.	25 = MB
2 = VOLT	14 = KGal	26 = RPM
3 = AMP	15 = MGal	27 = %
4 = KV	16 = GPM	28 = x10
5 = KW	17 = MGD	29 = x100
6 = KVAR	18 = SEC	30 = x1k
7 = KWHR	19 = DEG	
8 = WATT	20 = DEG F.	
9 = N.U.	21 = DEG C.	
10 = FEET	22 = R HUM.	
11 = INCH	23 = WndSp	

Figure 9.13
Resol/UNITS

Example: Write ten (10) Table 1 Points (Points 20 to 29), the values will be 0 to 9.

```
100 INTEGER I,P
110 FOR I= 0 TO 9
120 P= I+20
130 TBLWRT P,I
140 NEXT I
```

Example: Write value 23 to Table 1, Point 20, High Limit

```
100 INTEGER X, HL, PT
110 HL= $100*6 '6 is high limit column
120 PT= 20 ' point 20
130 X=23
140 TBLWRT HL+PT,X
```

9.6.34. TRACE ON and TRACE OFF

TRACE ON causes the line number of each line to print as it is executed. TRACE OFF disables TRACE ON.

Note that the line numbers will be sent to the selected file (as specified by a FILE statement), whether it is console, or printer.

Example:

```
10 INTEGER K
20 FOR K=1 TO 20
30 IF K>15 THEN TRACE ON
40 NEXT K
50 TRACE OFF
```

9.6.35. WAIT <expr>

The WAIT statement delays the current task from executing until <expr> tics has elapsed. This is the best way to have a delay in a multitasking program because it requires no computer time. By contrast, a FOR/NEXT-loop delay uses computer time (best used by other tasks) and does nothing useful.

If all tasks in a program are in a WAIT simultaneously, then <Ctrl-C> will not kill the program until one of the tasks finishes its WAIT.

9.6.36. WCLEAR

WCLEAR erases the currently-selected window. The entire window is erased, so if a window is created, framed (with WFRAME), then cleared, the frame will also be removed unless the window is resized after being framed.

This example creates a window, frames it, and clears it.

```
10 WSELECT 1
20 WINDOW 0,0,10,10
30 WFRAME "_", "|"
```

```
40 WAIT 500
50 WCLEAR
```

9.6.37. WFRAME <horizontal character>,<vertical character>

WFRAME draws a frame around a window. A frame is simply an outline to give a clear depiction of the window's borders.

The two arguments specify the characters which will outline the window. BASIC-180 doesn't support true graphics since graphics controllers are different on all systems, so these two characters simulate a graphics box around the window. The first argument, <horizontal character>, is used to draw the upper and lower window borders. The vertical character is used to draw the left and right window borders. The preferred characters are an underscore ("_") for the horizontal character and the vertical line ("|") for the vertical character. Of course, any other character may be used.

WFRAME draws the frame inside of the window, so it actually occupies space in the window. It is often a good idea to frame a window, but have the frame outside of the borders of the window so that output directed to the window will not run into the border and so the frame won't be erased by a WCLEAR. This is easy to do. Define a window which is one character larger in all directions than the required window. Frame it, then redefine the window to the needed size. For example, the following program generates a window, frame, and a smaller window inside the frame. The usable window size is 10 x 10 characters.

```
10 WSELECT 1
20 WINDOW 10,10,20,20    ! Draw a window 1 character too large.
30 WFRAME "_", "|"             ! Frame it.
40 WINDOW 11,11,19,19    ! This defines the actual window.
50 PRINT "*"                   ! Put something in the window.
```

9.6.38. WINDOW

WINDOW <UL row>,<UL column>,<LR row>,<LR column>

The WINDOW statement defines the size of a window. A window may not be used until it is both selected (using WSELECT) and defined (using WINDOW). The minimum size for a window is 2 by 2 characters.

The first two arguments define the upper-left (UL) row and column of the window, while the second two arguments define the lower-right (LR) row and column. A window is completely specified by designating its upper-left and lower-right corners. BASIC-180 counts rows from 0 (top of the screen) to 23 (bottom of the screen) and columns from 0 (left-hand side of the screen) to 79 (right-hand side of the screen). For example, "WINDOW 0,0,23,79" defines a window which is the size of the entire screen. If the user attempts to define a nonsense window (for instance, LR row less than UL row). BASIC-180 will set a default window size.

Once a window is defined and selected, all console output will go to that window until another window is selected. BASIC-180 will prevent access to any part of the screen outside of the borders of the window.

Example:

```
10 WSELECT 0            !Always select a window first
20 WINDOW 5,20,10,40
30 PRINT "HELLO"
```

9.6.39. WPOKE <expr1>,<expr2>

WPOKE acts like a 16-bit POKE. It places the value of <expr2>, which must be from 0 to 65535, into memory location <expr1>.

USE WITH CAUTION!

The following program places 1234 at $8700.

```
10 INTEGER K
20 WPOKE $8700,1234
30 STOP
```

On HD64180 systems, WPOKE places the data in the segment specified by the DEFMAP statement. The physical address is formed as follows:

Physical address = (WPOKE address) AND 0FFF+ (DEFMAP address) * 2 12

The address supplied to WPOKE <u>must</u> be less than $1000 (2 12) or BASIC-180 will AND it with $0FFF. Careful selection of a DEFMAP value will let you access any location in physical memory.

If DEFMAP is set to -1, no address translation takes place. The complete 16-bit address supplied to WPOKE will be used as a logical address in the HD64180's current map.

9.6.40. WSAVE <integer array>

WSAVE is used to save the contents of the currently-selected window to an integer variable array. This feature, coupled with WUPDATE, which restores a window from an array, allows the user to generate pop-up menus and save windows to disk.

WSAVE requires an integer array as an argument. Strings may not be used. In BASIC-180, arrays must be specified with an argument, so generally it is best to specify the array with a subscript of 1 (e.g. T(1)).

WSAVE saves all printable characters found in the specified window to the array. The first word (2 bytes) will contain the number of characters saved. The characters will then be packed two to a word into the array. A carriage return will be saved after the rightmost character in each line. Remember, spaces are characters, too. The array should, therefore, be dimensioned (using the INTEGER statement) to: (the number of expected characters divided by 2) + 1 + the number of rows.

CAUTION:	BASIC-180, in the interest of speed, does not check for subscript overflow while filling the array during WSAVE, so it is a good idea to make the array a little on the large size. An array size of 1000 will permit saving an entire 80x24 screen.

Example:

```
10 INTEGER T(1000)
20 WSELECT 1
30 WINDOW 10,10,20,20
40 WFRAME "_", "|"
50 WAIT 500
60 WSAVE T(1)
70 ERASE
80 WUPDATE T(1)
90 WAIT 500
```

9.6.41. WSELECT <window number>

WSELECT is used to enable the windowing system and to specify which of up to 10 windows is to be used. The argument is an integer from 0 to 9 which specifies the window number. If this argument is more than 9 then windows will be turned off for that task. To disable windowing altogether, WSELECT a <window number> greater than 10.

WSELECT must be issued before any other windowing statements are executed. If a selection is not made, BASIC-180 will ignore the windowing statements.

```
10 WSELECT 0              ! Always select a window first.
20 WINDOW 5,20,10,40
30 PRINT "HELLO"
```

9.6.42. WUPDATE <integer array>

WUPDATE is the converse of WSAVE. It redraws the entire window and its contents from <integer array>, which must have been saved using a WSAVE statement.

As in WSAVE, the argument must be an integer array, and should be specified as, for example, T(1).

```
10 INTEGER T(1000)
20 WSELECT 1
30 WINDOW 10,10,20,20
40 WFRAME "_", "|"
50 WAIT 500
60 WSAVE T(1)
70 ERASE
80 WUPDATE T(1)
90 WAIT 500
```

9.7. Functions and User-Defined Functions

Functions are called by referencing them in an expression. In BASIC-180, each function returns an INTEGER, REAL, or STRING argument. These are the BASIC-180 functions.

ACOS	COS	RND
ASC	EXP	SIN
ASIN	GET	SQR
ATAN	HST	STR$
BAND	KEY	TAN
BOR	LEN	TBLRD
BXOR	LOG	VAL
CHR$	MID$	WPEEK
CONCAT$	PEEK	

Figure 9.14
Functions

9.7.1. ACOS(<expr>)

REAL
Calculates the arccosine of <expr>, and returns this value in degrees.

9.7.2. ASC(<sexpr>)

INTEGER
Returns the ASCII equivalent of the first character in the string <sexpr>. ASC is the converse of CHR$.

9.7.3. ASIN(<expr>)

REAL
Calculates the arcsine of <expr>, which is returned in degrees.

9.7.4. ATAN(<expr>)

REAL
Calculates the arctangent of <expr> and returns this value in degrees.

9.7.5. BAND(<expr1>,<expr2>)

INTEGER
Logically ANDs <expr1> and <expr2> as 16-bit integers. A bitwise AND is performed. Each of the 16 bits is individually ANDed.

9.7.6. BOR(<expr1>,<expr2>)

INTEGER
Logically ORs <expr1> and <expr2> as 16-bit integers. A bitwise OR is done. Each bit is individually ORed.

9.7.7. BXOR(<expr1>,<expr2>)

INTEGER
Logical XORs <expr1> and <expr2> as 16-bit integers. A bitwise XOR is done.

9.7.8. CHR$(<expr>)

STRING
Returns a one-character equivalent to the integer <expr>. <Expr> must be between 1 and 255. CHR$ is the converse of ASC.

9.7.9. CONCAT$(<sexpr1>,<sexpr2>)

STRING
Concatenates two strings into one string; <sexpr2> is appended after <sexpr1>.

9.7.10. COS(<expr>)

REAL
Calculates the cosine of <expr>, which must be in degrees.

9.7.11. EXP(<expr>)

REAL
Computes e<expr>. A number can be raised to another power (i.e., x Y) by using: EXP(LOG(X)*Y).

9.7.12. GET

INTEGER
Returns one character from the current file. INPUT and INPUT$ read an ASCII line terminated by a carriage return, so they can't read binary files. Since GET only reads single characters, it can read binary files.

9.7.13. HST(<expr>)

UNSIGNED INTEGER
HST provides access to Historical data records. When <expr> is a number less than the maximum possible sample number (eg, 61648), it specifies the sample record number to retrieve. Each sample record consists several values returned in 4 word sized values. Each request for a given sample record will return the next word of the sample. The formats of the four

words is shown below. If <expr> changes in value (ie, indicates a new sample record is being accessed), the first word of the new sample record will be returned. Subsequent accesses to that same sample record will return the second, third and fourth words in order.

If <expr> equals -1, the function will return the index number

If <expr> equals -2, the function will return the index of the top sample (latest or most recently recorded sample).

If <expr> equals -3, the function will return the index of the end sample (oldest recorded sample or end of memory).

If <expr> equals -4, the function will return the word number (0-3) which was returned on the last access to the current sample.

If <expr> equals -5, the function will return the maximum sample index (indicates memory size).

If <expr> equals -6, the function will decrement the sample index and return the same word (eg, contents of the current word number) from the previous sample. This allows easy searching of samples for matching criteria.

Example:

```
100 S= HST(-2)      ;GET INDEX OF LATEST SAMPLE
110 V(1)= HST(S)    ;GET 1ST WORD OF SAMPLE
120 V(2)= HST(S)    ;GET 2ND WORD OF SAMPLE
130 V(3)= HST(S)    ;GET 3RD WORD OF SAMPLE
140 V(4)= HST(S)    ;GET 4TH WORD OF SAMPLE
.
.
160 S=S-1
170 V(1)= HST(S)    ;GET 1ST WORD OF PREVIOUS SAMPLE
```

	HI BYTE (8 BITS)	/	LO BYTE (8 BITS)
1st word-	POINT	/	STATION
2nd word-	DP+DAY	/	MONTH+TYPE
3rd word-	TIME STAMP		(HR, MIN, SEC)
4th word	DATA VALUE		

Figure 9.15
HST WORD Formats

DP field	bits 7-6	=	DP
DAY field	bits 0-5	=	DAY
TIME STAMP	bits 15 - 11	=	HR
	bits 10 - 5	=	MIN
	bits 4 - 0	=	SEC/2
TYPE Field:	bit 7	=	TotalVal flag
	bit 6	=	Dig/Anl flag,
	bit 5	=	CurVal/MaxMin flag
	bit 4	=	Max/Min flag.
	bits 3-0	=	month.

Figure 9.16
HST WORD Field Formats

9.7.14. KEY

INTEGER
Returns the ASCII value of the character the keyboard currently has ready. KEY returns a 0 if no character is ready. Note that the console is always read regardless of which file number is active. KEY returns an integer representation of the character (i.e., its ASCII value). If a string is needed, convert it using CHR$.

KEY reads the current character from the keyboard and resets the console's UART. Therefore, the following construct will not work since when the second KEY is executed, the character is already gone (having been read by the first KEY):

```
10 IF KEY=0 THEN 10
20 PRINT CHR$(KEY)          ;This program won't work correctly.
30 GOTO 10
```

Instead, set a variable equal to KEY and test and print the variable, as in the following example.

```
10 INTEGER L
20 L=KEY
30 IF L=0 THEN 20
40 PRINT CHR$(L)
50 GOTO 20
```

9.7.15. LEN(<sexpr>)

INTEGER
Returns the length of the string argument <sexpr>.

9.7.16. LOG(<expr>)

REAL
Calculates the natural logarithm (base e) of <expr>.

> Note: to calculate LOG base 10 of a REAL number use the following function:

```
10 REAL LG10,N
20 REM This function returns the log base 10 of (N)
30 DEF LG10(N)
40 LG10=LOG(N)/LOG(10.)
50 FNEND
```

In general, the LOG base B of a number N can be calculated by the expression "LOG(N)/LOG(B)" where B and N are both real numbers.

9.7.17. MID$(<sexpr>,<expr1>,<expr2>)

STRING
Returns <expr2> characters of <sexpr> starting at character <expr1>.

9.7.18. PEEK(<expr>)

INTEGER
Returns the 8-bit contents of memory address <expr>.

```
10 POKE $80,1
20 PRINT PEEK($80)
```

On HD64180 systems, PEEK places the data in the segment specified by the DEFMAP statement. The physical address is formed by:

Physical address=(PEEK address) + (DEFMAP address) * 2 12

The addresses supplied to PEEK <u>must</u> be less than $1000 (2 12) or BASIC-180 will AND it with $0FFF. Careful selection of a DEFMAP value will let you access anywhere in physical memory.

If DEFMAP is set to -1, no address translation takes place. The 16-bit address supplied to POKE will be used as a logical address in the HD64180's current map.

9.7.19. RND

INTEGER
Generates a pseudorandom number between -32,767 and 32, 767. It's a good idea to reseed the random number generator at the start of your program by executing the RANDOMIZE statement.

9.7.20. SIN(<expr>)

REAL
Calculates the sine of <expr>, which must be in degrees.

9.7.21. SQR(<expr>)

REAL
Calculates the square root of <expr>.

9.7.22. STR$(<expr>)

STRING
Converts the number given as its argument, <expr>, to a string. STR$ is the converse of VAL.

9.7.23. TBLRD(<expr>)

INTEGER
Allows access to Real Time System Data Tables. (Also see procedure TBLRD in section 9.6.33)

The variable <expr> is the source register (or address) in Table 1 or Table 2.

See 9.6.33.1 for Calculating the BASIC address "WORD"

> Note: If the source address is in Table 1 and it is designated as a digital point, then only the lower byte will be returned.

Example: Read Current Value of seven (7) Table 1 Points from 20 to 26

```
10 INTEGER I, V(6)
20 FOR I= 0 TO 6
30 V(I)=TBLRD(I+20)
40 PRINT V(I) 'for debug
50 NEXT I
```

Example: Read Table 2, Line 3, Reg 2 into variable V

```
100 INTEGER T2,LX,ROW,REG,V
110 T2=$8000 : LX=$100
120 ROW=3 * LX
130 REG=2
140 V=TBLRD(T2 + ROW + REG)
150 PRINT V
```

Example: Read Absolute register 2, (Table 2) into variable X

```
100 INTEGER T2ABS,REG,X
110 T2ABS=$E000 : REG=2
120 X = TBLRD(T2ABS + REG)
130 PRINT X
```

9.7.24. TAN(<expr>)

REAL
Calculates the tangent of <expr>, which must be in degrees.

9.7.25. VAL(<sexpr>)

REAL
Returns the numeric value of the number at the beginning of the string expression given as VAL's argument. VAL is the converse of STR$.

9.7.26. WPEEK(<expr>)

INTEGER
Returns the 16-bit contents of memory address <expr>.

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I acknowledge reading and understand the terms of this agreement.

Signature	Date
Please Print Name	Serial Number

APPENDIX E

Ground-Water Discharge Monitoring Log

Water Discharge Monitoring Log Database, 96-20 222nd Street, Queens Village, New York

WATER DISCHARGE MONITORING LOG DATABASE							
		Totalizer	Total	Flow Rate			
		Reading	Flow	(gallons	Cease	Commence	
Date	Time	(gallons)	(gallons)	per minute)	Discharge	Discharge	Comments

APPENDIX F

Permits

DEP

New York City
Department of
Environmental
Protection

Bureau of
Water Supply
and Wastewater
Collection

59-17 Junction Blvd.
Corona, New York
11368
718 · 595 · 5330

RT F. APPLETON
Commissioner

Deputy Commissioner

August 27, 1993

Karen A. Fay, P.E.
Remedial Engineering, P.C.
1377 Motor Parkway
Suite 403
Islandia, New York 11788

Re: Dewatering Permit; 96-20 222nd Street; Queens Village, Borough of Queens

Dear Ms. Fay:

This is in response to your August 1993 letter requesting permission to discharge approximately 57,600 gallons per day of groundwater continuously for a 12-month period, to the sanitary sewer at 96-20 222nd Street in Queens.

Based upon the information, schematic and analytical data submitted, you are hereby authorized to discharge up to 57,600 gpd of groundwater as specified in your submission, over a period of 12 months, starting immediately, to the sanitary sewer at the above mentioned location, as shown on the Abatement I Site Plan Sketch.

This discharge will be by gravity flow through an existing house connection to the 42" sanitary sewer in 222nd Street. In addition a flow meter with a Recorder Register as located on the Site Plan Sketch shall be installed.

Program Development Section approval for this groundwater discharge has been granted by letter dated August 25, 1993.

The discharger shall indemnify and hold the City harmless for any damage or liability incurred by the City in the event that the discharger results in overloading the capacity of the discharge sewer. See copy of proposed Indemnify Agreement attached to be signed and filed with the discharge application.

If you have any further questions concerning this matter, please telephone Mr. Irving Ganz, P.E., at (718) 595-5192.

Very truly yours,

Magdi Farag

MAGDI FARAG, P.E., CHIEF
Division of Sewer Regulation
and Control

Special Indemnity
Agreement (Present Date)

Albert F. Appleton
New York City Department of
Environmental Protection
59-17 Junction Boulevard
Elmhurst, NY 11373

Re: Dewatering Permit

Dear Commissioner Appleton:

New York City Transit Authority hereby agrees to indemnify and to save harmless, to the fullest extent permitted by law, the City of New York, the New York City Water Board, and the New York City Municipal Water Finance Authority (hereinafter referred to collectively as the "City") and their respective officers, representatives, agencies, contractors, servants, and employees from and against any and all claims, suits, actions, proceedings, and loses that may arise after the date of this agreement from the construction, maintenance, operation, or use of any sewer connection to the City Sewer System.

Very truly yours,

August 25, 1993

Mr. Ron Lattanzio, President
Inspeco Consultants
11-17 Grand Street
New York , N.Y. 10013

Re: Pfizer Inc.
File Case #1875

Dear Mr. Lattanzio:

This is in response to your August 13, 1993 letter, requesting permission to discharge approximately 57,600 gallons per day (gpd) of groundwater continuously for a 12- month period, to the sanitary sewer at 96-20 222nd Street in Queens.

Based upon the information, schematic and analytical data submitted, you are hereby conditionally authorized to discharge up to 57,600 gpd of groundwater as specified in you submission, over a period of 12 months, starting immediately, to the sanitary sewer at the above mentioned location.

This conditional approval, however, is subject to you obtaining a groundwater discharge permit from the Division of Sewer Regulation and Control.

In addition you must submit groundwater analytical results for the recovery well every month, accompanied by chain of custody, to include pH, total petroleum hydrocarbons, oil and grease and heavy metals (cadmium, chromium hexavalent, copper, cyanide amenable, lead mercury nickel and zinc.) If any of the analytical results exceed a limit in the sewer use regulations, you must immediately cease discharge.

If you have andy further questions concerning this matter, please telephone Mr. Peter Garofalis, Project Coordinator. at 718-595-4943.

Sincerely,

Vincent Sapienza

VINCENT SAPIENZA, P.E., CHIEF
Program Development Section

cc: Grande
Farag / Ganz
Sapienza / Garofalis
File C-1875

PG/ta

#595-5/93

THIS PERMIT MUST BE IN POSSESSION OF PLUMBER

THE CITY OF NEW YORK

BUREAU OF WATER REGISTER BOROUGH OF [illegible]

Nº 62502 $200

[illegible] SEWER PERMIT

CONNECTION

Date [illegible]

PLUG OR NEW SEWER HOUSE CONNECTION

[illegible] Two Hundred Dollars,

receipt of which is acknowledged, PERMISSION IS HEREBY GIVEN to

(Name) [illegible]

(Address) [illegible] Ave

who is licensed to perform such works, to PLUG OR INSTALL A NEW

( ) SANITARY ( ) STORM ( ) COMBINED SEWER HOUSE CONNECTION

to the premises located at 96-30 [illegible]

(House Number and Street Name)

known as BLOCK 10729 LOT NO. 114

The permittee named herein shall indemnify and hold harmless the City of New York against any and all claims which may arise from the performance of the work covered by this permit.

This permit is issued subject to the strict observance of all laws, rules and regulations enacted for the protection of the City so far as they may apply and is subject to revocation at any time by the Commissioner, or in the event of failure of the permittee to comply with any of the terms or conditions upon which the same is granted.

It is understood and agreed that the work proposed shall be executed in a good and workmanlike manner and to the satisfaction of the Commissioner, in accordance with the provisions of the Administrative Code of the City of New York and any appropriate [illegible], and any applicable rules and regulations.

For Bureau of Water Register

ALBERT F. APPLETON, COMMISSIONER
DEPT. OF ENVIRONMENTAL PROTECTION

Permits are issued only to licensed [illegible] and payment made [illegible]

This is NOT A PERMIT TO OPEN THE STREET OR SIDEWALK

JUN 02 '94 09:16 JRF FILING SVC 718 649 3453

FORM NO.

THE CITY OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF SEWERS
APPLICATION FOR PERMIT

NATURE OF DISCHARGE INSTALLATION: De Watering Plant — TO INSTALL AND SET METER(S) FOR DISCHARGE(S) OF GROUNDWATER INTO CITY SEWER SYSTEM AND TO INSTALL SINGLE/MULTIPLE SEWER CONNECTION(S).

BOROUGH OF: Queens BUILDING DEPT. NO.(S): N/A

LOCATION: 96-20 222 Street TAX BLOCK NO.: 10779

TAX LOT NO.(S): 114

1. PLAN

Sketch Attached

[illegible stamp: This permit is valid for thirty ...]

ALL DRAINS TO BE GRAVITY LINES ONLY

2. a) BUILDING USE:

b) NO & SIZE OF CONNECTION REQUIRED: 1-2"

3. DEP APPROVAL LETTER DATE: 4/19/94 (copy letter 8/27/93)

c) LOCATION: 96-20 222 Street

d) ALLOWABLE DISCHARGE: 51,600 gallons per day

4. PROJECTED DURATION OF PROJECT: As per letter 8/27/93 for 12 months

It is understood and agreed that the work proposed shall be executed in a good and workman-like manner and to the satisfaction of the Commissioner, in accordance with the provisions of the Administrative Code of The City of New York and any amendments thereto, and any applicable rules and regulations.

NAME OF THE LICENSED PLUMBER (print): John Moreno

SIGNATURE OF THE LICENSED PLUMBER: [signature]

ADDRESS OF THE LICENSED PLUMBER: 1833 McDonald Ave Brooklyn NY

Plumber's License Number: 11885

BUREAU OF SEWERS
comments and approval stamp

DATE: 5/26/94

	UNIT COUNT	FEE PER UNIT	PERMIT FEE
CONNECTIONS	1	$200.00	$200.00
METERS			

TOTAL PERMIT FEE $

CITY OF NEW YORK DEPT. OF ENV. PROT. BUREAU OF ... PERMIT ... M.C. DATE 06-2?-94

PAID

NOTE: APPROVAL VALID FOR ONE (1) YEAR

FILL IN PERMIT NUMBERS ABOVE
DATE: 6/2/94 CHECK FORM FEE PAID CLERK [signature]

THIS PERMIT MUST BE IN POSSESSION OF PLUMBER

THE CITY OF NEW YORK

BUREAU OF WATER REGISTER BOROUGH OF [illegible]

№ 62482 $200

SEWER PERMIT

DOMESTIC SPRINKLER/ DOM

Date 5-23-94

PLUG OR NEW SEWER HOUSE CONNECTION

This permit is valid for thirty (30) days

In consideration of 200 HUNDRED Dollars,

receipt of which is acknowledged, PERMISSION IS HEREBY GIVEN to

(Name) John Morano

(Address) 23-32 McDonald Ave

who is licensed to perform such work to PLUG OR INSTALL A NEW

(X) SANITARY ( ) STORM ( ) COMBINED SEWER HOUSE CONNECTION

to the premises located at 96-20 230th St

(House Number and Street Name)

known as BLOCK 10709 LOT NO. 114

The permittee named herein shall indemnify and hold harmless the City of New York against any and all claims which may arise from the performance of the work covered by this permit.

This permit is issued subject to the strict observance of all laws, rules and regulations enacted for the protection of the City so far as they may apply and is subject to revocation at any time by the Commissioner, on the event of failure of the permittee to comply with any of the terms or conditions upon which the same is granted.

It is understood and agreed that the work proposed shall be executed in a good and workmanlike manner to the satisfaction of the Commissioner, in accordance with the provisions of the Administrative Code of the City of New York and any amendments thereto, and any applicable rules and regulations.

Permits are issued only in Bureau of Water Register and payment made in Cashier's Office.

APPLETON, COMMISSIONER
DEPT. OF ENVIRONMENTAL PROTECTION

Per Bureau of Water Register

B.F. 538-10M [illegible]-730059-1(82) 346

THIS IS NOT A PERMIT TO OPEN THE STREET OR SIDEWALK

W.R.124-5M-707115(75) 346

SEC.	BLOCK	LOT	VOLUME	FOLIO	PERMIT NO.
	10789	282			93912 № ~~91385~~

NOTE: REMOTE RECEPTACLES ARE REQUIRED FOR ALL NEW METER INSTALLATIONS.

PERMIT TO SET METER

NEW YORK

DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF WATER REGISTER

THIS PERMIT TO BE RETURNED TO OFFICE WHERE ISSUED

3/11 1994

Permission is hereby given Matthew Castillo

To set 1" inch Water Meter No

In premises 96-20 222 nd Street

To cover:

Meter Location: Driveway

Owner's Name Address

~~Meter on inlet or outlet~~ — place draw cock on outlet within six feet—for testing purposes.

Subject to the rules and regulations on front and reverse side hereof.

TEST

ALBERT F. APPLETON, COMMISSIONER

DEPT. OF ENVIRONMENTAL PROTECTION

I hereby certify that all connections are proper, and premises metered in accordance with permit.

Date set 19

(Plumber)

(Address)

RETURN OF PERMITS

106. RETURN PERMITS THE DAY FOLLOWING COMPLETION OF WORK WITHIN 30 CALENDAR DAYS.

CHECK

THE CITY OF NEW YORK
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

BOROUGH : QUEENS

PERMIT # : 041-94143-001
RECORDED # : NONE
PREVIOUS # : NONE

STREET OPENING PERMIT
PERMIT VALID FROM 05/23/94 TO 06/22/94

FEES (NON-REFUNDABLE):
ADMIN **135.00

PERMIT TYPE 0114
PAVEMENT TYPE ASPHALT
SIDEWALK TYPE CONCRETE
ISSUE DATE 05/23/94

TOTAL FEE $***135.00 PAID

PERMISSION HEREBY GRANTED TO :
NAME : H & M PLUMBING & HEATING
CONTACT NAME : FRAN RUSSO
PHONE : (718) 645 - 4022
ADDRESS : 2232 MCDONALD AVENUE BROOKLYN NY 11223
PLUMBER (464)

LICENSE # : 11805
PERMITTEE # : 00470
CONTRACT # :

TO OPEN THE ROADWAY AND/OR SIDEWALK AT :
HOUSE # : 96-20
ON STREET : 222 STREET
FROM STREET : JAMAICA AVENUE
TO STREET :

SPECIFIC LOCATION : BET 96-97 AVES

FOR A MAXIMUM LENGTH OF 6 FEET

FOR THE PURPOSE OF : REPAIR SEWER
PLUG SEWER, 1-3X6

ALL WORK MUST ADHERE TO THE FOLLOWING STIPULATIONS : 010 013 023 030

010	EXTENSION	THIS PERMIT MAY BE EXTENDED ONCE ONLY, FOR A PERIOD OF 14 DAYS AT $40. HOWEVER IT MUST BE PRESENTED FOR EXTENSION NO LATER THAN 5 BUS DAYS PRIOR TO EXPIRING.
013	MTCCC	MAINTAIN MINIMUM 5 FOOT CLEAR SIDEWALK
023	MTCCC	MAINTAIN ONE 11 FOOT LANE FOR TRAFFIC
030	MTCCC	WARNING SIGNS AND TRAFFIC SAFETY DEVICES SHALL BE PROVIDED, INSTALLED, MAINTAINED AND REMOVED BY THE PERMITTEE IN ACCORDANCE WITH THE 'NEW YORK STATE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES'.

PERMIT ORIGINALLY PRINTED ON 05/23/94 AT 14:56 BY GEORGE IN QUEENS

PAGE 1 OF 1

PERMITTEES SHALL COMPLY WITH ALL APPLICABLE LAWS, RULES, AND SPECIFICATIONS OF THE CITY OF NEW YORK AND DEPARTMENT OF TRANSPORTATION, AND WITH THE TERMS AND CONDITIONS OF THE PERMIT. FAILURE TO COMPLY MAY RESULT IN REVOCATION OF THE PERMIT BY THE COMMISSIONER.

ELLIOT G. SANDER

PER