OPERATION & MAINTENANCE MANUAL

J & B Mobile Home Park

1340 Highway 82 E
Magnolia, AR 71753

Waste Storage/Land Application - No Discharge Permit

Prepared for:

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I. PROJECT DESCRIPTION

A. Introduction

The J & B Mobile Home Park is located 2.9 miles east of the City of Magnolia, Arkansas on Highway 82. The mobile home park is currently owned by Mr. & Mrs. Jerry Lemley. The mobile home park has a maximum capacity of 44 lots on a total of 30.6 acres. The existing septic tank system is inadequate for the mobile home park, and will be incorporated into the proposed waste storage and land application system. The wastewater to be land applied will consist solely of domestic sewage from the mobile home park. Magnolia Utilities water records for the entire park indicate a typical water usage rate of 5,000 gallons per day or 1.83 million gallons per year.

B. Wastewater Collection, Treatment & Irrigation System

The wastewater generated from the mobile home park will be gravity feed from each of the 4 existing 1,000 gallon septic tanks into the lift station by way of a 6 inch PVC collection line. The750 gallon lift station will pump wastewater into the lagoon pond at a volumetric flow rate of 17 gallons per minute or 24,480 gallons per day with two 2 HP, 3 phase, Myers Model WG20-43 grinder pumps in a duplex arrangement. The lift station control panel will be outfitted with both an audio/visual alarm system and an automatic dialer system which will call the operator when a problem occurs at the lift station requiring the operator's immediate attention. See Appendix 'A' for more information regarding operation of the Myers pumps, recommended maintenance, and troubleshooting.

The two lagoon ponds will have a capacity of 450,000 gallons each allowing for 180 days of combined storage at 5,000 gallons per day, not including the required minimum of 2 foot freeboard. When the water level in the first lagoon pond reaches its maximum height, it will gravity drain through a 4 inch PVC pipe into the second lagoon pond. Upon reaching maximum capacity, the water in the second lagoon will gravity drain through an in-line tablet chlorinator into the holding pond. The tablet chlorinator is a Norweco Bio-Dynamic Model LF2000 capable of chlorinating a maximum of 10,000 gallons per day. See Appendix 'B' for further information in the "Bio-Dynamic Installation and Operation Manual." The holding pond will have a maximum capacity of 311,000 gallons or 60 days, and will also allow for the required minimum 30 minute detention time for the chlorine and wastewater mix. All three ponds will be lined with bentonite clay to prevent seepage. The clay will be blended into the existing soil at an application rate of 3 lbs/ft^2 and compacted. Finally, this layer of blended bentonite clay will be covered with 12 inches of soil and compacted. All side slopes and top of berm will be seeded with grass to prevent erosion. Maintenance of the ponds shall include mowing as required to prevent tall weeds from growing on the sides that would prevent wave action from wind. Additional information regarding operation of the treatment plant, recommended maintenance, and troubleshooting is provided in Appendix 'H' – EPA Operations Manual for Stabilization Ponds.

Two submersible pumps will transfer the effluent from the holding pond directly to the two irrigation heads through 3 inch PVC pipe at a flow rate of 100 gallons per minute each. Each 5 HP, 3 PH, 6 inch diameter submersible Sandhandler pump will supply one irrigation head with 100 GPM, and each

irrigation head will apply effluent to 1 acre of land. More information on the Sandhandler submersible pumps and motors can be found in Appendix 'C'. Downstream of each pump will be a Badger Meter with integral strainer (see Appendix 'D') for measuring volume irrigated for the ADEQ Permit Report submittal. With this submersible pump arrangement and large holding pond capacity, great flexibility can be achieved in irrigation scheduling since irrigation is not allowed when the ground is wet or during freezing conditions. The irrigation pumps will be controlled by a float switch in the holding pond, as well as by a Hunter ProC controller with a Hunter Rain/Freeze-Clik Sensor. The float switch will stop the pumps when the holding pond level reaches a minimum of 2 feet. The submersible pumps and motors must stay submerged at all times. The Hunter rain sensor will shut off the pumps as soon as it starts raining, and will not allow irrigation until the sensor is completely dry. The Hunter freeze sensor will not allow the pumps to operate when temperatures fall below 37^{o}F. Additional information on the Hunter ProC controller and sensor can be found in Appendix 'E'. The two irrigation sprinkler heads are the Nelson Big Gun Model F100. The Sandhandler pump, with its 5 HP motor, will have a design point of 88 GPM at 140 feet of head or 61 psi. This flow rate and pressure will allow each Nelson irrigation head to cover a diameter of 235 feet or an area of 1 acre at a trajectory angle of 24 degrees.

If conditions allow for up to 1 inch of effluent to be applied on the 2 acres of total irrigation area in 1 day, the amount of effluent irrigated will be equal to 54,309 gallons or 10.9 days of discharge from the mobile home park at 5,000 gallons per day. With both irrigation pumps operating at the same time at an average of 88 GPM each, the 1 inch of effluent will be applied in 10.3 hours. The design of this system gives the operator great flexibility in deciding when to irrigate given existing and future weather and site conditions; since 1 day's irrigation event can discharge nearly 11 days' worth of effluent from the mobile home park.

C. Cover Crop

The proposed cover crop for the application site will be a combination of common Bermuda grass and Marshall Ryegrass. The Bermuda grass is a relatively low growth, low maintenance cover that flourishes in the warm spring and summer months of southern Arkansas. Bermuda grass crop yield rates for southern Arkansas can be up to 7 tons per acre according to the "Forage and Pasture/Forage Management Guide/Self Study Guide 3: Bermuda grass" from the University of Arkansas Cooperative Extension Service. Nitrogen uptake rates for common Bermuda grass at a yield rate of 7 tons per acre is estimated to be 300 pounds per acre per year according to the Potash and Phosphate Institute's Plant Food Uptake for Southern Crops and Table 4-11 of the *Process Design Manual for Land Treatment of Municipal Wastewater,* USEPA, October 1981.

During the fall and winter months Marshall Ryegrass is to be seeded in the early fall in preparation of the winter season. If the previous year's crop of ryegrass was allowed to go to seed, the operator may only have to seed every other year to maintain a dense growth of ryegrass during the winter. According to the "Winter Annual Grasses for Livestock in Arkansas" by the University of Arkansas Cooperative Extension Service, the annual ryegrass crop yield rates for southern Arkansas will have an average yield rate of 10,096 pounds per acre or 5 tons per acre. The nitrogen uptake rate for ryegrass is estimated to

be 178 pounds per acre per year according to Table 4-11 of the *Process Design Manual for Land Treatment of Municipal Wastewater,* USEPA, October 1981.

D. Harvesting Method

With the cover crop being common grasses, the 2 acre application area will be regularly mowed with a lawnmower/bush hog or cut for hay. The site should be monitored monthly, with harvesting taking place more frequently as needed to facilitate growth. The irrigation of the effluent to the harvest area should be shut off prior to mowing within an adequate amount of time, depending on the season, to allow for drying of the soil. The irrigation of the effluent should remain shut off until mowing is complete.

II. NO-DISCHARGE PERMIT REQUIREMENTS

The J&B Mobile Home Park wastewater treatment system operates under the authority of the No-Discharge Permit issued by the Arkansas Department of Environmental Quality (ADEQ). Waste shall not be discharged from the facility to waters of the state or onto land in any way that may result in runoff to the waters of the state. Wastewater shall not be allowed to produce runoff that may be discharged in ditches, streams, etc. Bypassing of the disposal system is prohibited and will result in revocation of the permit or other appropriate enforcement action by ADEQ. Any violations of the permit must be reported to ADEQ immediately. The facility shall be operated by qualified personnel and maintained in good operating condition at all times. A State Licensed wastewater treatment plant operator will be responsible for the operation and maintenance of the facilities, including reporting and recordkeeping. See the No-Discharge Permit for the required operator's license classification. Monitoring, reporting, and recordkeeping requirements can be found in the No-Discharge Permit in Appendix 'G'.

APPENDIX 'A'

LIFT STATION

Myers®
Pentair Water

WG20/WGX20 Series

Standard and Hazardous Location
2 HP Submersible Grinder Pumps

WG20 -

WGX20 -

FM Approved

DESIGNED FOR RESIDENTIAL, LIGHT COMMERCIAL & INDUSTRIAL APPLICATIONS

The Myers WG/WGX20 Series are rugged 2 horsepower submersible centrifugal grinder pumps designed for residential, light commercial or industrial applications. It is especially suited for use in pressure sewer applications or in systems with long discharge runs or high static heads. The WG/WGX20 Series features a patented cutter mechanism and recessed impeller design to efficiently grind typical domestic sewage solids into a fine slurry. These pumps are available in standard construction and construction for use in Class 1, Group D hazardous locations.

The WG/WGX20 Series can be installed in a variety of packaged systems. Factory-assembled simplex or duplex packages with guide rail systems or suspended systems are available. Individual rail components are also available for installation in on-site concrete systems. Myers offers a complete line of submersible sump, sewage, effluent, grinder, solids handling wastewater pumps, controls, basins, and accessories. For additional information, please contact your local Myers representative or the Myers Ashland, Ohio sales office at 419-289-1144.

Ideal for use in pressure sewer systems.

- Choice of standard, high flow or high head designs.
- Recessed impeller provides steep non-overloading operating curve.

Durable motor will deliver many years of reliable service.

- Oil-filled motor for maximum heat dissipation and constant bearing lubrication.
- Recessed impeller reduces radial bearing loads, increases bearing life.
- High torque capacitor start/run single phase or three phase motors for assured starting under heavy load.
- Seal leak probes and on-winding heat sensors warn of seal leak condition and stop motor if motor overheats. Helps prevent costly motor damage.

The WG/WGX20 Series is designed for easy maintenance.

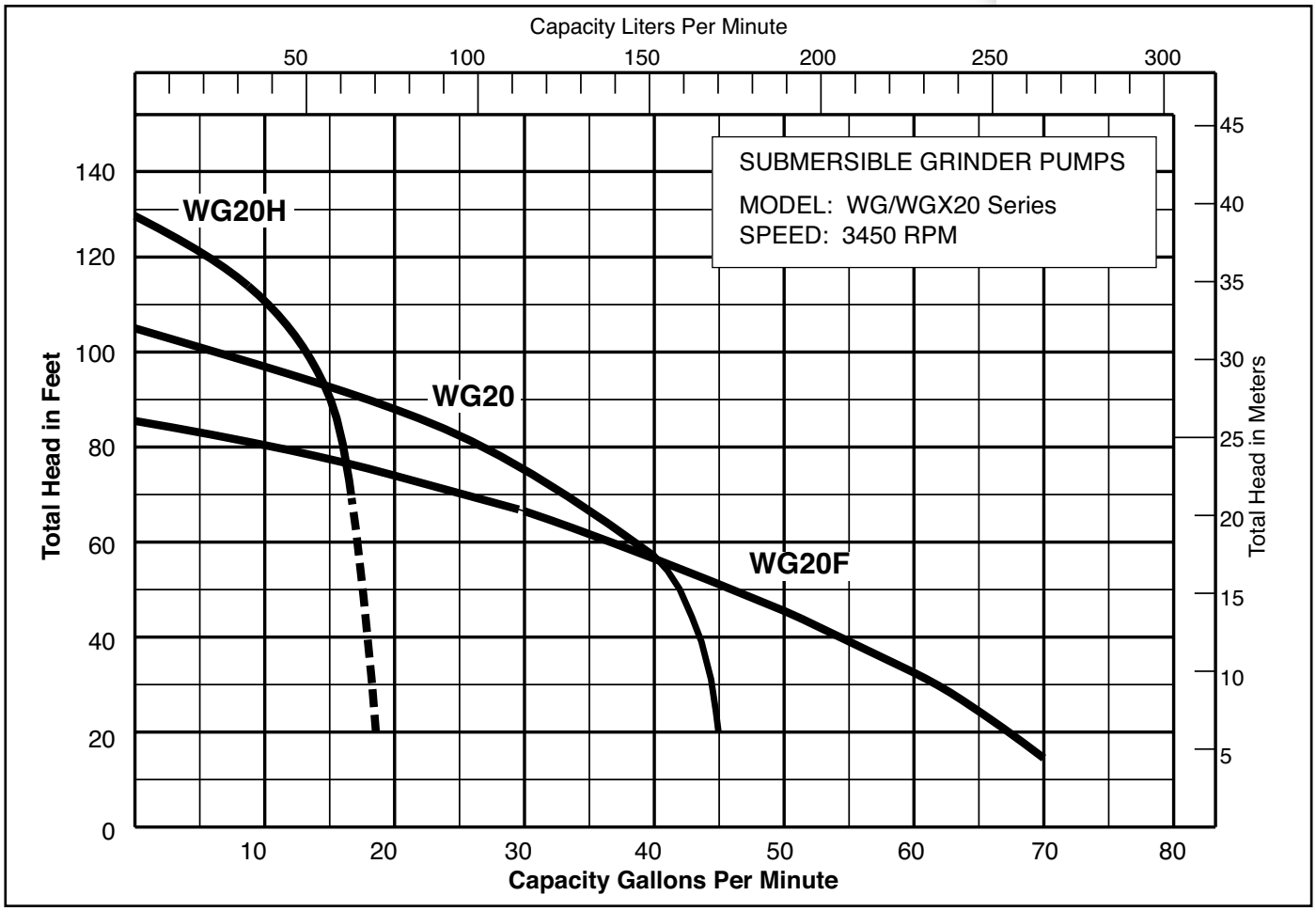
- Shredding ring and grinder impeller are replaceable without dismantling pump or motor.

Product Capabilities		
Capacities To	70 gpm	260 lpm
Heads To	105 ft.	32.1 m
Liquids Handling	domestic raw sewage	
Intermittent Liquid Temp.	up to 140°F	up to 60°C
Winding Insulation Temp. (Class F)	311°F	155°C
Motor Electrical Data (Single phase motors are capacitor start and capacitor run type. Myers control panels or capacitor kits are required for proper operation and warranty.)	2 HP, 3450 RPM 1 ph – capacitor start/run. 208 or 230 volts; 60 Hz 3 ph – induction run 200, 230, 460, 575 volts, 60 Hz	
Third Party Approvals	WG - UL, CSA WGX - CSA, FM	
Acceptable pH Range	6 – 9	
Specific Gravity	.9 – 1.1	
Viscosity	28 – 35 SSU	
Discharge, NPT	1¼ in.	31.75 mm
Min. Sump Dia. (Simplex) (Duplex)	24 in. 36 in.	61.0 cm 91.4 c

NOTE: Consult factory for applications outside of these recommendations.

Construction Materials	
Motor Housing, Seal Housing, Cord Cap and Volute Case	cast iron, Class 30, ASTM A48
Impeller	recessed, bronze
Power and Control Cord	SOOW
Mechanical Seals Standard Optional	 dbl. tandem carbon & ceramic lower tungsten carbide
Pump, Motor Shaft	416 SST
Fasteners	300 series SST
Shredding Ring Grinder Impeller	440 SST, 58-60 Rockwell

3450 RPM PERFORMANCE CURVE



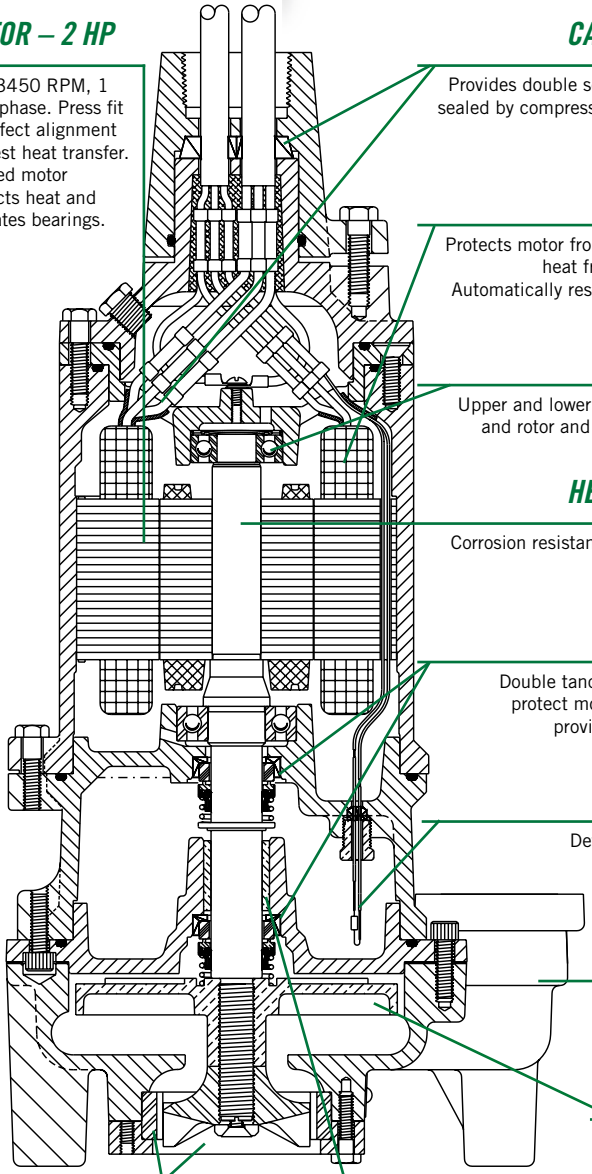
Available Models		Motor Electrical Data										
Standard	Hazardous Location	HP	Volts	Phase	Hertz	Start Amps	Run Amps	Run KW	Start KVA	Run KVA	NEC Code Letter	Service Factor
WG20-01	WGX20-01	2	200	1	60	50.0	15.0	2.8	10.0	3.0	F	1.25
WG20-21	WGX20-21	2	230	1	60	44.0	12.5	2.8	10.1	2.8	F	1.25
WG20-03	WGX20-03	2	200	3	60	30.0	9.5	2.9	10.4	3.3	F	1.25
WG20-23	WGX20-23	2	230	3	60	27.5	8.4	2.9	11.0	3.3	F	1.25
WG20-43	WGX20-43	2	460	3	60	13.8	4.2	2.9	11.0	3.3	F	1.25
WG20-53	WGX20-53	2	575	3	60	11.0	3.4	2.9	11.0	3.3	F	1.25
WG20F-01	WGX20F-01	2	200	1	60	50.0	15.0	2.8	10.0	3.0	F	1.25
WG20F-21	WGX20F-21	2	230	1	60	44.0	12.5	2.8	10.1	2.8	F	1.25
WG20F-03	WGX20F-03	2	200	3	60	30.0	9.5	2.9	10.4	3.3	F	1.25
WG20F-23	WGX20F-23	2	230	3	60	27.5	8.4	2.9	11.0	3.3	F	1.25
WG20F-43	WGX20F-43	2	460	3	60	13.8	4.2	2.9	11.0	3.3	F	1.25
WG20F-53	WGX20F-53	2	575	3	60	11.0	3.4	2.9	11.0	3.3	F	1.25
WG20H-21	WGX20H-21	2	230	1	60	44.0	12.0	2.8	10.1	2.8	F	1.25

ADVANTAGES BY DESIGN

Myers®
Pentair Water

STATOR – 2 HP

2 hp, 3450 RPM, 1 and 3 phase. Press fit for perfect alignment and best heat transfer. Oil-filled motor conducts heat and lubricates bearings.



CABLE ENTRY SYSTEM

Provides double seal protection. Cable jacket sealed by compression fitting. Individual wires sealed by epoxy potting.

HEAT SENSOR

Protects motor from burnout due to excessive heat from any overload condition. Automatically resets when motor has cooled.

BALL BEARINGS

Upper and lower ball bearings support shaft and rotor and take axial and radial loads.

HEAVY 416 SST SHAFT

Corrosion resistant. Reduces shaft deflection due to grinding loads.

SHAFT SEALS

Double tandem mechanical shaft seals protect motor. Oil-filled seal chamber provides continuous lubrication.

SEAL LEAK PROBE

Detects water in seal housing, activates warning light in control panel.

VOLUTE CASE

Cast iron 1¼" NPT vertical discharge.

IMPELLER

Bronze recessed impeller handles ground slurry without clogging or binding. Provides unobstructed flow passage. Reduces radial loads. Pump-out vanes help keep trash from seal, reduces pressure at seal faces.

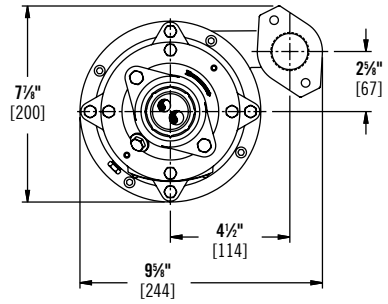
GRINDER ASSEMBLY

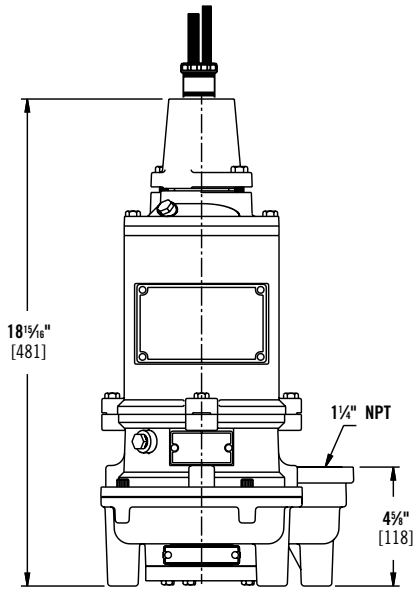
Grinder impeller and shredding ring are replaceable without dismantling pump. Constructed of 440 SST hardened to 56-60 Rockwell.

SLEEVE BEARING

Takes radial load; provides flame path.

DIMENSIONS [Dimensions in mm]





NOTE: Myers reserves the right to make revisions to its products and their specifications, and to this brochure and related information, without notice.

Pentair Water™

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SENSAPHONE®

Sensaphone 1400 User's Manual

SENSAPHONE®

1400

Environmental Monitoring System

User's Manual

Version 1.24

Every effort has been made to ensure that the information in this document is complete, accurate and up-to-date. Phonetics, Inc. assumes no responsibility for the results of errors beyond its control. Phonetics, Inc. also cannot guarantee that changes in equipment made by other manufacturers, and referred to in this manual, will not affect the applicability of the information in this manual.

First Edition, version 1.24, October, 2011

Written and produced by Phonetics, Inc.

Please address comments on this publication to:

Phonetics, Inc.
901 Tryens Road
Aston, PA 19014

Important Safety Instructions

Your Sensaphone 1400 has been carefully designed to give you years of safe, reliable performance. As with all electrical equipment, however, there are a few basic precautions you should take to avoid hurting yourself or damaging the unit:

- Read the installation and operating instructions in this manual carefully. Be sure to save it for future reference.
- Read and follow all warning and instruction labels on the product itself.
- To protect the Sensaphone 1400 from overheating, make sure all openings on the unit are not blocked. Do not place on or near a heat source, such as a radiator or heat register.
- Do not use your Sensaphone 1400 near water, or spill liquid of any kind into it.
- Be certain that your power source matches the rating listed on the AC power transformer. If you're not sure of the type of power supply to your facility, consult your dealer or local power company.
- Do not allow anything to rest on the power cord. Do not locate this product where the cord will be abused by persons walking on it.
- Do not overload wall outlets and extension cords, as this can result in the risk of fire or electric shock.
- Never push objects of any kind into this product through ventilation holes as they may touch dangerous voltage points or short out parts that could result in a risk of fire or electric shock.
- To reduce the risk of electric shock, do not disassemble this product, but return it to Sensaphone Customer Service or another approved repair facility when any service or repair work is required. Opening or removing covers may expose you to dangerous voltages or other risks. Incorrect reassembly can cause electric shock when the unit is subsequently used.
- If anything happens that indicates that your Sensaphone 1400 is not working properly or has been damaged, unplug it immediately and follow the procedures in the manual for having it serviced. Return the unit for servicing under the following conditions:
    1. The power cord or plug is frayed or damaged.
    2. Liquid has been spilled into the product or it has been exposed to water.
    3. The unit has been dropped, or the enclosure is damaged.
    4. The unit doesn't function normally when you're following the operating instructions.
- Avoid using a telephone (other than a cordless type) during an electrical storm. There may be a remote risk of electric shock from lightning.

- Do not use the telephone to report a gas leak in the vicinity of the leak.

CAUTION: To reduce the risk of fire or injury to persons, read and follow these instructions:

1. Replace the battery only with the same or equivalent type recommended by the manufacturer.
2. Do not dispose of the battery in a fire. The cell may explode. Check with local codes for possible special disposal instructions.
3. Do not open or mutilate the battery. Released electrolyte is corrosive and may cause damage to the eyes or skin. It may be toxic if swallowed.
4. Exercise care in handling battery in order not to short the battery with conducting materials such as rings, bracelets, and keys. The battery or conductor may overheat and cause burns.

FCC Requirements

Part 68: The Sensaphone 1400 complies with 47 CFR, Part 68 of the rules. On the back of the unit there is a label that contains, among other information, the Certification Number and the Ringer Equivalence Number (REN) for this equipment. You must, upon request, provide this information to your local telephone company.

The REN is useful to determine the quantity of devices that you may connect to your telephone line and still have all of those devices ring when your telephone number is called. In most, but not all areas, the sum of the REN's of all devices connected to one line should not exceed five (5.0). To be certain of the number of devices that you may connect to your line, you may want to contact your local telephone company to determine the maximum REN for your calling area.

The applicable certification jack USOC for this equipment is: RJ11C. The facility interface code (FIC) for this equipment is: 02LS2.

A compliant telephone cord and modular plug are provided with equipment. This equipment is designated to be connected to the telephone network or premises wiring using a compatible modular jack which is Part 68 compliant. See Installation Instructions for details.

This equipment may not be used on coin service units provided by the telephone company. Connection to party lines is subject to state tariffs. Contact the state public utility commission, public service commission or corporation commission for information.

Should the 1400 cause harm to the telephone network, the telephone company may discontinue your service temporarily. If possible, they will notify you in advance. But if advance notice isn't practical, the telephone company may temporarily discontinue service without notice and you will be notified as soon as possible. You will be informed of your right to file a complaint with the FCC. The telephone company may make changes in its facilities, equipment, operations, or procedures where such action is reasonably required in the operation of its business and is not inconsistent with the rules and regulations of the FCC that could affect the proper functioning of your equimenpt. If they do, you will be notified in advance to give you an opportunity to maintain uninterrupted telephone service.

If you experience trouble with the 1400, or you need information on obtaining service or repairs, please contact:

Phonetics, Inc.

901 Tryens Road

Aston, PA 19014

Toll-Free: 1-877-373-2700

FAX: 610-558-0222

If the equipment is causing harm to the telephone network, the telephone company may ask that you disconnect this equipment from the network until the problem has been corrected or until you are sure that the equipment is not malfunctioning.

Part 15: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

General Requirements for all Automatic Dialers

When programming emergency numbers and (or) making test calls to emergency numbers:

1. Remain on the line and briefly explain to the dispatcher the reason for the call.
2. Perform such activities in the off-peak hours, such as early morning or late evenings.

Canadian Department of Communications Statement

Notice: The Canadian Department of Communications label identifies certified equipment. This certification means that the equipment meets certain telecommunications network protective operational and safety requirements. The Department does not guarantee the equipment will operate to the user's satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. In some cases, the company's inside wiring associated with a single line individual service may be extended by means of a certified connector assembly (telephone extension cord). The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs to certified equipment should be made by an authorized Canadian maintenance facility designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas.

> **CAUTION**: Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate.

The Ringer Equivalence Number (REN) assigned to each terminal device denotes the percentage of the total load to be connected to a telephone loop which is used by the device to prevent overloading. The termination on a loop may consist of any combination of devices subject only to the requirement that the total of the Ringer Equivalent Numbers of all the devices does not exceed 5.0. For Sensaphone 1400, the AC Ringer Equivalent Number is 0.6B.

2 YEAR LIMITED WARRANTY

PLEASE READ THIS WARRANTY CAREFULLY BEFORE USING THE PRODUCT.

THIS LIMITED WARRANTY CONTAINS SENSAPHONE'S STANDARD TERMS AND CONDITIONS. WHERE PERMITTED BY THE APPLICABLE LAW, BY KEEPING YOUR SENSAPHONE PRODUCT BEYOND THIRTY (30) DAYS AFTER THE DATE OF DELIVERY, YOU FULLY ACCEPT THE TERMS AND CONDITIONS SET FORTH IN THIS LIMITED WARRANTY.

IN ADDITION, WHERE PERMITTED BY THE APPLICABLE LAW, YOUR INSTALLATION AND/OR USE OF THE PRODUCT CONSTITUTES FULL ACCEPTANCE OF THE TERMS AND CONDITIONS OF THIS LIMITED WARRANTY (HEREINAFTER REFERRED TO AS "LIMITED WARRANTY OR WARRANTY"). IF YOU DO NOT AGREE TO THE TERMS AND CONDITIONS OF THIS WARRANTY, INCLUDING ANY LIMITATIONS OF WARRANTY, INDEMNIFICATION TERMS OR LIMITATION OF LIABILITY, THEN YOU SHOULD NOT USE THE PRODUCT AND SHOULD RETURN IT TO THE SELLER FOR A REFUND OF THE PURCHASE PRICE. THE LAW MAY VARY BY JURISDICTION AS TO THE APPLICABILITY OF YOUR INSTALLATION OR USE ACTUALLY CONSTITUTING ACCEPTANCE OF THE TERMS AND CONDITIONS HEREIN AND AS TO THE APPLICABILITY OF ANY LIMITATION OF WARRANTY, INDEMNIFICATION TERMS OR LIMITATIONS OF LIABILITY.

1. WARRANTOR: In this Warranty, Warrantor shall mean "Dealer, Distributor, and/or Manufacturer."

2. ELEMENTS OF WARRANTY: This Product is warranted to be free from defects in materials and craftsmanship with only the limitations and exclusions set out below.

3. WARRANTY AND REMEDY: Two-Year Warranty — In the event that the Product does not conform to this warranty at any time during the time of two years from original purchase, warrantor will repair the defect and return it to you at no charge.

This warranty shall terminate and be of no further effect at the time the product is: (1) damaged by extraneous cause such as fire, water, lightning, etc. or not maintained as reasonable and necessary; or (2) modified; or (3) improperly installed; or (4) misused; or (5) repaired or serviced by someone other than Warrantors' authorized personnel or someone expressly authorized by Warrantor's to make such service or repairs; (6) used in a manner or purpose for which the product was not intended; or (7) sold by original purchaser.

LIMITED WARRANTY, LIMITATION OF DAMAGES AND DISCLAIMER OF LIABILITY FOR DAMAGES: THE WARRANTOR'S OBLIGATION

UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AT THE WARRANTOR'S OPTION AS TO REPAIR OR REPLACEMENT. IN NO EVENT SHALL WARRANTORS BE LIABLE OR RESPONSIBLE FOR PAYMENT OF ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL AND/OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY LABOR COSTS, PRODUCT COSTS, LOST REVENUE, BUSINESS INTERRUTPION LOSSES, LOST PROFITS, LOSS OF BUSINESS, LOSS OF DATA OR INFORMATION, OR FINANCIAL LOSS, FOR CLAIMS OF ANY NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS IN CONTRACT, BREACH OF WARRANTY OR TORT, AND WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE. IN THE EVENT THAT IT IS DETERMINED IN ANY ADJUDICATION THAT THE LIMITED WARRANTIES OF REPAIR OR REPLACEMENT ARE INAPPLICABLE, THEN THE PURCHASER'S SOLE REMEDY SHALL BE PAYMENT TO THE PURCHASER OF THE ORIGINAL COST OF THE PRODUCT, AND IN NO EVENT SHALL WARRANTORS BE LIABLE OR RESPONSIBLE FOR PAYMENT OF ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL AND/OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY LOST REVENUE, BUSINESS INTERRUTPION LOSSES, LOST PROFITS, LOSS OF BUSINESS, LOSS OF DATA OR INFORMATION, OR FINANCIAL LOSS, FOR CLAIMS OF ANY NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS IN CONTRACT, BREACH OF WARRANTY OR TORT, AND WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE.

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It must be clear that the Warrantors are not insuring your premises or business or guaranteeing that there will not be damage to your person or property or business if you use this Product. You should maintain insurance coverage sufficient to provide compensation for any loss, damage, or expense that may arise in connection with the use of products or services, even if caused by Warrantors' negligence. The warrantors assume no liability for installation of the Product and/or interruptions of the service due to strikes, riots, floods, fire, and/or any cause beyond Seller's control, further subject to the limitations expressed in any License Agreement or other Agreement provided by Warrantors to purchaser.

The agreement between the Warrantors and the Purchaser, including but not limited to the terms and conditions herein shall not be governed by the Convention for the International Sale of Goods. Where applicable, the Uniform Commercial Code as adopted by the State of Delaware shall apply.

4. PROCEDURE FOR OBTAINING PERFORMANCE OF WARRANTY: In the event that the Product does not conform to this warranty, the Product should be shipped or delivered freight prepaid to a Warrantor with evidence of original purchase.

5. LEGAL REMEDIES AND DISCLAIMER: Some jurisdictions may not allow, or may place limits upon, the exclusion and/or limitation of implied warranties, incidental damages and/or consequential damages for some types of goods or products sold to consumers and/or the use of indemnification terms. Thus, the exclusions, indemnification terms and limitations set out above may not apply, or may be limited in their application, to you. If the implied warranties can not be excluded, and the applicable law permits limiting the duration of implied warranties, then the implied warranties herein are to be limited to the same duration as the applicable written warranty or warranties herein. The warranty or warranties herein may give you specific legal rights that will depend upon the applicable law. You may also have other legal rights depending upon the law in your jurisdiction.

6. CHOICE OF FORUM AND CHOICE OF LAW: In the event that a dispute arises out of or in connection with this Limited Warranty, then any claims or suits of any kind concerning such disputes shall only and exclusively be brought in either the Court of Common Pleas of Delaware County, Pennsylvania or the United States District Court for the Eastern District of Pennsylvania.

Regardless of the place of contracting or performance, this Limited Warranty and all questions relating to its validity, interpretation, performance and enforcement shall be governed by and construed in accordance with the laws of the State of Delaware, without regard to the principles of conflicts of law.

Effective date 08/01/2005
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901 Tryens Road
Aston, PA 19014
Phone: 610.558.2700 Fax: 610.558.0222
www.sensaphone.com

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CHAPTER 1: INTRODUCTION

Congratulations on your purchase of the Sensaphone 1400. The 1400 is a powerful monitoring, alarm, and event logging system. It can monitor equipment and environmental conditions using four universal Zones with scaleable range, built-in power failure detection, sound level monitoring, and one relay output for manual control, or automatic control from alarms. The Sensaphone 1400 also features user-recordable voice for ID and all monitored zones, numeric paging, and built-in line seizure.

The Sensaphone 1400 is a fully programmable environmental monitoring system for unattended or remote applications. The unit will monitor and alarm on four zones: these can be N.O./ N.C.(Normally Open or Normally Closed) contact, 4–20mA, or 2.8K or 10K thermistor (temperature sensor). The unit will also monitor AC power, sound level, and battery condition. On the front of the unit are LED indicators to show the operating status. Each zone (including power, sound and battery) has a status LED indicating the alarm status of the Zone. There is also an LED to indicate if the Output is On, an LED for Phone In-Use status and an LED for System-On status.

The unit is programmed using the built-in keypad and voice response menus. All programming is stored in nonvolatile memory so that all programming is retained even without power. The unit is capable of performing alarm event logging of the four universal Zones, power, and sound. The event logging (history) is also stored in nonvolatile memory. A battery-backed real-time clock is also included to time-stamp logged events. The alarm event history can be heard through the built-in speaker or remotely over the telephone. A complete status report of all monitored conditions can also be heard simply by calling the 1400.

The unit comes in a plastic NEMA-4 enclosure with tabs for wall or panel mounting. Terminal connections for Zones, outputs and power are easily accessible from the front of the unit. The 1400 is powered by a plug-in adapter and has a 6V 1.3AH rechargeable backup battery located behind the panel. Circuitry in the unit will maintain

precise charging of the battery system. The unit also includes built-in Line Seizure capability to ensure that the telephone line is available when necesssary.

FEATURES

The Sensaphone 1400 Includes the following features:

- Four Zones configurable as temperature, 4–20mA, or dry contact
- Scaleable Range for 4–20mA Zones
- Calibration for each Zone
- Each Zone can be individually enabled or disabled
- Power monitor
- Fully automatic input configuration. No Jumpers!
- High sound-level monitor (w/optional external mic)
- 1 relay output (manual or automatic control)
- 10 status LEDs
- Dial out to eight telephone numbers
- User-recordable voice messages
- Alarm dialout via voice and numeric pager
- Built-in Line Seizure
- Microphone for on-site listen-in (w/optional external mic)
- Time-stamped Alarm History
- Surge protection on all Zones, telephone line and power supply
- Rechargeable battery backup
- NEMA-4 enclosure

LAYOUT

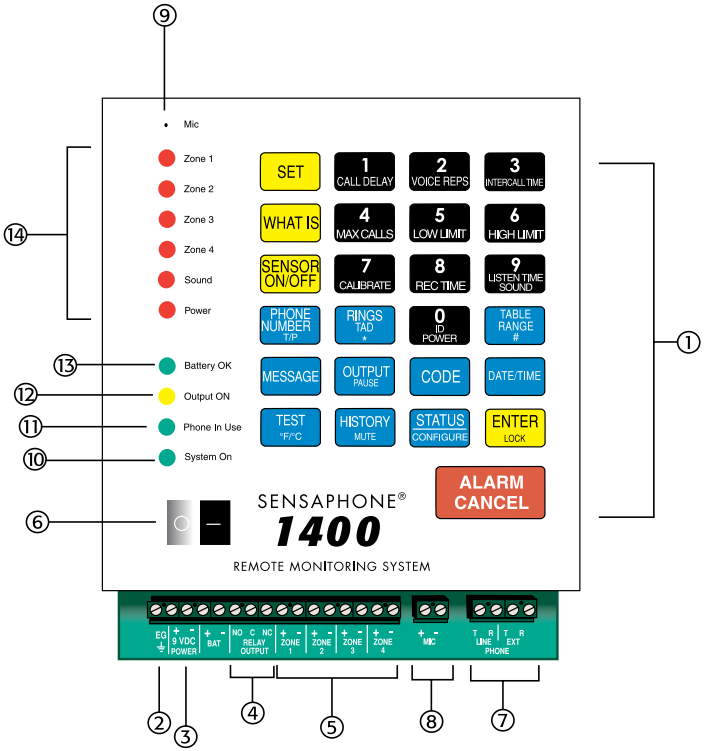


Figure 1: 1400 diagram

1. Programming Keypad
2. Grounding Terminal
3. 9VDC Power Terminals
4. N.O./N.C. Relay Output Terminals
5. 4 Zone Terminals
6. Power Button
7. Phone Network/Extension Terminals
8. External Mic Terminals
9. Built-in Condenser Mic
10. System On LED
11. Phone-in-use LED
12. Output On LED
13. Battery OK LED
14. Zone Alarm LEDs

TECHNICAL SUPPORT

Reading this instruction manual will help you install and program the 1400 easily. Programming and voice recording are performed locally using the built-in keypad. Some programming can also be accessed via touch-tone phone.

If there are any questions or problems that arise upon installation or operation, please contact Technical Support at:

SENSAPHONE
901 Tryens Road
Aston, PA 19014
Toll-Free Phone: 1-877-373-2700
FAX: 610-558-0222
support@sensaphone.com

CHAPTER 2: INSTALLATION

OPERATING ENVIRONMENT

The Sensaphone 1400 should be mounted and operated in a clean, dry environment. The unit is microprocessor-controlled and as a result it should not be installed near devices that generate strong electromagnetic fields. Such interference is typically generated by power switching equipment such as relays or contactors. A poor operating environment may result in unwanted system resets and/or system lockup. The temperature range the unit can operate in is 32°F to 122°F (0°C to 50°C). If the unit needs to operate below freezing, a heater should be installed nearby.

Mounting the 1400

The NEMA-4 enclosure comes with hardware for wall or panel mounting. The four tabs are attached by screwing the round bubble-end of a tab to each of the four rear corners of the enclosure. Then mount the unit in a position that allows easy access to the Zone terminal block and keypad. Also, there must be a power outlet and telephone jack close to the unit.

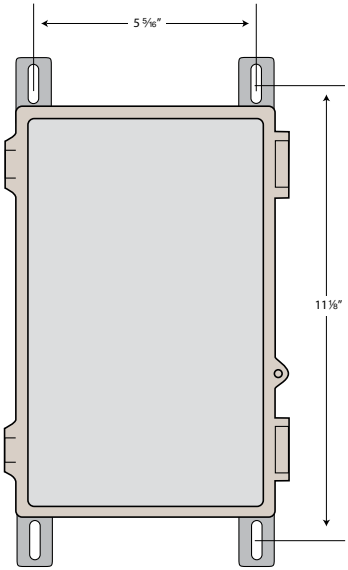


Figure 1: Mounting Dimensions

Locking the Enclosure

The 1400 enclosure can be locked by installing a small luggage-style padlock through the loop on the front door of the enclosure. See Figure below.

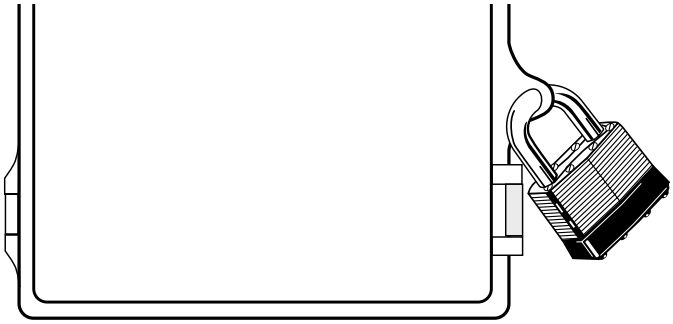


Figure 2: Locking the Enclosure

Grounding

Connect a heavy gauge (#14AWG) copper wire to the earth ground terminal on the left end of the panel and connect the other end to a ground rod or metal cold water pipe (See Figure 3). It is extremely important that the earth ground connection be as short as possible. The ground rod should have sufficient depth to provide a low impedance connection to earth. This connection is required for the surge/lightning protection circuits to function properly.

> **NOTE**: Proper earth grounding of the 1400 is required for warranty coverage.

Ground rods can typically be found at local electrical supply houses and/or hardware stores. Be sure to contact your state *"Call before you dig"* hotline at least **two** days before you install your ground rod, to insure that it is safe to install the ground rod in a chosen area.

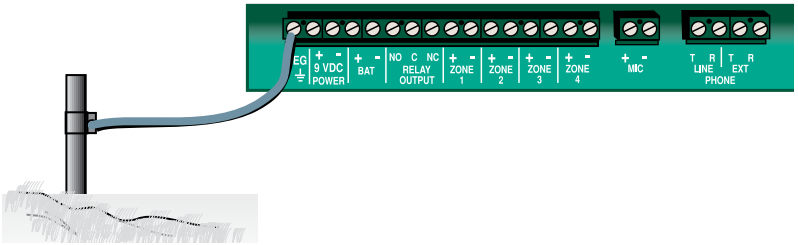


Figure 3: Grounding the 1400

Wiring Connectors

The 1400 includes compression-type liquid-tight connectors for routing wires into the enclosure. To use these connectors, turn them *counter-clockwise to loosen* (or open-up) the compression washer. Insert all cables through the two connectors. When finished turn them *clockwise to secure and seal* the 1400 from the outside environment. If you don't have enough cables to obtain a snug fit you can insert a small piece of soft PVC insulation or rubber tubing to take up the extra space.

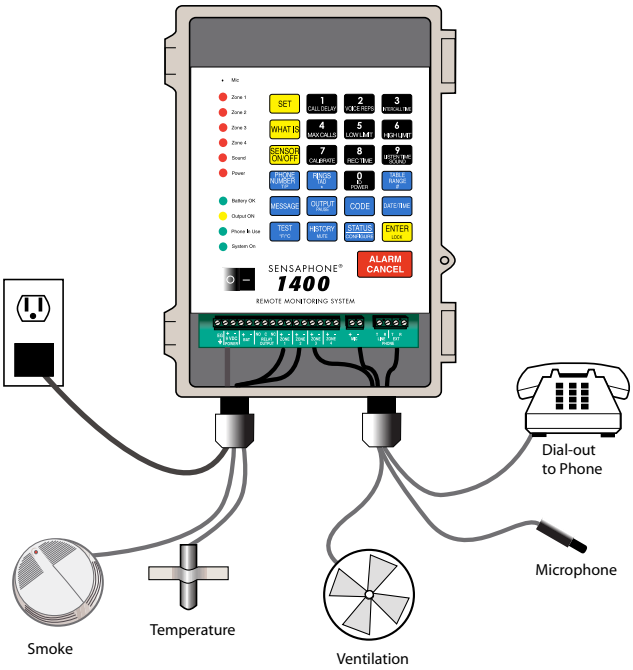


Figure 4: Typical connections from 1400

TURNING THE 1400 ON

Plug the unit's transformer into a 120VAC 60Hz outlet. Toggle the power switch on to start the unit. The System-On LED should glow steadily and the unit will say "Hello." The unit will not turn on if AC power is not present, regardless of the state of the battery.

Note that when the unit is turned off, all programming is retained in non-volatile memory.

Backup Battery

The Sensaphone 1400 includes a 6V 1.3AH sealed lead-acid gel-cell rechargeable battery for system back-up in the event of a power failure. The battery will provide approximately 24 hours of backup time. Actual backup time will depend upon the temperature, battery age, dialing activity, and state of the relay output. The battery is located behind the main panel.

The 1400 will automatically charge the battery whenever the power switch is turned on and the power transformer is plugged in. The battery should provide 3–5 years of service, depending on temperature and charge/discharge cycles, before needing replacement. See Appendix B for battery replacement instructions.

The 1400 also includes a 3V lithium battery to retain the date and time when main power is off. The lithium battery should provide 8-10 years of service life.

> **NOTE**: Have batteries serviced by qualified service personnel only.

TELEPHONE LINE

Connect the 1400's Phone jack to a standard 2-wire analog phone line. The unit dials using pulse or tone, with loop start only. The 1400 will recognize ringer frequencies from 16 to 60 Hz and will operate with all standard analog telephone systems that accept pulse or tone dialing.

Certain private telephone systems and public switching equipment may not accept the unit's dialing or may generate an unacceptable ring signal. In those cases, a dedicated line may be required for the

unit. Consult the supplier of your telephone system if you encounter problems.

> **CAUTION**: Never install telephone wiring during a lightning storm. Never install telephone jacks in wet locations unless the jack is specifically designed for wet locations. Never touch uninsulated telephone wires or terminals unless the telephone line has been disconnected at the network interface. Use caution when installing or modifying telephone lines.

Line Seizure

Line seizure gives the 1400 the ability to "seize" the telephone line when it needs to dial out. For example, if an emergency occurs which puts the 1400 in alarm mode, the unit will be able to dial out even if a telephone has been left off the hook. To the right of the LINE terminals is another set of terminals labeled EXT. These terminals can be used to share the line with other devices (telephone, fax machine, modem) and to give the 1400 priority in the event of an emergency. To make use of this feature you must have all the extension devices originate from the EXT terminals. Whenever the unit must make an alarm phone call, the unit will disconnect any current phone calls and seize the line for its own use. The unit will continue to seize the line until the alarm has been acknowledged. To ease installation, an optional accessory is available (FGD-0060 Line Seizure Kit) which provides an RJ31x modular wall jack, cable, and wiring instructions.

> **NOTE**: The Line Seizure Kit is *not* required for the 1400 seizure capability to function correctly. The Kit allows the disconnection of the 1400 system from the telephone line while ensuring continued telephone operation—useful if the 1400 is, for instance, temporarily removed for service.

WIRING SENSORS AND TRANSDUCERS

The 1400 Zones are compatible with NO/NC dry contacts, 2.8K and 10K thermistors, and 4–20mA transducers. To prevent an alarm from occurring while wiring the sensors, it is recommended that the zone alarm be disabled [SENSOR ON/OFF] + [Zone #1–4]. After wiring all of your sensors you will need to configure the zones

using the [SET] + [CONFIGURE] command. *See Chapter Four for more information on Disabling Zone alarms and Configuring Zones.*

Recommended sequence for adding a new sensor:

1. Disable the Zone's alarm.
2. Wire up the sensor.
3. Configure the Zone.
4. Enable the Zone.

> **NOTE**: If a false alarm occurs while wiring a sensor, you can quickly acknowledge it by pressing the [ALARM/CANCEL] key. See Chapter Five for more information on User Acknowledgment Codes.

Temperature: The unit will accept 2.8K or 10K thermistors. These should be wired to a Zone terminal and the adjacent ground terminal. For recommended thermistors check the accessory list or thermistor data in the appendices. Thermistor temperature range:

2.8K: -109°F to 115°F (-85°C to 57°)
10K: -87ºF to 168ºF (-66ºC to 76ºC)

Dry Contacts: Only contacts which have no voltage or current applied may be used. Connect the contact to a Zone terminal and an adjacent ground terminal. Do NOT try to monitor a contact that switches 120VAC. This will permanently damage the unit.

4–20mA: A 4–20mA transducer requires you to have an external DC power supply for the transducer. Connect the positive wire of your transducer to the positive terminal of your DC power supply. Connect the negative terminal of the transducer to a Zone terminal on the Sensaphone 1400. Connect the negative terminal from your power supply to the adjacent ground terminal on the 1400.

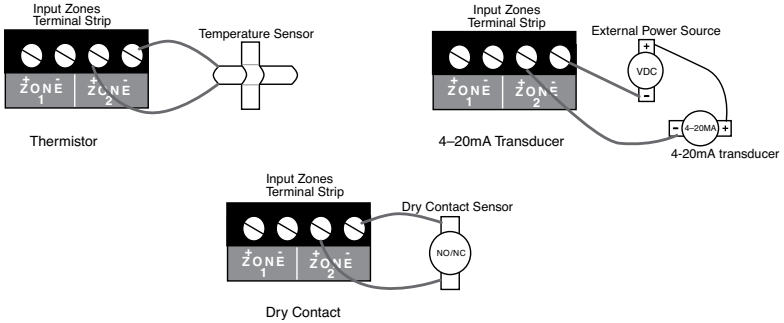


Figure 5: Different Sensor Types connected to the Terminal Block

External Microphone

An (optional) external microphone may be connected to the MIC terminals to allow remote listen-in capabilities and high sound level detection. (**NOTE**: The built-in microphone is for message recording only.) An external microphone with a 25' cable may be ordered from your Sensaphone supplier: Part number FGD-0057. The microphone connects to the terminals labeled MIC. Be sure to observe proper polarity when connecting the microphone: Red wire to + and Black wire to – . *See Chapter Five for information on programming the Listen-in Time, High Sound Alarm Recognition Time, and Sound Level Sensitivity (calibration).*

Wiring Recommendations

The 1400 will work fine in indoor environments using unshielded cable. When wiring will be subject to long lengths (>250') or if run outdoors, it is highly recommended that shielded cable be used and that the shield be connected to an earth ground. Also, be sure to use the appropriate gauge wire based on the distance and sensor type. See chart below:

Wire Gauge	Thermistor	NO/NC Contact & 4–20mA
#24	250'	1000'
#22	500'	2000'
#20	1000'	4000'

When preparing wire for connection to the terminal blocks, strip ¼" of insulation from the conductor (see figure below).

Figure 6: Wire stripped for connection

LED INDICATORS

The LEDs provide on-site alarm and status information. Listed below are descriptions of how the LEDs work.

Zones 1–4, Power and Sound:

LED Off: Zone OK

LED Blinking Fast: Alarm condition exists but recognition time has not been met

LED Blinking Slowly: Unacknowledged alarm exists

LED On: Acknowledged alarm exists

Battery:

LED On: Battery OK

LED Blinking: Battery condition low

LED Off: No battery/critically low battery condition

Output On:

LED On: Output relay on

LED Off : Output relay off

Phone-In-Use:

LED On: Unit is communicating on the phone line

LED Off: Unit is not using the phone line

System-On:

LED On: System power on

LED Off : System power off

CHAPTER 3: QUICK START GUIDE

This section presents a brief guide and some helpful hints for first-time users of the 1400. Follow the instructions for installation before attempting to program the unit.

HOW THE KEYPAD COMMANDS WORK

The 1400 uses simple keypad commands to program and check all pertinent parameters. All of the keypad commands begin with either the SET, WHAT IS, or SENSOR ON/OFF keys. The SET key is used to program parameters. When performing a programming sequence, the command will typically require the SET key followed by the parameter to be programmed, followed by a value, and then the ENTER key at the end. For example, to program the Call Delay you would press [SET] + [CALL DELAY] + [value] + [ENTER]. To check your programming , you would press the WHAT IS key followed by the parameter (in this case, [WHAT IS] + [CALL DELAY].

The SENSOR ON/OFF key is generally used to enable and disable functions or to toggle a function on and off. For example, to disable a Zone you would press [SENSOR ON/OFF] + [Zone #] or to turn the speaker Mute on you would press [SENSOR ON/OFF] + [HISTORY/MUTE].

ABORTING A COMMAND

If you are in the middle of a command and you make a mistake, you can abort the command by either pressing the ALARM CANCEL key or by simply waiting for the command to time out (typically 30 seconds). When you abort a command, the unit will say “Error 1” to indicate that the command has not been executed successfully.

ERROR MESSAGES

When programming parameters in the 1400 you may get an error message if you inadvertently enter an incorrect value. If the unit says “Error 1,” it means that you entered a value that is out of range or have aborted the command. If Remote Programming Security

Code is enabled *(see Chapter Five)*, and you enter the incorrect security code, the unit will answer with "Error 2" and offer you a second chance to enter the correct code.

ACKNOWLEDGING A FALSE ALARM

While programming the unit you may inadvertently set off an alarm. Once an alarm occurs, the unit will start its alarm processing routine, which will prevent you from performing any other keypad function until the alarm is acknowledged. To acknowledge an alarm and stop the unit from making any phone calls, press [ALARM CANCEL]. This will acknowledge the alarm *(assuming that you have not entered any custom acknowledgment codes)*. If you have entered one or more custom acknowledgment codes, then enter the code as required.

RECOMMENDED PROGRAMMING STEPS

Listed below are the basic programming steps to get you up and running. The chapters that follow provide detailed programming instructions as well as additional options to customize the operation of your 1400.

Parameter	Chapter #
1. Set the Date & Time	5
2. Configure Zones	4
3. Set Alarm Limits	4
4. Record Zone voice messages	5
5. Record ID voice message	5
6. Set ID number	5
7. Set dialout telephone numbers	5

CHAPTER 4: ZONE PROGRAMMING

This chapter explains the keyboard commands for the monitoring functions of the Sensaphone 1400. This includes:

- Configure Zone Type
- Enable/Disable Zones
- Temperature Scale
- Table Range for 4-20mA sensors
- Alarm Recognition Time
- Alarm Limits
- Zone Calibration
- AC Power Monitoring Enable/Disable
- AC Power Recognition Time
- Sound Level Monitoring Enable/Disable
- Sound Level Recognition Time
- Sound Level Calibration

AUTOMATIC ZONE CONFIGURATION

The 1400 is compatible with normally open, normally closed, 2.8K thermistor (temperature), 10K thermistor (temperature), and 4-20mA type sensors. All of the Zones are configured simultaneously by keying in a simple key sequence after connecting all of your sensors. Make sure all sensors are in their normal state. All 4–20mA transducers should be powered on.

> **NOTE**: New temperature sensors will default configure to 2.8K. If you are connecting any 10K sensors to the 1400, these **must** be configured manually. Any sensor that was previously configured as either 2.8K or 10K will maintain proper thermistor type. *(See the Manual Configuration section)*

1. Press the SET key.

2. Press the CONFIGURE key.

The 1400 will prompt, “Enter 0 for automatic configuration, enter zone number for manual configuration.” If you press “0”, the 1400 will scan each Zone input and determine the input type.

The Zones are now considered normal. If a *normally closed* Zone becomes open, an alarm will occur. If a *normally open* Zone becomes closed, an alarm will occur.

MANUAL ZONE CONFIGURATION

If you would like to program the Zone type (NO, NC, temperature, 4–20mA) without going through the automatic process that scans all Zones, this command will allow you to configure a single Zone. This command is useful if you have alarms on other channels and cannot use the automatic configuration process, or if you wish to configure the Zone type without actually connecting the sensor.

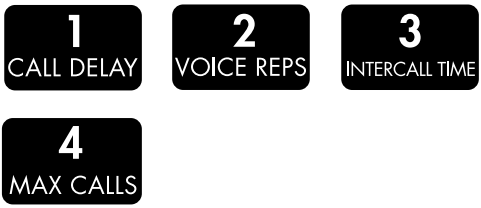
> **NOTE**: You **MUST** use manual configuration for any zone connecting to a 10K temperature sensor.

1. Press the SET key.

2. Press the CONFIGURE key.

The 1400 will prompt, “Enter 0 for automatic configuration, enter zone number for manual configuration.”

3. Press the corresponding Zone key (1–4).



The 1400 will say “Enter Mode.”

4. Press the key which corresponds to the type of Zone according to the table below:

   1: NO Dry Contact
   2: NC Dry Contact
   3: 2.8K Thermistor (temperature sensor)
   4: 10K Thermistor (temperature sensor)
   5: 4–20mA

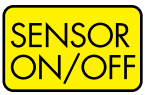
5. Press ENTER.

The 1400 will recite the programmed Zone input configuration.

ENABLE/DISABLE ZONE ALARMS

This function allows you to enable or disable a Zone (1-4) for dialout during an alarm. An enabled Zone will respond to an alarm and allow dialout. A disabled Zone will not initiate a dialout, but it will still be included in the status report, preceded by the word "disabled." This command is useful while you are wiring your Zones or at any other time you would like the alarms to be ignored. The default setting for all Zones is enabled *(on)*.

1. Press the SENSOR ON/OFF key.



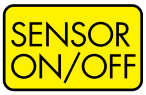
2. Press the corresponding number key (1–4) of the Zone you want to enable/disable. 1400 will say "Zone (1–4) Alarm On/Off" to indicate enabled or disabled respectively.

3. Repeat key sequence to change.

ENABLE/DISABLE SOUND LEVEL ALARM

This function allows you to enable or disable the sound alarm for dialout. When enabled, a high sound level at the remote microphone (optional)—*that meets the programmed recognition time and level*—will trip a sound alarm and the unit will dial out. Disabling sound will prevent a sound alarm dialout. The default setting is enabled *(on)*.

1. Press the SENSOR ON/OFF key.



2. Press the Sound Alarm key (9). 1400 will say "Sound Alarm

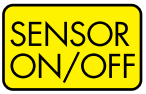
On/Off" to indicate enabled or disabled respectively.

3. Repeat the steps to change.

ENABLE/DISABLE POWER

This function allows you to enable or disable AC power failure monitoring (0). Enabled AC power monitoring will respond to an alarm and allow dialout. Disabled AC power monitoring will not initiate a dialout alarm. The default setting is enabled *(on)*.

1. Press the SENSOR ON/OFF key.

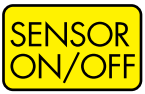


2. Press the power key (0) to enable/disable. 1400 will say "Power Alarm On/Off" to indicate enabled/disabled.

3. Repeat the steps to change.

CONFIGURE TEMPERATURE SCALE

The 1400 can read temperature in degrees Fahrenheit or Celsius. The default is degrees Fahrenheit.



2. Press the F/C key.

The 1400 will say "degrees Fahrenheit" or "degrees Celsius" to indicate the current setting. Repeat the key sequence to change.

CONFIGURE TABLE RANGE FOR 4–20mA SENSORS

The 1400 allows you to create a unique linear table for each 4–20mA sensor. The Table Low (4mA) and Table High (20mA) values are used to define the lower and upper range of your 4–20mA sensor. For example, suppose you are using a 4–20mA transducer to measure the depth of water in a 15 foot well. Simply enter a Table Low value of 0 and a Table High value of 15 and the 1400 will scale the Zone to read between 0 and 15. The low and high table range can be set from -10,000 to +10,000 [Defaults: low=0, high=100]. To make a value negative, precede the value with the [RINGS/TAD/*] key.

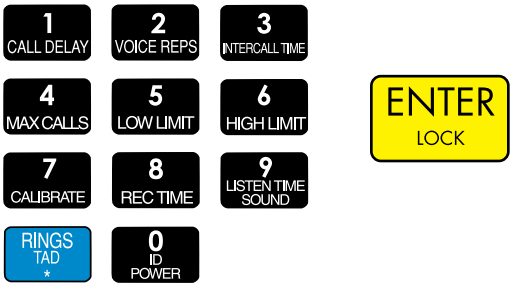
1. Press the SET key.

2. Press the TABLE RANGE key. 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone number (1–4). 1400 will say “Enter Low Number.”

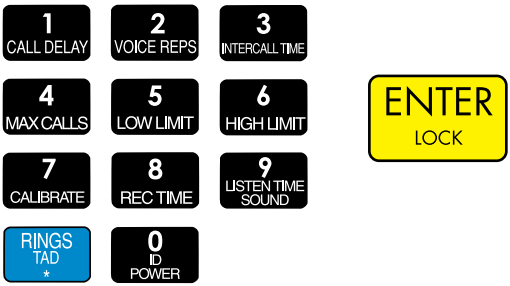
4. Using the number keys, enter the Table Low value, then press

ENTER.



The 1400 will say "Enter High Number."

5. Using the number keys, enter the Table High value and press ENTER.



The 1400 will say "OK."

1. Press the WHAT IS key.

2. Press the TABLE RANGE key. 1400 will say "Enter Zone Number."

3) Press the corresponding Zone number (1–4).

The 1400 will say “Low” and speak the low table value, then it will say “High” and speak the high table value.

ALARM RECOGNITION TIME

The Alarm Recognition Time is the length of time an alert condition

must be present before a valid alarm exists and dial-out is activated. If a condition exists and then clears within the recognition time, it is not considered an alarm. This is useful to prevent nuisance dialouts for momentary alarm conditions or on self-correcting equipment. Each Zone can be programmed with a different recognition time, including Power Alarms and Sound Level Alarms. The default recognition time is 3 seconds for *Zones*, 5 minutes for *Power*, and 8 seconds for *Sound* level. You may program the recognition time for Zone and Power Alarms from 0 seconds up to 540 minutes. Sound Level Alarms may be programmed from 5 to 60 seconds.

> **NOTE**: When the main power fails, the 1400 will announce out loud "Power is OFF" every 15 seconds. It will do this regardless of the programmed recognition time. As a result, when the programmed recognition time is finally met, the unit will dial immediately and not wait the programmed Call Delay time. The Power Alarm is the *only* one treated in this fashion.

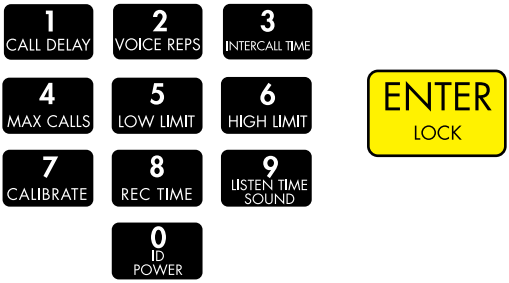
1. Press the SET key.

2. Press the REC TIME key. 1400 will say "Enter Zone Number."

3. Press the corresponding Zone key (1–4), Power(0), or Sound(9).

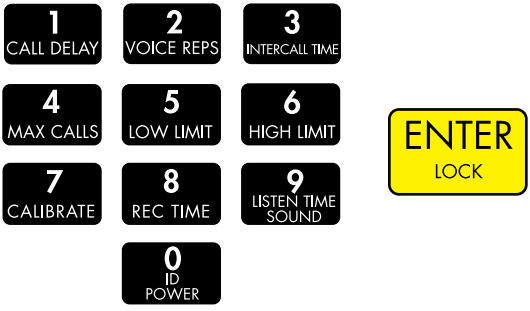
The 1400 will say “Enter minutes.”

4. Using the number keys, enter minutes. Then press ENTER.



The 1400 will say “OK, enter seconds.”

5. Using the number keys, enter seconds. Then press ENTER.



1400 will say “OK.”

1. Press the WHAT IS key.

2. Press the REC TIME key.

1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1–4), Power(0), or Sound (9).

The 1400 will recite the programmed recognition time for that Zone.

ALARM LIMITS

The Alarm Limits determine the level at which a temperature or 4–20mA Zone has reached the alarm threshold. The input value must *exceed* the Alarm Limit to trip an alarm. Each Zone has a programmable Low and High Alarm Limit. The default settings are Low Limit=0 and High Limit=100. The range of programming for 2.8K thermistors is -109° to 115°F (-85° to 57°C). The range of programming for 10K thermistors is -87° to 168°F (-66° to 76°C). For zones configured as 4–20mA, the range of programming is -10,000 to 10,000. To make a value negative, precede the value with the [RINGS/TAD/*] key.

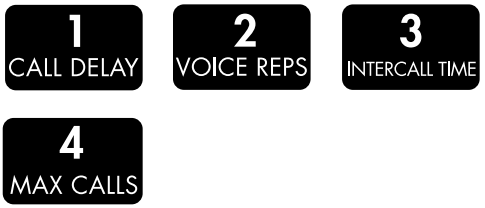
> **NOTE**: Only Zones configured as temperature or 4–20mA can have Alarm Limits programmed.

1. Press the SET key.

2. Press the LOW LIMIT key.

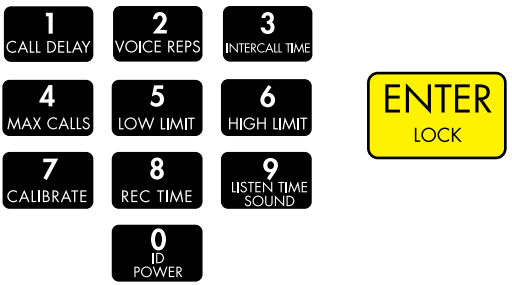
The 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1–4)).



The 1400 will say “Enter Low Alarm Limit.”

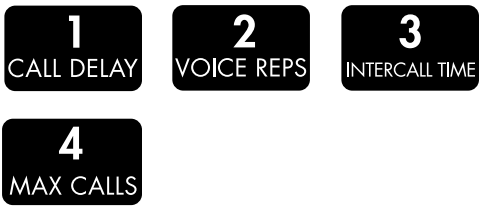
4. Using the number keys, enter a value. Then press ENTER.



1. Press the SET key.

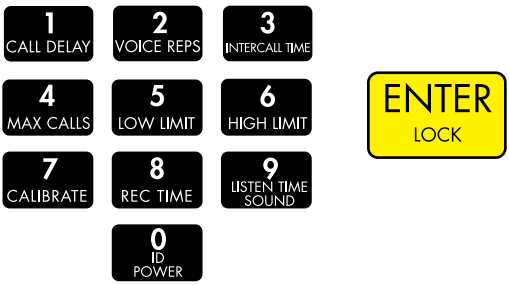
2. Press the HIGH LIMIT key. 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1-4).



The 1400 will say “Enter High Alarm Limit.”

4. Using the number keys, enter a value. Then press ENTER.



1. Press the WHAT IS key.

2. Press the LOW LIMIT key. 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1–4). 1400 will say the programmed value.

1. Press the WHAT IS key.

2. Press the HIGH LIMIT key. 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1-4). 1400 will say the programmed value.

ZONE CALIBRATION

Due to tolerance variations or other factors, you may need to

program an offset to calibrate the sensor. The offset can range from -15 to +15 for Zones configured as temperature, and -100 to +100 for Zones configured as 4–20mA. Setting a positive number will add that number to the Zone reading. Setting a negative number will subtract the programmed value from the Zone reading. For instance, if a temperature sensor consistently read two degrees high, you could use the calibration feature to adjust that temperature down two degrees. To make a value negative, precede the value with the [RINGS/TAD/*] Key.

1. Press the SET key.

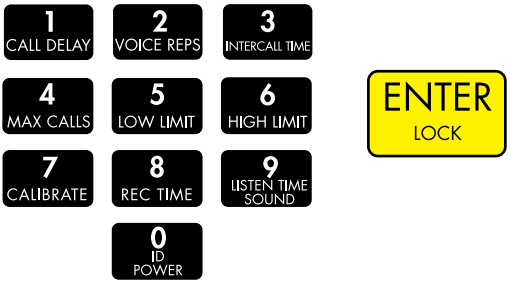
2. Press the CALIBRATE key.

The 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1–4).

The 1400 will say “Enter Number.”

4. Enter the number. Then press ENTER.



The 1400 will say “OK.”

1. Press the WHAT IS key.

2. Press the CALIBRATE key. 1400 will say “Enter Zone Number.”

3. Press the corresponding Zone key (1–4).

The 1400 will recite the programmed calibration.

SOUND LEVEL CALIBRATION

This feature allows you to program the level of sound that will cause the 1400 to respond to an alarm and dial out. **NOTE**: This applies *only* to the (optional) external microphone. It may be useful to desensitize the 1400 to sound if installed in an area with a

relatively high noise level, or where a loud noise occurs frequently but is not associated with an alarm. In some applications, it may be desirable to increase sound sensitivity to low sound levels. The sensitivity setting (calibration) for Sound Alarm monitoring ranges from 1 to 160. A value of 1 makes the microphone the MOST sensitive to changes in sound. The value 160 makes the microphone the LEAST sensitive to sound. The default value is 32.

1. Press the SET key.

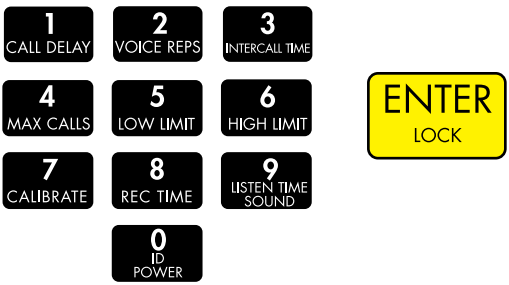
2. Press the CALIBRATE key.

The 1400 will say, “Enter Zone Number.”

3. Press the SOUND key.

The 1400 responds: “Enter number.”

4. Using the number keys, enter a value for sound calibration and press ENTER.



The 1400 will say, “OK.”

1. Press the WHAT IS key.

2. Press the CALIBRATE key. 1400 will say “Enter Zone Number.”

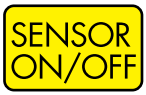
3. Press the SOUND key.

The 1400 will recite the programmed sound sensitivity level.

DESIGNATING A ZONE AS UNUSED

This feature allows you to mark selected Zones, Power, or Sound as unused, which will prohibit them from going into alarm and will also leave them out of the status report. Note that programming for the selected Zone will be preserved when the Zone is marked as “unusued” and will not be reconfigured if automatic Zone configuration is activated.

1. Press the SENSOR ON/OFF key.



2. Press the SET key.

The 1400 will say “Enter Zone Number.”

3. Press the corresponding number of the Zone you wish to mark as unused.

The 1400 will respond by saying Zone 1–4, Power, or Sound “Off/On.” Repeat the key sequence to place the Zone back in use.

EXIT DELAY

The Exit Delay feature is useful when you are using your 1400 for security monitoring. This feature allows you to exit a building without tripping a security alarm. When tripping an alarm is unavoidable, yet a true alert condition has not actually occurred, the alarm response—including dial-out—can be temporarily suppressed.

The 1400 is able to suppress and then reset its dial-out function

automatically through use of the Status Report. This is especially convenient when an alert condition is created upon exiting a monitored door, and there is no way to cancel from the local keypad.

> **Note**: The Exit Delay feature applies only to Zones configured as NO/NC.

Example: You are planning to exit through a monitored door. Prior to exiting, you initiate a Status Report recitation at the 1400 keypad by pressing [WHAT IS], followed by [STATUS], (key sequence shown below). This allows you the duration of the status report to exit without activating the 1400's programmed response to an alarm. At the conclusion of the status report, normal alarm response is reactivated.

1. Press WHAT IS.

2. Press STATUS.

The 1400 recites the full Status Report; during this time, you are able to exit the monitored area without tripping an alarm.

TEMPERATURE-ONLY STATUS REPORT

You can receive a limited status report that only includes inputs configured as temperature. This can be useful when you don't care to listen to the entire status report.

1. Press the WHAT IS key

2. Press the TEST key.

CHAPTER 5: COMMUNICATION PROGRAMMING

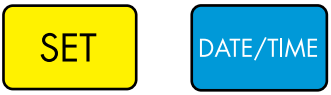
This chapter explains the keyboard commands for programming the communications functions of the 400. This includes programming, interrogating and/or resetting of:

- Date and Time
- Voice Messages
- ID Number
- Alarm Dial-out Telephone Numbers
- Special Dialing Options
- Dial-out Test Mode
- Tone or Pulse Dialing
- Rings Until Answer
- Call Delay Time
- Intercall Time
- Call Progress
- Voice Repetitions
- Maximum Number of Calls
- Telephone Answering Device Compatibility
- Listen-in Time
- Programming Security Code
- Speaker Mute
- Callback Acknowledgment

DATE and TIME

The 1400 has an internal clock/calendar that is used to time-stamp events and maintain alarm history. To program the date and time:

1. Press SET, followed by the DATE/TIME key.



2. The unit will say "Enter the date." Enter the date in month/day/year (mm/dd/yy) format using two digits for each. For example, if the date was January 7, 2005 you would enter 010705, then press ENTER.

3. Next, the unit will say "OK, enter the time." Enter the time in 24-hour format (e.g. 3:00PM = 15:00) using hours/minutes (hh/mm) format. For example, if the time was 1:30PM you would enter 1330, then press ENTER.

4. To check the date and time press WHAT IS, followed by DATE/TIME. The unit will announce the date and time.

NOTE: The internal clock is powered by an onboard lithium battery which should provide 8–10 years of service life.

To program only the Date or only the Time, you can simply press the ENTER key when prompted and the unit will keep its current value. For example, to program a new TIME but keep the current DATE, press [ENTER] when prompted for the Date. The unit will keep the current setting and then prompt you to enter the new Time.

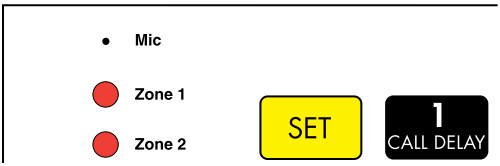
VOICE MESSAGES

The 1400's digital speech recording feature allows you to record custom messages for each of the four Zones and an ID Message. This means that when the 1400 calls you during an alarm, you will hear a personalized Voice Message identifying the unit and telling you exactly what alarm condition exists. You can record a separate message for each of the four Zones. The message can run a maximum of 5 seconds. The ID Message can be a maximum of 8 seconds. You can shorten the message length by pressing the ENTER key after reciting the message.

The **ID Message** is used to identify the unit. This could be a particular building name, its location (address or city), or some other identifier.

To program the ID Message:

1. Locate the condenser mic.



2. Press the SET key.

3. Press the MESSAGE key. The 1400 will say "Enter Message Number."

4. Press the ID key (number 0 key).

5. When the unit beeps, begin speaking your message into the microphone. The unit will say "OK," when the recording time has elapsed; then it will play back your recorded message.

To play back the ID Message:

1. Press the WHAT IS key.

2. Press the MESSAGE key.

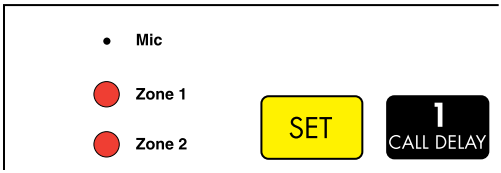
3. Press the ID key (number 0 key).

The 1400 will play back your recorded message.

The **Zone Messages** are used to identify the device or condition being monitored such as temperature, humidity, equipment alarms, security alarms, etc.

To program the Voice Message for a Zone:

1. Locate the condenser mic.



2. Press the SET key.

3. Press the MESSAGE key. The 1400 will say, “Enter Message Number.”

4. Press the number key for the corresponding Zone.

5. When the unit beeps, begin speaking your message into the microphone. The unit will say "OK," when the recording time has elapsed; then it will play back your recorded message.

To play back the message for a Zone:

1. Press the WHAT IS key.

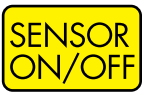
2. Press the MESSAGE key.

3. Press the corresponding Zone number key.

The 1400 will play back your recorded message.

To erase a Zone or ID message:

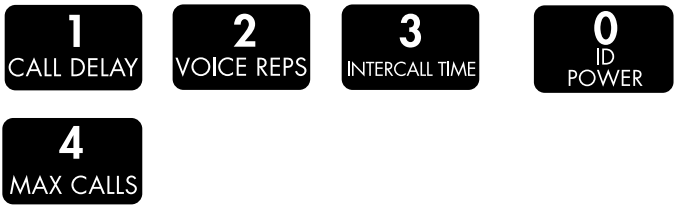
1. Press the SENSOR ON/OFF key.



2. Press the MESSAGE key.

The 1400 will say "Enter message number."

3. Press the Zone Number or ID key.



The 1400 will say, “Message erased.”

ID NUMBER

The ID Number is the identification number of the 1400. This number is typically the telephone number where the unit is installed, or it may be designated using any number that best suits your application. The purpose of the ID Number is to immediately provide the source of any alarm, especially when using multiple 1400 units in a complex monitoring system. The ID number is announced during voice alarm messages and displayed on pagers. The ID Number can be up to 16 digits long.

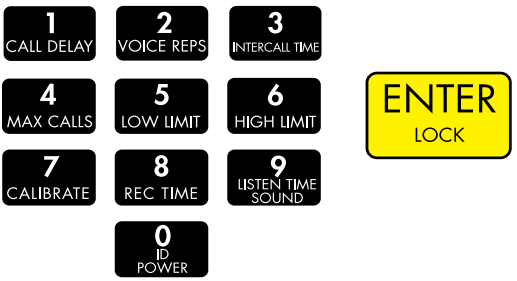
When the 1400 is called from a remote location, it always begins its message with the identification number: "Hello, this is (ID Number)." If no ID Number is programmed, the unit will say, "Hello, this is Sensaphone 1400."

To program the ID Number:

1. Press the SET key.

2. Press the ID key (number 0 key).

3. The unit will say "Enter ID number." Using the number keys, enter the unit's phone number, then press ENTER.



If the number was accepted, the 1400 will say "OK."

To play back the ID Number:

1. Press the WHAT IS key.

2. Press the ID key (number 0 key).

The 1400 will recite the ID Number.

To erase the ID Number:

1. Press the SET key.

2. Press the ID key (number 0 key).

The 1400 will say “Enter ID Number.”

3. Press the ENTER key.

The 1400 will say “ID Number erased.”

ALARM DIAL-OUT TELEPHONE NUMBERS

The Sensaphone 1400 will dial up to eight 48-digit phone numbers to report alarm conditions. These are the numbers that will be called during an alarm dial-out. The unit can deliver an alarm message via voice telephone call or numeric page. The telephone numbers are dialed sequentially 1 through 8. Therefore, program the first number you want called as Phone #1, the second one as Phone #2, and so on. A pause, pound or asterisk can be added to the phone number to access different phone and beeper systems (see special dialing options). Once the alarm is acknowledged, all dial-out stops.

Voice Dialout

When 1400 calls in Voice mode it will announce the ID Message and the alarm message. Afterward it will ask for the acknowledgement code. If a correct code is entered, the unit will stop dialout. If the wrong code is entered it will hang up and continue dialing the next number.

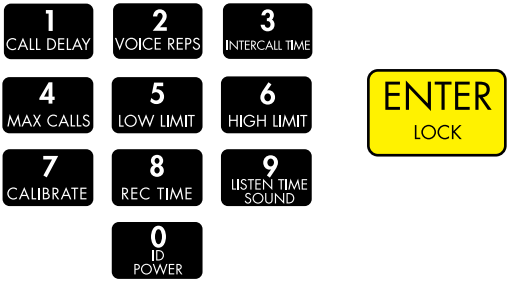
To program a VOICE dial-out telephone number:

1. Press the SET key.

2. Press the PHONE NUMBER key. The 1400 will say “Enter Number.”

3. Select which Phone number to program. Press any unassigned number key (keys 1–8) to represent the new telephone number entry. 1400 will respond “Enter number.”

4. Enter the phone number using the number keys, and then press ENTER. Be sure to enter "1" + area code if required. If installed on a PBX system, be sure to enter a "9" if required.



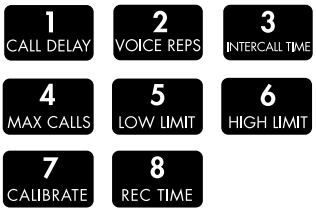
1400 will say "OK."

To play back a programmed dial-out telephone number:

1. Press the WHAT IS key

2. Press the PHONE NUMBER key. 1400 will say "Enter Number."

3. Select an assigned Phone number (keys 1–8).



The 1400 will recite the number programmed. If there is no number programmed, 1400 will say "No number."

To erase a dial-out telephone number:

1. Press the SET key.

2. Press the PHONE NUMBER key. The 1400 will say “Enter Number.”

3. Select an assigned Phone Number (keys 1–8), and press ENTER.

The 1400 will say “Number (1–8) erased.”

Numeric Pager Dialout

When programming the 1400 to dial a Numeric pager there are two methods that can be used: **Automatic** mode and **Manual** mode.

The only difference is that in Automatic mode the 1400 will automatically try to sense when the call has been answered and then send the ID Number and zone numbers. In some instances, the automatic answer detection and timing from the 1400 is incompatible with the paging service, and the Manual mode must be used.

> **NOTE**: If your phone system requires you to dial a ‘9’ followed by a pause to get an outside line, you *must* use **Manual** mode and insert *pauses* at the end of the number.

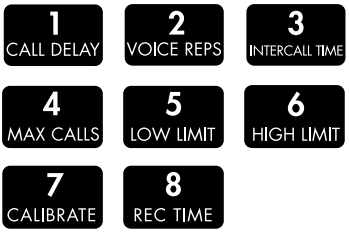
When the 1400 calls your Numeric Pager it will leave the programmed ID Number along with the Zone number that is in alarm. If it’s reporting a Power alarm, it will send the ID Number followed by the number “0”; if it’s reporting a Sound alarm, the 1400 will send the ID Number followed by the number “9”. To acknowledge the alarm you will have to call the unit back and enter an acknowledgement code, otherwise the unit will continue dialing the remaining numbers.

To program a NUMERIC PAGER using AUTOMATIC Mode:

1. Press the SET key

2. Press the PHONE NUMBER key. 1400 will say “Enter Number.”

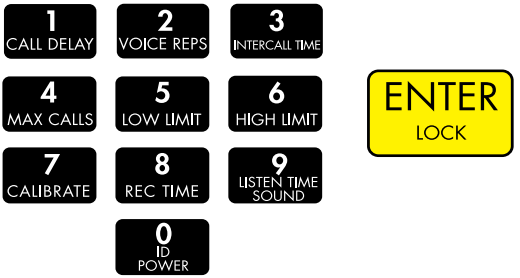
3. Select which Phone number to program. Press any unassigned number key (keys 1–8) to represent the new telephone number entry. 1400 will respond “Enter number.”



4. Press CODE 1 (This tells 1400 this is a Numeric Pager call).

The 1400 will say “Pager.”

5. Enter the pager number using the number keys. Then press ENTER.



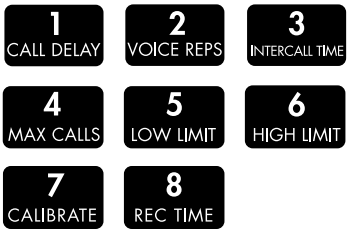
The 1400 will say “OK.”

To program a NUMERIC PAGER using the MANUAL Mode:

1. Press the SET key

2. Press the PHONE NUMBER key. 1400 will say “Enter Number.”

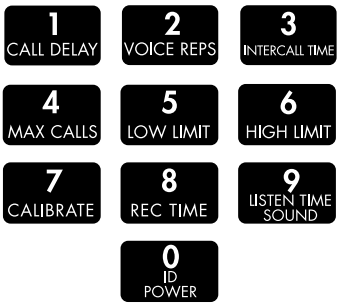
3. Select which Phone number to program. Press any unassigned number key (keys 1–8) to represent the new telephone number entry. 1400 will respond: “Enter number.”



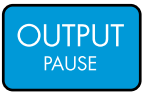
4. Press CODE 1 (This tells 1400 this is a Numeric pager call).

The 1400 will say “Pager.”

5. Enter the pager telephone number using the number keys.



6. Press the PAUSE key twice.



NOTE: Depending on your pager service, you may need to insert a longer or shorter delay (additional/ fewer pauses). Two pauses is the recommended starting point. Use the Dial-out Test Mode to help determine the proper number of pauses for your pager service. When it is programmed properly, you will hear the 1400 dial your pager service, then wait (based on the number of pauses) until the call has been answered, and then send another series of Touch-Tones and hang up.

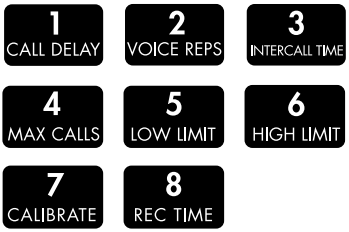
7. Press the ENTER key.

To play back a NUMERIC PAGER number:

1. Press WHAT IS

2. Press the PHONE NUMBER key

3. Select the programmed Phone Number from the number keys (keys 1–8). The 1400 will recite the type of call, “pager,” followed by the pager number assigned to that key.



SPECIAL DIALING OPTIONS

The 1400 has provisions for special dialing requirements. These including dialing a * or #, inserting a two-second pause, or forcing the system to wait for the called party to answer. These options are typically used when: (a) the unit is connected to a PBX and must dial a prefix such as '9' or extension to reach an outside line; (b) when dialing a business and stepping through menus to reach a specific extension; or (c) when a pager service is answered by a voice menu. The special dialing commands can be inserted as part of the dialout telephone number. Valid commands are listed below.

- A # tone can be dialed by inserting the TABLE RANGE/# key in the telephone number.

- The * tone can be dialed by inserting the RINGS/TAD/* key in the telephone number.

- A two-second pause can be inserted in the dialout telephone number by pressing the PAUSE key.

- The 1400 can be instructed to wait for the call to be answered before dialing additional digits. This is useful if you need to call a company's main number and then dial additional digits to go to a specific extension (Example: 888-555-1200—wait for answer—227). Note that the unit will automatically wait for answer after dialing the last programmed digit. Press CODE 2 to make the unit wait for an answer, as in the example.

Change to Touch-Tone Dialing

In a situation where you must use pulse dialing, pressing CODE 3 will change all following digits to Touch-Tone.

Special Dialing Code Summary

Special Dialing Codes for the 1400 are:

Code 1: Numeric pager type
Code 2: Wait for answer
Code 3: Change to Touch-Tone

DIAL-OUT TEST MODE

The 1400 allows you to test your telephone programming by simulating an alarm dialout to any programmed telephone number. This can be a valuable tool for insuring that your programming is correct and also for troubleshooting dialing problems. In this mode all signals on the telephone line are audible through the local speaker.

To test a dialout phone number:

1. Press the SET key.

2. Press the TEST key.

The 1400 will say "Enter Number."

3. Press a number key (1–8) corresponding to the phone number entry you wish to test, and press ENTER.

The 1400 will dial the number and announce the date and time for voice calls, or send its ID number for pager calls.

To manually dial a phone number:

1. Press the SET key.

2. Press the TEST key.

The 1400 will say “Enter number.”

3. Press 0 to enter manual dialing mode. The 1400 will go off-hook and you should hear a dial tone through the speaker. Press any number keys to dial a telephone number.

4. Press ALARM CANCEL to hang up and exit the test.

ALARM ACKNOWLEDGMENT CODES

When the 1400 detects an alarm, it starts dialing each telephone number until it receives acknowledgment or reaches the maximum number of calls. There are two acknowledgment modes: The default, Single-User mode is for users who are not concerned with knowing who responds to and acknowledges the alarm. In this mode, the default code of "555" is used. In Single-User mode an alarm can be acknowledged by pressing the ALARM CANCEL button on the keypad, or by entering the *Acknowledgment Code* of 555 over the telephone using touch tones.

In Multiple-User mode, up to 8 custom Acknowledgment Codes can be created in order to track who acknowledges alarms. These are 5-digit custom codes, replacing the default "555." The 5-digit Acknowledgment Code comprises the user's entry number (1–8) plus a four-digit number. Up to eight different Acknowledgment Codes may be programmed into the unit to identify individual users in the Alarm History Log.

When the unit makes a telephone call in *Voice* mode it will prompt the user to enter an Acknowledgment Code. If this is entered correctly, the 1400 will say "Alarm Acknowledged." When an alarm message is sent to a *pager*, the person who receives the page will have to call the unit back to acknowledge the alarm. In Single-User mode, the user must enter "555" to acknowledge the alarm. In Multiple-User mode, the user must enter his or her 5-digit Acknowledgment Code.

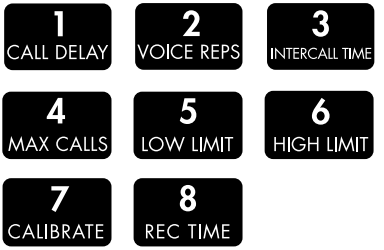
To Program Multiple-User Acknowledgment Codes:

1. Press SET

2. Press CODE

The 1400 will say "Enter Code Number."

3. Press a number (1–8) to assign the user.



The 1400 will say “Enter code.”

4. Enter the additional four digits of your personal code.

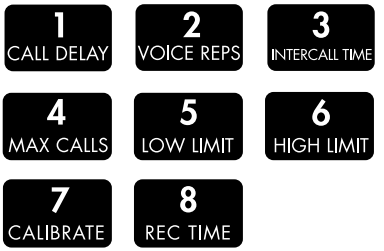
The 1400 will say “OK.”

To play back an Acknowledgment Code:

1. Press WHAT IS

2. Press CODE

3. Press an assigned number entry 1–8.



The 1400 will recite the Acknowledgment Code for the selected telephone number entry.

> **Note**: In default Single-User mode, the unit will announce “555” immediately after pressing the CODE key.

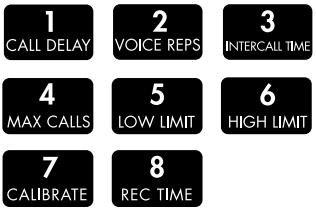
To erase an Acknowledgment Code:

1. Press the SET key.

2. Press the CODE key.

The 1400 will say “Enter Code Number.”

3. Press an assigned user number, 1–8.



4. Press the ENTER key.

The 1400 will say “Code [number] Erased.”

> **Note**: If no User Codes are programmed, the unit automatically defaults to Single-User mode (i.e., the default code of “555”).

ALARM HISTORY

The 1400 will retain historical information on the last 10 alarms. The information retained includes: Zone number, the time/date that the alarm occurred, and the User number that acknowledged the alarm.

To hear the Alarm History:

1. Press the WHAT IS key.

2. Press the HISTORY key.

The unit will recite the history for the last 10 alarms. A sample report is shown below:

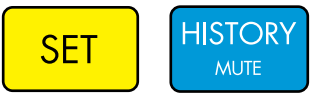
"Zone 1 (custom message) alarm high at 3:31PM April 8, 2005 acknowledged by number 4"

"Zone 3 (custom message) alarm low at 2:35AM March 27, 2005 acknowledged by number 1"

In Single-User mode, the report will state "Alarm acknowledged" for alarms acknowledged via telephone. It will state "Manual acknowledgment" for alarms acknowledged at the keypad. In Multiple-User mode, the report will state the user number that acknowledged the alarm. If the maximum number of calls have been made, the report will state "Automatic acknowledgment."

Deleting the Alarm History:

The Alarm History can be deleted by pressing SET, then HISTORY.



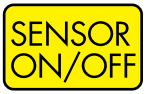
The 1400 will say "Erased."

TONE OR PULSE DIALING

The 1400 can dial out in pulse or touch-tones. All numbers will be called using the chosen dialing method. The default is TONE.

To program as either Tone or Pulse:

1. Press the SENSOR ON/OFF key.



2. Press the PHONE NUMBER(T/P) key.

The unit will say “Tone” to indicate that Tone dialing is enabled, it will say “Pulse” when pulse dialing is enabled.

RINGS UNTIL ANSWER

The Rings Until Answer is the number of rings that must occur before 1400 answers the phone. This value can be from 1 to 15. The default value is 4.

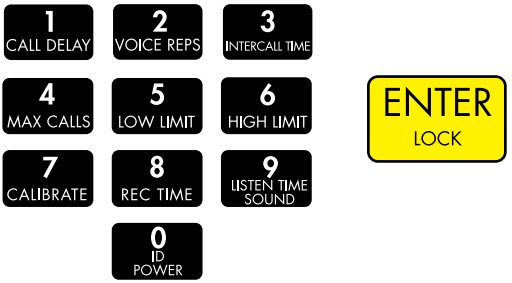
To program Rings Until Answer:

1. Press the SET key

2. Press the RINGS key.

The 1400 will say “Enter number.”

3. Using the number keys, enter a value and press ENTER.



The 1400 will say “OK.”

To play back the Rings Until Answer:

1. Press the WHAT IS key

2. Press the RINGS key.

The 1400 will recite the programmed value.

CALL DELAY TIME

The call delay time is the length of time the 1400 will announce an alarm before it starts the dial-out sequence. This only applies to the first call. To set delay time *between* calls, see INTERCALL TIME. The default call delay time is 30 seconds. It can be programmed from 0 to 60 minutes. The purpose of Call Delay is to allow time for personnel at the 1400's installation site to respond to and cancel an alarm before dial-out begins. During this time, the unit will audibly repeat its "alarm" message and the front panel alarm LED will blink.

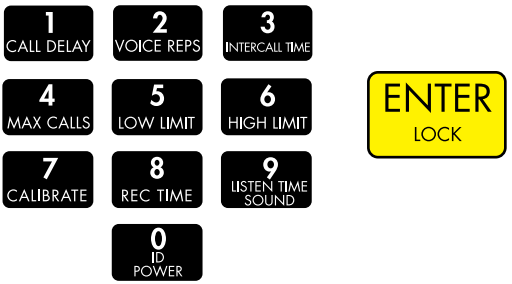
To program call delay time:

1. Press the SET key.

2. Press the CALL DELAY key.

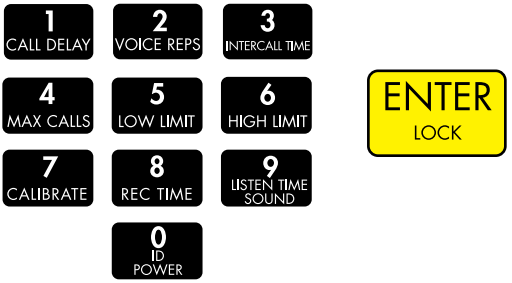
The 1400 will say "Enter minutes."

3. Enter the number of minutes using the number keys. Then press ENTER. To keep the previous setting, just press ENTER.



The 1400 will say "Enter Seconds."

4. Using the number keys, enter the number of seconds, and then press ENTER. To keep the previous setting, just press ENTER.



The 1400 will say "OK."

To play back the call delay time:

1. Press the WHAT IS key

2. Press the CALL DELAY key

The 1400 will recite the programmed time.

INTERCALL TIME

The Intercall Time is the programmable period of time the 1400 waits between making alarm phone calls. Intercall Time is activated ***only after alarm dial-out to the first telephone number fails to be acknowledged.*** This period can be programmed from 10 seconds to 60 minutes. The default Intercall Time is 30 seconds.

> **TIP**: When the 1400 is programmed to make calls to pagers, make sure the intercall delay time is long enough to give the person carrying the pager some time to get to a phone to call the unit back.

If an incoming telephone call is received by the 1400 during the Intercall Time (in between dialing of subsequent telephone numbers to report an alarm), it will answer the incoming call and immediately report any existing alarms. The manner in which the incoming call is answered depends upon whether or not TAD is enabled or disabled *(See Telephone Answering Device (TAD) compatibility):*

If TAD is disabled (default), Rings Until Answer will be the programmed number of rings.

If TAD (Telephone Answering Device) is enabled, Rings Until Answer will be **1**.

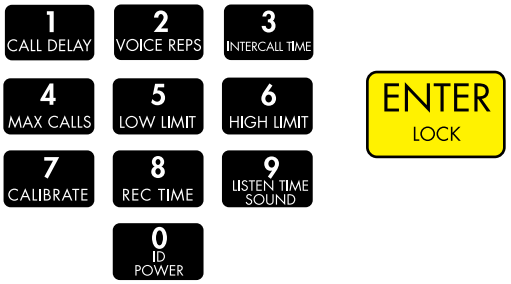
To program intercall time:

1. Press the SET key.

2. Press the INTERCALL TIME key.

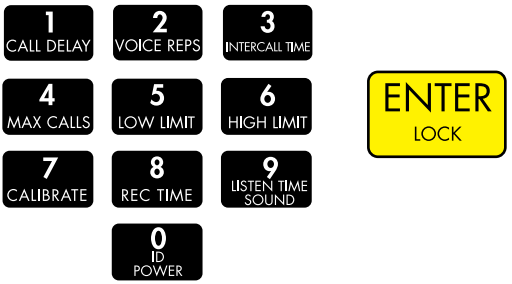
The 1400 will say “Enter minutes.”

3. Using the number keys, enter the number of minutes, and then press ENTER. To keep the previous setting, just press ENTER.



The 1400 will say “Enter seconds.”

4. Using the number keys, enter the number of seconds, and press ENTER. To keep the previous setting, just press ENTER.



The 1400 will say “OK.”

To play back the Intercall Time:

1. Press the WHAT IS key

2. Press the INTERCALL TIME key

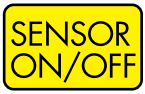
The 1400 will recite the programmed time.

CALL PROGRESS

The 1400 monitors call progress when it dials out for an alarm. If 1400 encounters a busy signal or receives no answer after ten rings, the unit hangs up, waits the programmed intercall time and then dials the next phone number. When dialing some beeper/pager services, the line may be answered before receiving a ringback. This may interfere with the call progress detection and result in a failed call to certain phone systems or beeper/pager services. If this occurs, disable call progress detection. Default setting is *Enabled*.

To enable/disable call progress detection:

1. Press the SENSOR ON/OFF key.



2. Press the STATUS/CONFIG key.

The 1400 will respond “Call Progress Enabled/Disabled” to indicate that call progress has been turned on or off respectively.

3. Repeat key sequence to change.

VOICE REPETITIONS

The voice repetitions is the number of times the 1400 will recite the alarm message per phone call when it dials out. This can be programmed from 1 to 10 repetitions. The default value is 3 repetitions.

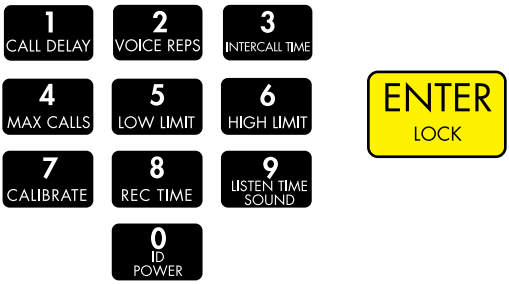
To program the voice repetitions:

1. Press the SET key

2. Press the VOICE REPS key.

The 1400 will say, “Enter number.”

3. Using the number keys, enter a value and then press ENTER.



The 1400 will say “OK.”

To play back the number of voice repetitions:

1. Press the WHAT IS key.

2. Press the VOICE REPS key.

The 1400 will recite the number programmed.

MAX CALLS

The 1400 has the ability to acknowledge itself by using the Max Calls function. The unit keeps a count of the number of phone calls it makes for a particular alarm. Once the number of calls made reaches Max Calls, the 1400 will acknowledge the alarm and stop the dialout process. The unit indicates it has reached max calls by saying “alarm acknowledged by (ID Number).” The max calls can be programmed from 0 to to 255. The default is 100.

> **NOTE**: If only one Phone Number is programmed, 1400 will dial a maximum of 15 times, regardless of the programmed value of max calls, as required by FCC rules.

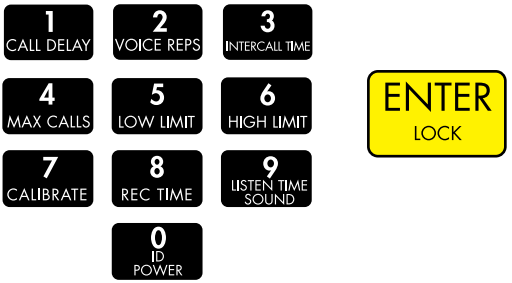
To program Max Calls:

1. Press the SET key.

2. Press the MAX CALLS key.

1400 will say “Enter number.”

3. Using the number keys, enter a value, then press ENTER.



The 1400 will say “OK.”

To play back Max Calls:

1. Press the WHAT IS key.

2. Press the MAX CALLS key

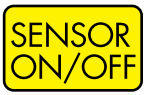
The 1400 will recite the value of max calls.

TELEPHONE ANSWERING DEVICE (TAD) COMPATIBILITY

The 1400 can be used on the same telephone line as a telephone answering device, such as an answering machine, fax machine, or modem. This feature allows you to call in to the 1400 and bypass the answering device. Default setting is *Off [disabled]*.

To use TAD:

1. Program the 1400's Rings Until Answer to a greater number than the rings until answer for your answering device. For example, 1400 RINGS = 5, device rings = 3.
2. Press the SENSOR ON/OFF key.



3. Press the TAD key.

The 1400 will say "TAD On." (If the 1400 says "TAD Off" repeat steps 2 and 3.)

4. Once TAD is on, allow the phone to ring once when you call the unit and then hang up. The 1400 recognizes that a call was made and activates a 30 second internal timer. This allows you 30 seconds to call the 1400 back.
5. Call back within 30 seconds. The 1400 will override the answering device on this incoming call and answer the phone on the first ring. The 1400 resets the TAD timer after one incoming call is received. If you want to call the unit again, you must repeat steps 4 and 5.

LISTEN-IN TIME

The Listen-In Time is the amount of time you can listen to sounds at the unit's location during a status call-in. An external microphone (optional) is required to listen in to on-site sounds. The programmable range is 0 to 255 seconds. The default setting is 0 seconds (disabled).

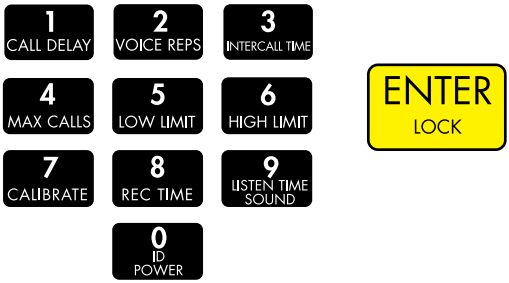
To program the Listen-In Time:

1. Press the SET key.

2. Press the LISTEN TIME key.

The 1400 will say "Enter seconds."

3. Using the number keys, enter the seconds, then press ENTER.



The 1400 will say "OK."

To play back the Listen-in Time:

1. Press the WHAT IS key.

2. Press the LISTEN TIME key

The 1400 will recite the time programmed.

REMOTE PROGRAMMING SECURITY CODE (LOCK)

The 1400 can be locked to prevent unauthorized call-in access to its programming. You may, however, listen to a status report without unlocking the 1400. To remotely edit programming parameters or record messages, you must call in and unlock the 1400 by entering the four-digit lock/unlock code.

If you enter the correct code, you will gain access to the 1400 to use the phone commands. If you enter the incorrect code, the 1400 will say "Error 2" and allow you a second chance to enter the correct code. If the second attempt is also wrong, the unit will say "Error 2, good-bye" and disconnect. You cannot program or change the lock code remotely.

For an explanation of how to use remote programming, see Chapter Seven.

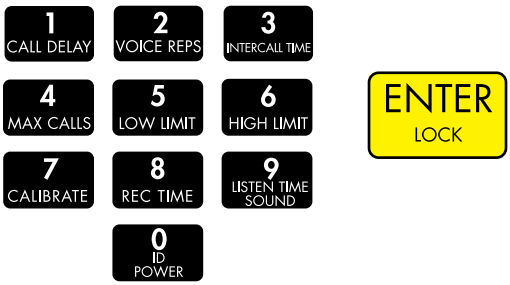
To set the security code:

1. Press the SET key.

2. Press the LOCK key.

The 1400 will say "Enter security code."

3. Using the number keys, enter 4 digits, and press ENTER.



The 1400 will say "OK."

To play back the security code:

1. Press the WHAT IS key.

2. Press the LOCK key.

The 1400 will recite the security code.

To remove the security code:

1. Press the SET key.

2. Press the LOCK key.

The 1400 will say “Enter security code.”

3. Press ENTER.

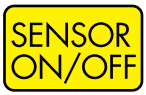
The 1400 will say “Security code erased.”

SPEAKER MUTE

When the 1400 dials out with an alarm, it recites the alarm message over the phone and at the monitor site. The Speaker Mute command allows you to silence the 1400 at the monitor site.

To Mute the speaker:

1. Press the SENSOR ON/OFF key.



2. Press the MUTE key

The 1400 will say “Mute On” to indicate that the speaker mute is on. It will say “Mute Off” to indicate when the speaker mute is off.

3. Repeat key sequence to change.

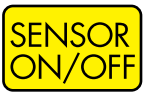
CALLBACK ACKNOWLEDGMENT

This is an optional feature that can be enabled using the keypad *(default=disabled)*. It allows an alarm to be acknowledged simply by calling the unit and letting the line ring 10 times. When this feature is enabled it will temporarily make the Rings Until Answer set to 10 when an unacknowledged alarm exists. If you receive a call via Voice or Pager and are unable to send touch-tones, you can call the unit back, let the line ring 10 times, and the unit will answer and say "...Alarm Acknowledged."

> **NOTE**: If TAD is also enabled, then you must call the 1400, let it ring once, hang up, and then call the unit back within 30 seconds. The unit will answer on 1 ring and acknowledge the alarm.

To Enable the Callback Acknowledgment Feature:

1. Press SENSOR ON/OFF.



2. Press CODE.

The 1400 will say "Callback Acknowledgment Enabled/Disabled" to indicate that Callback Acknowledgment is enabled. Repeat the key sequence to disable.

CHAPTER 6: CONTROLLING THE OUTPUT

The 1400 includes a relay output that can be used to control a light, siren, or other device. The output is a Form-C Normally Open/ Normally Closed mechanical relay and is rated for up to 120VAC 2A. A sample wiring diagram is shown below:

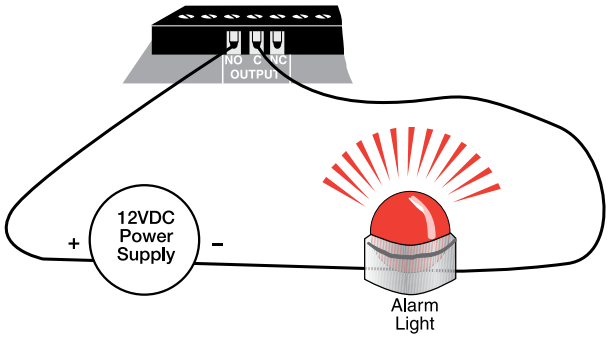


Figure 1: Relay output connected to alarm

The output can be programmed to operate in one of 7 automatic modes or it can operate in manual mode (default). The 7 *automatic* modes allow the output to automatically turn on and off based on individual alarms or any alarm. In *manual* mode the output is controlled via keypad command or remotely via touch-tone phone *(See Chapter 7)*. A description of each mode is shown below:

AUTOMATIC MODES

Mode 1: Output on when zone 1 goes into alarm. Off when alarm is acknowledged.

Mode 2: Output on when zone 2 goes into alarm. Off when alarm is acknowledged.

Mode 3: Output on when zone 3 goes into alarm. Off when alarm is acknowledged.

Mode 4: Output on when zone 4 goes into alarm. Off when alarm is acknowledged.

Mode 5: Output on when a Sound alarm occurs. Off when alarm is acknowledged.

Mode 6: Output on when a Power alarm occurs. Off when alarm is acknowledged.

Mode 7: Output on when any alarm occurs. Off when all alarms are acknowledged.

MANUAL MODE

Mode 0: Output controlled manually via keypad command or touch-tone telephone.

When programmed for Manual mode, the command to switch the output is:

SENSOR ON/OFF + OUTPUT.

The 1400 will respond “ON” or “OFF” to indicate the state of the output.

> **Note**: If the 1400 says “Error,” the output is not programmed for manual mode.

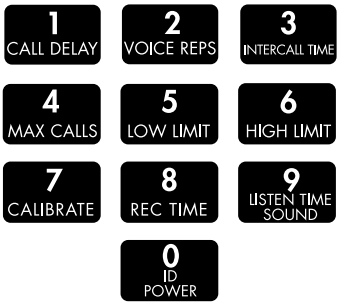
To program the Output Mode:

1. Press the SET key.

2. Press the OUTPUT key.

The 1400 will say “Enter output mode.”

3. Using the number keys, enter a value for the output mode.



4. Press the ENTER key.

The 1400 will say "OK" and recite a description of the mode selected, such as "Automatic on Zone 1" or "Manual." Note that when *Mode 7* is selected, the 1400 will simply say "Automatic on Alarm," meaning that the output will automatically turn on when any alarm occurs.

To play back the programmed Output Mode:

1. Press WHAT IS.

2. Press OUTPUT.

The 1400 will recite the programmed output mode.

CHAPTER 7: OPERATION

After installation and programming have been completed, the Sensaphone 1400 is fully operational. This chapter explains how the 1400 operates.

ALARM DIALOUT AND ACKNOWLEDGMENT

There are three stages to a complete alarm event: 1) Alarm Recognition, 2) Alarm Notification, 3) Acknowledgment. Note that not all alert conditions will go through each stage. For example, some may not meet the recognition time.

Alarm Recognition

1. The 1400 monitors four zones plus sound level and power failure. When the status of a zone changes or exceeds user-programmed limits, it causes an alert condition.
2. If the alert condition lasts long enough to meet its programmed recognition time, the alert condition becomes an alarm and the 1400 begins the alarm notification sequence.

Alarm Notification

The 1400 can make two types of phone calls: Voice and Numeric Pager.

Dialout Note: Call Progress

The 1400 monitors call progress when dialing out. If the 1400 dials out and encounters a busy signal or no answer after 10 rings, the unit hangs up, waits the programmed intercall delay time, and then dials the next phone number.

> **NOTE**: Dial-tone and call-progress detection may optionally be disabled.

Alarm Dialout—Voice

When dialing out to a destination programmed as "voice," the 1400 waits for the phone to be answered, then recites its user-recorded identification message, then the message identifying the zone or zones that have gone into alarm.

Below is an example of what the 1400 might say during a typical "voice" dialout:

> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Enter acknowledgment code."

In this example, the number of Voice Message Repetitions was set to three.

> **NOTE**: If the call reaches an answering machine, the message will be recorded, but the 1400 will be talking over your outgoing message, so you will probably lose part of the first alarm message repetition.

Alarm Dialout—Pager

When dialing out to a destination programmed as "Numeric Pager," the 1400 leaves its programmed ID number on the display of a numeric pager along with the zone number(s) in alarm.

> **IMPORTANT**: When dialing out to a phone number programmed as "Numeric Pager," the 1400 DOES NOT speak a voice message. It calls the pager company or service, enters the number to be displayed on the beeper, then hangs up.

ALARM ACKNOWLEDGMENT

Alarm Acknowledgment—Voice Dialout

Repeated below is the same example of what the 1400 might say during a typical "voice" dialout:

> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Enter acknowledgment code."

1400 will now wait 10 seconds for a Touch-Tone acknowledgment code to be entered. After the last digit of the acknowledgment code has been received, the 1400 will respond by saying: "Alarm Acknowledged." The alarm has been acknowledged and the unit will hang up. Once the alarm has been acknowledged, the dialout process stops.

If a Touch-Tone acknowledgment code is not received, the 1400 will offer you a second chance to enter it, responding with: "beep," "error," "Enter acknowledgment code." If the acknowledgement code is still not received, then the 1400 will respond by saying: "beep," "error," "goodbye." The alarm has not been acknowledged. The 1400 will hang up and wait the programmed INTERCALL TIME before making the next phone call. During this time you may call the unit back from a Touch-Tone phone and the unit will give a voice report. Once you receive the complete report, enter the code to acknowledge the alarm.

> **NOTE**: An alarm cannot be acknowledged using a pulse (rotary) telephone unless the *Callback Acknowledgment* feature is enabled.

Alarm Acknowledgment—Numeric Pager Dialout

The 1400 will dial out to your pager service and leave a number on the display of your beeper. *(See Chapter Five)* The unit will then hang up without speaking a voice message and wait for you to call back and enter an acknowledgment code. This waiting period is called the INTERCALL TIME. During this time you may call the unit back from a Touch-Tone phone to receive a report of the alarm condition and acknowledge the alarm by entering the acknowledgment code.

> **NOTE**: An alarm cannot be acknowledged using a pulse (rotary) telephone unless the *Callback Acknowledgment* feature is enabled.

Below is an example of what the 1400 will say when you call it back to acknowledge a typical alarm:

> "Hello, this is 555-2278, 'Acme Medical Laboratory,' Zone One, 'Temperature in Refrigerator One,' a high temperature alarm exists, it is now 50 degrees Fahrenheit, too high. Listen to sound for ten seconds."
>
> "Enter acknowledgment code."

The 1400 will now wait 10 seconds for a Touch-Tone acknowledgment code to be entered. After the last digit of the acknowledgment code has been received, the 1400 will respond by saying: "Alarm Acknowledged." The alarm has been acknowledged and the unit will hang up. Once the alarm has been acknowledged, the dialout process stops.

If a Touch-Tone acknowledgment code is not received, the 1400 will offer you a second chance to enter it, responding with: "beep," "error," "Enter acknowledgment code." If an acknowledgement code is still not received, then the 1400 will respond by saying: "beep," "error," "goodbye." The alarm has not been acknowledged. The 1400 will hang up and wait for you to call back and enter the acknowledgment code. This waiting period is called the INTERCALL TIME. During this time you may call the unit back from a Touch-Tone phone and the unit will give a voice report. Once you receive the complete report, enter the code to acknowledge the alarm.

NOTE: An alarm cannot be acknowledged using a pulse (rotary) telephone unless the *Callback Acknowledgment* feature is enabled.

TIP: When the 1400 is programmed to make calls to pagers, make sure the intercall delay time is long enough to give the person carrying the pager some time to get to a phone to call the unit back.

Alarm Acknowledgment—Automatic (Max Calls)

The 1400 has the ability to acknowledge itself by using the Max Calls function. The unit keeps a count of the number of phone calls it makes for a particular alarm. Once the number of calls made reaches Max Calls, the 1400 will acknowledge the alarm and stop the dialout process. The default setting for Max Calls is 100.

CALL-IN STATUS

You can also call into the 1400 using a Touch-Tone telephone to obtain a status report. After answering, the 1400 will recite a status report. Immediately following the status report, the 1400 allows you to use Touch-Tone commands to enable/disable zones, change limits, control the output, etc. See the next section, Remote Commands via Touch-Tone Phone.

Below is an example of a voice status report:

"Hello, this is 555-2278, 'Acme Medical Laboratory'

"Zone one, 'Temperature in refrigerator one,' 38 degrees Fahrenheit, OK

"Zone two, 'Temperature in refrigerator two,' 40 degrees Fahrenheit, OK

"Zone three, 'Water pressure monitor,' OK

"Zone four, 'Nitrogen gas tank level in percent,' 15, too low, acknowledged alarm exists

"Sound is OK"

"Power is ON"

"Battery is OK"

"Output is off."

"Good-Bye"

REMOTE COMMANDS VIA TOUCH-TONE PHONE

You can issue a number of commands to the 1400 remotely using a Touch-Tone telephone. This command mode can be entered at any time during the status report. Simply press a Touch-Tone and the unit will halt the report and respond with "OK." You are now in Touch-Tone command mode. Commands are available to perform the following functions:

- Enable and disable zones, power monitoring, and sound monitoring
- Recite/Set High and Low alarm limits
- Recite/Set telephone numbers
- Record/Play custom voice messages
- Recite/Set the relay output
- Activate the microphone for listen-in
- Recite status report
- Recite alarm history

The commands are put together based on the letters of a touch-tone telephone. See typical telephone keypad layout below.

Figure 1: A telephone keypad

Many of the commands use three letters that represent an abbreviation of the selected command. For example, to Set a High limit on Zone 1 you would press S + H + 1 (or in numeric form 7 + 4 + 1)

The tables below list all of the touch-tone commands that are supported. Commands are listed in both character and numeric formats. The # key is used as an ENTER key. Use the * key to represent a negative sign or to represent the [CODE] key when programming telephone numbers.

Enable/Disable Zones

This command will toggle the selected zone between the enabled or disabled state.

Description	Touch-Tone Command
Enable/Disable Zone	* + Z(0) + (zone number)

Set and Recite High & Low Alarm Limits

The following commands are used to set or recite the Low Alarm Limit for any Zone.

Description	Touch-Tone Command
Set Zone Low Limit	S(7) + L(5) + (zone number) + (value) + #

Description	Touch-Tone Command
What Is Zone Low Limit	W(9) + L(5) + (zone number)

The following commands are used to set or recite the High Alarm Limit for any Zone.

Description	Touch-Tone Command
Set Zone High Limit	S(7) + H(4) + (zone number) + (value)+ #

Description	Touch-Tone Command
What Is Zone High Limit	W(9) + H(4) + (zone number)

Set and Recite Telephone Numbers

The following commands will allow you to program and recite dialout telephone numbers. You may need to use the Special Dialing Codes below.

Special Dialing Codes Summary

Code 1: Numeric pager type
Code 2: Wait for answer
Code 3: Change to Touch-Tone
Code 4: Pause
Code 5: *
Code 6: #

Description	Touch-Tone Command
Setting a phone number	S(7) + T(8) + (entry 1–8) + (telephone number) + #

Description	Touch-Tone Command
Reciting a phone number	W(9) + T(8) + (entry 1–8)

Record and Play Custom Voice Messages

The following commands will allow you to record and play back custom voice messages for the ID message (0) and each zone (1–4).

Description	Touch-Tone Command
Record a Message	S(7) + M(6) + (entry 0–4)

Description	Touch-Tone Command
Play a Message	W(9) + M(6) + (entry 0–4)

Control the Relay Output

The following commands will allow you to check the status of the relay output and to toggle the Relay Output On and Off.

Description	Touch-Tone Command
Reciting the Output Status	W(9) + R(7) + O(6)

Description	Touch-Tone Command
Switching the Output	S(7) + R(7) + O(6)

Activate Microphone Listen-in

The following command will allow you to activate the microphone listen-in for the programmed duration.

Description	Touch-Tone Command
Activate Mic Listen-in	M(6) + I(4) + C(2)

Request Status Report

The following command will initiate a status report.

Description	Touch-Tone Command
Recite status report	W(9) + S(7) + R(7)

Request Alarm History

The following command will recite the alarm history.

Description	Touch-Tone Command
Recite alarm history	H(4) + I(4) + S(7)

Hang-up

The following command will make the 1400 hang up the telephone line.

Description	Touch-Tone Command
Hang-up the phone line	B(2) + Y(9) + E(3)

NOTE: If a security code is enabled, the 1400 will prompt you with "Enter security code." Enter the four-digit keypad security code plus "#" to enter touch-tone command mode. If entered correctly, the 1400 will respond with "OK" and you can proceed to enter the commands. If entered incorrectly, the unit will give you one more chance. If it is incorrect a second time, the unit will say "Error, goodbye" and hang up.

APPENDIX A: Checking Your Sensaphone 1400 for Proper Operation

We recommend that you test your Sensaphone 1400 weekly to be sure it is functioning properly. This will ensure that when a problem arises the 1400 will be ready to alert the appropriate personnel. Phonetics, Inc. also recommends you keep a log of performed tests, and has provided you with a Test Log template at the back of this manual.

There are several tests that can be performed:

1. Call the unit and listen to the Status Report. This will test the unit's ability to answer the phone and speak a message. It will also verify that the inputs are reading properly, the alarm conditions are OK, the electricity is on, the microphone is functioning (optional), and that the batteries are OK.
2. Create a test alarm on each input and allow the unit to contact all programmed telephone numbers. This will make sure that the 1400 is programmed properly. It will also prepare personnel to respond appropriately when they receive a call from the 1400. Listed below are suggestions on how to trip test alarms:

   • Temperature sensors: Heat or cool the sensor.

   • Motion sensors: Have someone walk in front of the sensor.

   • Door/window sensors: open the door/window.

   • Water sensors: Apply a small amount of water beneath the sensor or use a wet towel and touch it to the sensor probes.

   • Humidity sensors: Raise the humidity around the sensor by holding a cup of very hot water beneath the sensor.

   • NO/NC Contacts: Open or close the contact.

Allow the unit to contact all programmed telephone numbers. This will make sure that the 1400 is programmed properly. It will also prepare personnel to respond appropriately when they receive a call from the 1400.

3. Test the batteries by unplugging the AC adapter and making sure that the 1400 continues to function. Check that the BATTERY OK LED remains on steady. Press WHAT IS, then STATUS on the keypad, and listen to the status report. Make sure the report states that "power is off" and "battery is OK." Keep the AC adapter unplugged so that a Power Failure alarm occurs. Allow the unit to dial all programmed telephone numbers while running on battery backup. Plug in the AC adapter after the unit has finished dialing all of the telephone numbers.

APPENDIX B: Replacing the Back-up Battery

The back-up battery will provide about 3–5 years of service life depending on usage and temperature. After 5 years (or when back-up time is insufficient) the battery should be replaced. Replacement batteries can be ordered from Sensaphone *(Part number BAT-0020)*. To replace the battery, follow the instructions below:

> **WARNING**: When removing and replacing the battery, be careful not to short out the battery terminals on the bracket or back panel. A large spark and/or battery damage could result.

1. Turn the power switch off and unplug the power transformer.
2. Loosen the compression wiring connectors and allow 6-10" of cable slack to come into the enclosure. This will make it easier to turn the panel over.
3. Remove the four corner screws securing the keypad/pcb panel and turn the panel over.
4. Remove the connectors from the battery by carefully pulling and wiggling the connectors from the battery tabs.
5. Remove the screws holding the battery bracket and remove the bracket.
6. Dispose/Recycle the old battery following local disposal regulations for lead batteries.
7. Attach the battery connector at the end of the BLACK wire to the -(negative) terminal of the new battery.
8. Attach the battery connector at the end of the RED wire to the +(positive) terminal of the new battery.
9. Insert the new replacement battery into the slot and replace the bracket. Secure the bracket with the two screws.
10. Place the main panel over the four metal stand-offs and reattach the four corner screws.

11. Readjust the cables through the compression connectors and secure the fittings.

12. Plug the power transformer into the outlet and turn on the power switch.

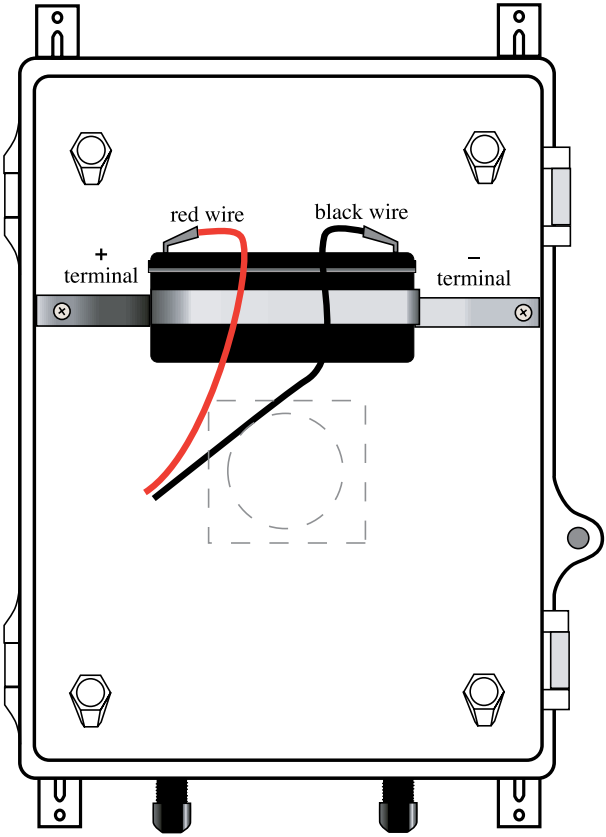


Figure 1: Back-up Battery placement

APPENDIX C: Troubleshooting the 1400

In the event that a problem is encountered, this section will assist you in determining the cause so you can return the unit to its normal monitoring routine with minimal interruption.

Most problems with the 1400 are easy to identify and quickly corrected. See the information under the following general headings:

- Communications/Dialout functions
- Temperature monitoring
- 4–20mA monitoring
- Sound level monitoring
- Other monitoring functions

If you have tried the solutions outlined in this section and are not satisfied with the results, call Sensaphone Technical Support toll-free at 1-877-373-2700. If it is determined that your 1400 requires repair please follow the instructions in Appendix H for returning your unit for service.

COMMUNICATIONS/DIAL-OUT:

Problem 1

The 1400 fails to dial out.

Cause	Solution
a) The telephone number may be incorrectly programmed.	Recheck programming steps and use the dial-out test mode to listen to the unit dial. Refer to Chapter 5.
b) Tone or pulse (the current dialing method) is not compatible with the telephone line on which the 1400 is installed.	Switch from the current setting: from tone to pulse, or from pulse to tone. Refer to Chapter 5.
c) Recognition Time is too long. An alert condition does not remain in effect long enough to become a valid alarm.	Reprogram Recognition Time. Set the Recognition Time to the minimum duration required to create a valid alarm. If possible, test the new setting by deliberately creating an alert condition. Refer to Chapter 4.
d) Max Calls is set to zero.	Reprogram Max Calls. It is a good idea to set your Max Calls to at least equal the number of dial-out telephone numbers programmed. Refer to Chapter 5.
e) The 1400 is connected to an incompatible telephone line.	The 1400 must be connected to a standard (2-wire analog) telephone line, not a digital extension to a phone system. If the unit will not dial out and the factors previously listed have been ruled out, try connecting the unit to a standard residential telephone line.

Problem 2

The 1400 will not answer the telephone when called for a Status Report or alarm acknowledgment.

Cause	Solution
a) Rings Until Answer is incorrectly programmed.	Recheck programming of Rings Until Answer. Refer to Chapter 5.
b) The 1400 is connected to an incompatible telephone line.	Some telephone systems will not allow the telephone to ring beyond 4 rings. If your 1400's Rings Until Answer is set at more than 4 rings, you may not be able to access the unit. Try setting the Rings Until Answer to less than 4 rings. If this does not correct the problem, it may indicate telephone line incompatibility. In this case, try connecting the 1400 to a standard, residential telephone line.

Problem 3

The 1400 will not answer the telephone for Callback Acknowledgment.

Cause	Solution
You did not allow the telephone to ring 10 times. Note: If the TAD (telephone answering device) is disabled, the telephone rings ten times before the 1400 answers. If the TAD is enabled, you must call and let the line ring once; hang up and call back again within 30 seconds. The 1400 will answer on the first ring and acknowledge the alarm.	When calling the 1400, and the TAD is disabled, allow the telephone to ring 10 times. Refer to Chapter 5.

COMMUNICATIONS/DIAL-OUT *(continued)*

Problem 4

The 1400 recites the alarm message or Status Report over the telephone, but is silent at the installation site.

Cause	Solution
The local voice mute feature is in effect.	Deactivate local voice mute. Refer to the programming steps in Chapter 5.

Problem 5

The 1400 and telephone answering device (sharing the same line) answer incoming calls simultaneously.

Cause	Solution
The 1400's number of Rings Until Answer is set to equal the number of rings set for the telephone answering device.	Change the number of Rings Until Answer for the 1400. Refer to Chapter 5.

TEMPERATURE MONITORING:

Problem 1

Can't program temperature limits; or the unit won't read the temperature sensor.

Cause	Solution
The zone isn't configured to read a temperature sensor.	Press SET and CONFIGURE to program the zone. For 10K thermistor, you must manually configure. See Chapter 4.

Problem 2

The temperature reading is -121° F or -85° C [2.8K]; or -87° F or -85° C [10K].

Cause	Solution
The temperature sensor has been disconnected or has broken wires.	Examine the wires to temperature sensor and connect or replace wiring.

Problem 3

The temperature reading is 115° F or 57° C [2.8K]; or 168° F or 76° C [10K].

Cause	Solution
Temperature sensor wires are touching or have shorted.	Verify and correct wiring.

TEMPERATURE MONITORING *(continued)*

Problem 4

Temperature reading is inaccurate.

Cause	Solution
a) The zone is configured for the wrong type of thermistor (i.e., 2.8k vs. 10k)	Manually configure the zone as described in Chapter 4.
b) Temperature sensing may be affected by a source of ambient heat (ie., direct sunlight, or heat duct proximity).	Try moving the sensor to a different location.
c) Temperature may require calibration.	After moving or placing the sensor away from ambient heat sources, the temperature may be calibrated to offset inaccurate normal reading by several degrees. Refer to Chapter 4.
d) The unit is using the wrong temperature scale (Fahrenheit vs. Celsius).	Verify temperature scale. Refer to Chapter 4.

4–20mA MONITORING:

Problem 1

Can't program 4–20mA range; or the unit won't read the 4–20mA sensor.

Cause	Solution
The zone isn't configured to read a 4–20mA sensor.	Press SET and CONFIGURE to program the zone. See Chapter 4 for information on zone configuration.

Problem 2

The zone input is not reading correctly.

Cause	Solution
a) No power connected to the transducer.	Connect a power supply as shown in Chapter 2.
b) Incorrect wiring.	Inspect wiring. Make sure polarity is correct as shown in Chapter 2.
c) The table range is incorrectly programmed.	Program the table range for the cailibrated range of the transducer.
d) The input is not configured for 4–20mA.	Configure the zone for 4–20mA. Refer to Chapter 4.
e) Multiple devices connected in loop.	The 1400's zone is single-ended and terminates to ground. Because of this, the 1400 must be the last device in the loop, and in some cases the ONLY device. For certain installations, it may be necessary to use a signal isolator.

SOUND LEVEL MONITORING:

Problem 1

False high sound alarms occur frequently.

Cause	Solution
a) The programmed sound sensitivity results in over-sensitivity to non-alarm sound as well as alarm sound.	Reprogram the sound sensitivity (calibration). Refer to Chapter 4.
b) Sound Recognition Time is too short.	Lengthen the sound Recognition Time. Refer to Chapter 4.

Problem 2

High sound does not cause an alarm.

Cause	Solution
a) The microphone is not close enough to the high sound source, or the programmed sound setting results in a lack of sensitivity to high sound.	Move the microphone closer or reprogram the sound sensitivity. Refer to Chapter 4.
b) No remote microphone (optional) connected to the unit.	Connect a remote microphone to the Mic terminals.

OTHER MONITORING:

Problem 1

Alarm status of a zone is incorrect.

Cause	Solution
Incorrect zone configuration.	Reconfigure the zone. See Chapter 4.

Problem 2

False power-out alarms.

Cause	Solution
Programmed Recognition Time is too short.	AC power may be subject to brief interruptions. To avoid frequent, false alarms, increase the power Recognition Time. Refer to Chapter 4.

Problem 3

The 1400 does not recognize power failure.

Cause	Solution
a) Battery is either incorrectly installed or drained.	To verify proper battery function, unplug the unit and verify continued operation using battery only. If unit ceases to function, replace the battery. Refer to Appendix B.
b) Recognition time setting is too long.	Reprogram Recognition Time. Set the Recognition Time to the minimum required before a valid alarm occurs. If possible, test the condition by deliberately creating an alert condition. Refer to Chapter 4.

OTHER MONITORING (continued)

Problem 4

The 1400 does not recognize any alarm.

Cause	Solution
a) Zones for alarm are disabled.	Enable the zones for alarm. See Chapter 4.
b) Programmed Recognition Time is too long.	Reprogram Recognition Time. Set the Recognition Time to the minimum required for a monitored condition to become a valid alarm. If possible, test the condition by deliberately creating an alert condition. Refer to Chapter 4.

Problem 5

The batteries drain prematurely.

Cause	Solution
The unit's AC transformer is unplugged or for some other reason full AC power is not available to the unit.	The batteries will take over powering the unit when the AC transformer is unplugged from the 120 VAC outlet. When storing the unit, be sure to turn the power switch off.

If the solutions offered above do not appear to correct the problem, apply the following steps, in the order shown.

- Turn the power switch off.
- Wait one minute for the 1400 to completely power down.
- Turn the power switch on.
- Reconfigure the zones. Refer to Chapter 4.

Refer to Chapter 2, Installation, for additional information on batteries and installation procedures. Contact Sensaphone Technical Support toll-free at 1-877-373-2700.

APPENDIX D: 2.8 and 10K Thermistor Tables

2.8K Thermistor Data

Degrees Celsius	Resistance (Ohms)
-50	187,625
-40	94,206
-30	49,549
-20	27,180
-10	15,491
0	9,142
10	5,572
20	3,498
30	2,256
40	1,491
50	1,009
60	697
70	490
80	351

10K Thermistor Data

Degrees Celsius	Resistance (Ohms)
-30	135.2K
-20	78.91K
-10	47.54
0	29.49K
10	18.79K
20	12.25K
30	8,194
40	5,592
50	3,893
60	2,760
70	1,990

APPENDIX E: 1400 Technical Specifications

Environmental Inputs

Number of Zones: 4

Zone Connector: terminal block

Zone Types: N.O./N.C. contact, 2.8K (-109° to 115° F; -85° to 57° C), and 10K thermistor (-87° to 168° F; -66° to 76° C), and 4–20mA (-10,000 to 10,000)

Zone characteristics: 28KΩ to 2.5V (temperature/contact) or 250 Ohms to ground (4–20mA)

A/D Converter Resolution: 10 bits ±2 LSB

Zone Protection: Metal oxide varistors, and fast-acting diode clamps

Microphone

Internal: for recording custom voice messages

External (optional): For listening in to on-site sounds and high sound level alarms

- Mic Connector: terminal block
- Mic Type: Electret Condenser
- Mic Impedance: 2.2KΩ

Phone Interface

Terminals for connection to a two-wire analog telephone line

Line seizure terminals for connecting extension telephone devices

LED Indicators: (4) Zone Alarms, Sound, Power, Battery OK, Phone in Use, Output On, and System On

Relay Output: 2A 120VAC/2A 24VDC—Programmable for automatic or manual switching

Power Supply

Power Supply: 120VAC/9VDC 60Hz 6W wall plug-in transformer (230VAC/9VDC 50/60Hz power supply optional)

Power Consumption: 5 Watts

Power Protection: Metal Oxide Varistor

Battery Backup: 6V 1.3 AH sealed gel cell, provides up to 24 hours of back-up time

Environmental

Operating Temperature: 32–122 deg F (0–50 deg C)

Operating Humidity: 0–90% RH non-condensing

Storage Temperature: 32–140 deg F

Physical

Dimensions: 12.1"h x 7.3"w x 4.5"d

Weight: 5 lbs.

Enclosures:

• Solid Door Enclosure: ABS/PC Blended Plastic, UL94-5VB Flammability rating, NEMA Type 1, 2, 3, 3R, 4, 4X, 12 & 13, IEC529, IP66.

• Clear Door Enclosure: ABS/PC blended plastic, UL94–5VB flammability rating; UV stabilized. NEMA Type 1, 2, 3, 3R, 4, 4X, 12 &13, IEC529–IP65.

Specifications subject to change

APPENDIX F: 1400 Quick Reference Guide

Communications

ID Number
Identification number of the 1400
[SET] or [WHAT IS] + [ID/POWER]
Range=0–16 digits, Default=blank

ID Message
Custom message identifying the 1400
[SET] or [WHAT IS] + [MESSAGE] + [ID/POWER]
Max: 8 seconds Default=N/A

Zone Message
Message identifying the zone in alarm
[SET] or [WHAT IS] + [MESSAGE] + [zone #]
Max:5 seconds Default=N/A

Voice Repetitions
Number of times alarm message is repeated over the phone
[SET] or [WHAT IS] + [VOICE REPS]
Min: 1 reps, Max: 10 reps Default=3 reps

Dial-Out Phone Numbers
Phone numbers dialed to report alarm conditions
[SET] or [WHAT IS] +[PHONE NUMBER] + [number 1–8]
Max: 8 numbers, 48 digits each Default=N/A

Call Delay
Time delay until first call is made
[SET] or [WHAT IS] + [CALL DELAY] (min:sec)
Min: 00:00 Max: 60:00 Default=00:30

Intercall Time
Time delay between phone calls
[SET] or [WHAT IS] + [INTERCALL TIME](min:sec)
Min: 00:10, Max: 60:00 Default=00:30

Max Calls
Number of calls until unit self-acknowledges
[SET] or [WHAT IS] + [MAX CALLS]
Min: 0 calls, Max: 255 calls Default=100 calls

(TAD) Answering Device Compatibility
Allows 1400 to bypass answering devices on the same line
[SENSOR ON/OFF] + [RINGS/TAD/*]
On or Off, Default=Off

Rings Until Answer
Number of rings until unit answers an incoming call
[SET] or [WHAT IS] + [RINGS/TAD/*]
Min: 1 ring, Max: 15 rings DEFAULT=4 rings

Speaker Mute
Turns off the speaker during alarm conditions
[SENSOR ON/OFF] + [MESSAGE/MUTE]
On or Off Default=Off

Call Progress
Disables call progress detection feature
[SENSOR ON/OFF] + [STATUS/CONFIGURE]
On or Off Default=On

Callback Acknowledgment Allows alarm acknowledgment with 10 rings
[SENSOR ON/OFF] + [CODE]
On or Off Default=Disabled *(off)*

Tone or Pulse Dialing Dialing method—touch-tone or pulse
[SENSOR ON/OFF] + [PHONE NUMBER T/P]
Tone or Pulse Default=Tone

Alarm Programming

Temp Alarm Limits High and low temperature alarm limits
[SET] or [WHAT IS] + [LOW LIMIT] or [HIGH LIMIT]+[zone #]
Min: -109°F/-65°C Max:168°F/76°C Default=Low: 0°F; High:100°F

4–20mA Table Range Defines upper and lower range of 4–20mA sensor
[SET] or [WHAT IS] + [TABLE RANGE] + [zone #]
Min: -10,000, Max: 10,000 Default=Low: 0, High:100

4–20mA Alarm Limits High and low alarm limits
[SET] or [WHAT IS] + [LOW LIMIT] or [HIGH LIMIT] + [zone #]
Min: -10,000, Max: 10,000 Default=Low: 0, High: 100

Zone Calibrate Offset correction factor [temp/4-20mA]
[SET] or [WHAT IS] + [CALIBRATE] + [zone #]
Min: -15°/-100, Max: 15°/100 Default=0

Auto. Zone Configuration Automatically configures all zones.
[SET] + [STATUS/CONFIGURE] + 0
Default=n/a

Manual Zone Configuration To configure an individual zone type (*required* for 10K Temp)
[SET] + [STATUS/CONFIGURE] + [zone #] + [type]
1 = NO, 2 = NC, 3 = 2.8K Temp, 4 = 10K 5 = 4–20mA
Default=n/a

Recognition Time Zones 1–4 Length of time a fault condition must exist to trip an alarm
[SET] or [WHAT IS] + [REC TIME] + [zone #]
Min:00:00, Max: 540:00 Default=00:03 (min:sec)

Rec Time: Power Failure Length of time the power must be off to trip an alarm
[SET] or [WHAT IS] + [REC TIME] + [POWER]
Min: 00:00, Max: 540:00 Default=05:00 (min:sec)

Rec Time: High Sound Level Length of time the sound must be high to trip an alarm
[SET] or [WHAT IS] + [REC TIME] + [SOUND]
Min: 00:05, Max: 00:60 Default=00:08 (min:sec)

Sound Level Alarm Sensitivity Microphone sensitivity for high noise level alarm
[SET] or [WHAT IS] + [CALIBRATE] + [SOUND]
Min: 1 (most), Max: 160 (least) Default=32

Enable/Disable Zone Turns zone alarm detection on or off
[SENSOR ON/OFF] + [zone #]
On or Off Default=Enabled *(on)*

Power Alarm Enable/Disable Turns power alarm detection on or off
[SENSOR ON/OFF] + [POWER]
On or Off Default=Enabled *(on)*

Sound Alarm Enable/Disable Turns high sound level alarm detection on or off
[SENSOR ON/OFF] + [SOUND]
On or Off Default=Enabled *(on)*

Temperature Scale Selects between Fahrenheit and Celsius
[SENSOR ON/OFF] + [TEST/°F/°C]
Fahrenheit or Celsius Default=Fahrenheit

Temperature-Only Status Report A limited status report that only includes inputs configured as temperature.
[WHAT IS] + [TEST]

Designating a Zone Unused Removes zone from status and alarm reports
[SENSOR ON/OFF] + [SET] + [zone #]
On or Off Default=on

Special Functions

Dial-Out Test Mode Simulates alarm to test telephone programming
[SET] + [TEST] + [# key 1–8]
Default=none

Listen-In Time Length of listen-in time during call-in status report
[SET] or [WHAT IS] + [LISTEN TIME]
Min: 0 sec, Max: 255 sec Default=00:00 (min:sec)

Acknowledgment Code To create an individual user's 4-digit acknowledgment code
[SET] + [CODE] + [# key 1–8]
Default=*555* for single-user mode

Date & Time Internal clock/calendar
[SET] or [WHAT IS] + [DATE/TIME/#]
Date: mmddyy, Time: hhmm Default=none

Alarm History Recites last 10 alarms
[WHAT IS] + [HISTORY]
Default=n/a

Reset History Clears the alarm history
[SET] + [HISTORY]
Default=n/a

Switch Output Turns output relay on or off (in manual mode)
[SENSOR ON/OFF] + [OUTPUT]
On or Off Default=off

Output Mode Program relay output as manual or automatic for specific zone
[SET] or [WHAT IS] + [OUTPUT] + [mode number]
Default=none

Remote Security Prohibits programming changes via telephone
[SET] or [WHAT IS] + [ENTER/LOCK] + [4 digit code]
Default=unlocked

Press [ENTER] after all Key Sequences starting with [SET].
Use [SET] to establish parameters, [WHAT IS] to verify them.

SPECIAL KEY FUNCTIONS

RING/TAD/*

Used to enter a minus sign for negative alarm limits or calibrations.

DIALOUT CODES

CODE 1 Numeric pager call type
CODE 2 Inserts a “Wait for answer”
CODE 3 Change to Touch-Tone dialing

APPENDIX G: Accessories

The sensors and accessories listed below are available from Phonetics, Inc., and represent the most commonly used devices. Other dry contact sensors or 4–20mA transducers, designed for more specialized applications, may also be used. Commercial or industrial electrical supply houses can provide devices to monitor virtually any condition. For further information, contact a Sensaphone Sales Associate toll-free at 1-877-373-2700.

PART NUMBER	SENSOR/ SWITCH
FGD-0006	Magnetic Reed Switch
FGD-0007	Passive Infra-Red Detector
FGD-0010	50' two-conductor #22AWG shielded accessory Cable
FGD-0013	Spot Water Detector
FGD-0022	Temp° Alert
FGD-0023	ISOTEL Surge Protector
FGD-0027	Humidistat
FGD-0049	Smoke Detector with Built-in Relay
FGD-0052	Humidity Transmitter
FGD-0053	24VDC Power Supply
FGD-0054	Power-Out Alert™
FGD-0056	Zone Water Detector w/Water Rope
FGD-0057	External Microphone
FGD-0060	Line Seizure Kit
FGD-0063	10' additional Water Rope for FGD-0056
FGD-0100	2.8K Remote Temperature Sensor
FGD-0101	2.8K Weatherproof Temperature Probe
FGD-0102	10K Weatherproof Temperature Probe
FGD-0205	Multipoint Wireless I/O System

APPENDIX H: Returning Your 1400 for Repair

In the event that the 1400 does not function properly, we suggest that you do the following:

1. Record your observations regarding the 1400's malfunction.
2. Call Sensaphone Technical Support toll-free at 1-877-373-2700 or e-mail support@sensaphone.com prior to sending the unit to Sensaphone for repair. Our product support specialists are able to diagnose and correct many unit setup and programming problems over the phone.

If the unit must be sent to Phonetics, Inc. for Servicing, please do the following:

1. Turn the power switch Off, disconnect all wiring and unplug the unit.
2. Carefully pack the unit to avoid damage in transit. Use the original container (if available) or a sturdy shipping box.
3. To avoid shipping delays, you must include the following information:

   a) Your name, address and telephone number.

   b) A note explaining the problem.

A convenient form is available for sending your unit in for repair. Just go to *www.sensaphone.com* and click *Support*, then *Repair Services.*

4. Ship your package to the address below:

   SERVICE DEPARTMENT
   Phonetics, Inc.
   901 Tryens Road
   Aston, PA 19014

5. Ship prepaid and insured via UPS or US Mail to ensure a traceable shipment with recourse for damage or replacement.

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Test Log

Date	Inputs	Dialout	Call-In	Battery		Tested By
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	

Date	Inputs	Dialout	Call-In	Battery		Tested By
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	
	Pass ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	*Pass* ☐ *Fail* ☐	

APPENDIX 'B'

TABLET CHLORINATOR

norweco®

BIO-DYNAMIC®

FOR MODEL LF 1000, MODEL LF 2000, MODEL LF 3000

INSTALLATION AND OPERATION MANUAL

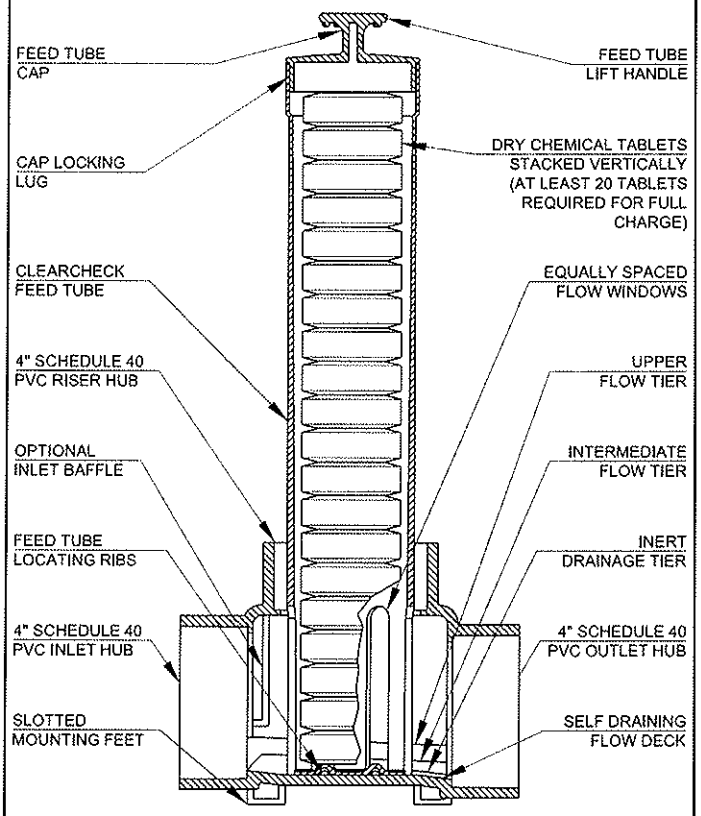
INTRODUCTION

Bio-Dynamic LF Series tablet feeders are complete dry chemical dosing systems for water, wastewater, stormwater and process water treatment. They are designed to provide automatic control over the chemical application rate and maximize installation flexibility. The LF Series tablet feeders consists of five separate models to accommodate flows ranging from less than 100 GPD through 400,000 GPD and chemical dosage ranging from 1 to 50 mg/L, depending upon the general component configuration, daily flow rate and the type of chemical tablets applied. All models of LF Series tablet feeders are manufactured from durable ABS and can be glued to Schedule 40 PVC piping. When properly installed, the Bio-Dynamic tablet feeders will provide long term, unattended operation and precise chemical application throughout their rated flow ranges. Please familiarize yourself with the contents of this manual before proceeding with installation and operation.

SYSTEM APPLICATION

Bio-Dynamic LF Series tablet feeders are designed to feed 2 5/8" diameter chemical tablets in gravity flow applications. These tablet feeders are not to be used for pressurized applications and must have a gravity outflow. Common applications for the LF Series tablet feeders are treating flows from septic tanks; aerobic treatment units; sand filters; rock reed filters; curtain drains; constructed wetlands; marine sanitation devices (MSD); individual, community and municipal drinking water systems; process water systems; reservoirs; water towers; cooling towers and irrigation systems. All LF Series tablet feeders can be installed at grade, in-line or below grade.

BIO-DYNAMIC® DRY CHEMICAL FEEDER



TABLET FEEDER MODEL LF 1000

HOW THE LF SERIES TABLET FEEDERS WORK

Bio-Dynamic LF Series tablet feeders are flow rated proportional chemical dosing units. Flow to be treated enters the tablet feeders through the 4" integral inlet hub. The liquid then proceeds to the flow deck where the chemical tablets are contained in one to three chemical feed tubes. The number of chemical feed tubes varies by model. The flow deck has three levels (tiers) which accommodate varying hydraulic loads and properly channels liquid to the chemical tablets. Active chemicals are released into the flow stream as the liquid erodes the tablets. When the incoming flow rate increases, the liquid level in the tablet feeder rises. The increase in liquid level causes the flow to contact more tablets, thereby providing the additional chemical release required for consistent treatment. As the flow decreases, it contacts fewer tablets, reducing the chemical dosage. After contact with the chemical tablets, properly treated liquid exits the tablet feeder through the 4" outlet hub.

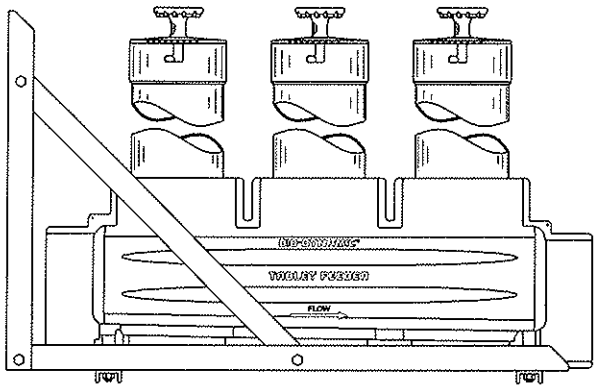
SYSTEM PERFORMANCE

Bio-Dynamic LF Series tablet feeders are listed as a chlorine dispenser for secondary effluent from residential wastewater treatment systems under NSF/ANSI Standard 46. Certification requires the use of Norweco Blue Crystal or Bio-Sanitizer disinfecting tablets and a chlorine contact tank of at least 11 1/2 gallons. Contact tank retention time must comply with the controlling regulatory jurisdiction. USEPA guidelines state "On the average, satisfactory disinfection of secondary wastewater effluent can be obtained when the chlorine residual is 0.5 ppm after 15 minutes contact." Significantly greater contact time can decrease disinfection efficiency and allow bacteria regrowth.

GENERAL INSTALLATION INSTRUCTIONS

Bio-Dynamic LF Series tablet feeders can be installed into any gravity flow water supply or wastewater treatment system. When used for potable water disinfection, the feeder is typically installed at grade following final filtration and just prior to a storage or detention tank. For wastewater disinfection applications, the tablet feeder is installed following clarification and prior to or in a chlorine contact tank. Installation can be at grade or direct buried. For dechlorination, feeders can be installed in or immediately following the chlorine contact tank. When chlorinating and dechlorinating effluent, two separate Bio-Dynamic tablet feeders must be installed. Do not mix chlorination and dechlorination tablets within the same tablet feeder.

FIGURE A



LF 3000 TABLET FEEDER WITH MOUNTING BRACKETS

CHAMBER MOUNTING BRACKETS

Integrally molded inlet and outlet hubs allow direct connection of the tablet feeder to Schedule 40 PVC piping. Adaptor couplings should be used, if necessary, to modify piping diameters and insure a secure piping connection to the tablet feeder. The effluent line must allow for a $^{1}/_{8}$" fall per linear foot of run along the entire piping run. All tablet feeders must be installed plumb and level to insure proper operation. Place a bubble level on the feeder before final installation to confirm the unit is plumb and level, side to side and end to end. Always recheck level after installation.

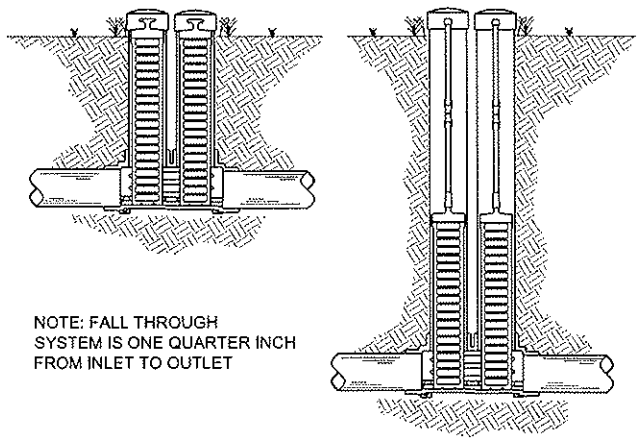
INSTALLATION AT GRADE

LF Series tablet feeders can be installed at grade, in-line or mounted in the contact tank of a water or wastewater treatment system. The installation should be accessible for routine operator maintenance. To mount the unit, use $^{5}/_{16}$" diameter corrosion resistant bolts to secure the four integrally molded mounting feet to the deck of the contact tank, concrete pad or mounting brackets, as required. For contact tank installations, use PVC or aluminum mounting brackets to prevent corrosion (See Figure A).

DIRECT BURIAL INSTALLATION

All models of LF Series tablet feeders may be installed below grade without a manhole or secondary enclosure. Prepare an excavation to the proper depth (See Figure B), including a sand or fine gravel leveling pad at least 4" thick. The tablet feeder must be supported by this pad before inlet and outlet piping is attached to the feeder. Excavated trenches should be smooth and free of debris to prevent damage to the pipe. Connecting lines should be laid continuously and unspliced to undisturbed earth beyond the limits of the excavation (See Figure C). Schedule 40 PVC, cast iron or similar materials may be used, subject to the approval of local codes. Attach the inlet and outlet lines to the inlet and outlet hubs using ABS compatible glue. A 4" Schedule 40 PVC pipe with tamper-proof cap (not supplied) will be used as a riser to grade. Connect the pipe to the riser hub using ABS compatible glue. Do not cement the cap. Check the system for plumb and level from side to side, end to end and vertically along the riser pipe. Backfill the excavation. Fine, loose fill should be used to backfill the excavation and plumbing line trenches. Exercise care when backfilling. Finished grade should be at least 6" below the top of the riser pipe and should slope away for surface drainage. Recheck that the feeder is plumb and level.

FIGURE B



NOTE: FALL THROUGH SYSTEM IS ONE QUARTER INCH FROM INLET TO OUTLET

LF 2000 SERIES TABLET FEEDERS

DIRECT BURIAL AND REMOTE DIRECT BURIAL

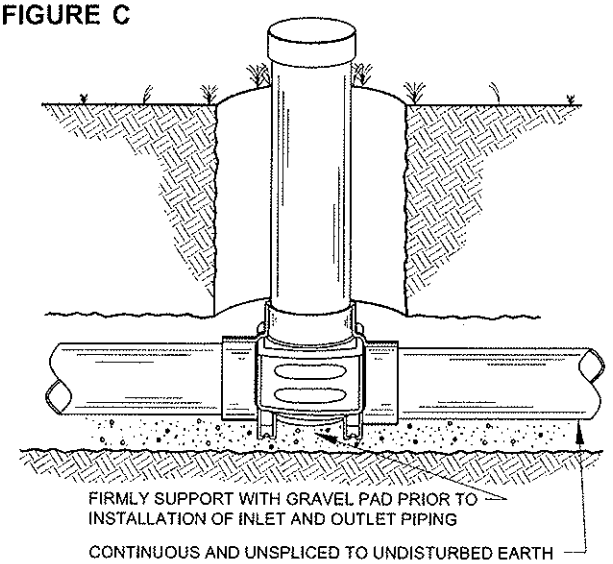
EXISTING SYSTEM RETROFIT

If the existing treatment system piping is in good condition, the feeder can be fitted directly into the appropriate location. When installing a tablet feeder into an existing disinfection system, it is recommended that the chlorine contact tank be pumped and thoroughly cleaned with a diluted bleach solution prior to installation of the feeder. Failure to properly clean the contact tank may result in inadequate disinfection of the wastewater. It is also necessary to inspect all upstream and downstream treatment components to confirm that they are installed and functioning properly.

TIERED FLOW DECK

A multi-tiered flow deck is incorporated in all LF Series tablet feeders. This allows consistent chemical application to low, sustained, variable, intermittent and surge flows. Liquid is channeled through the three tiers of the flow deck in proportion to the hydraulic load (See Figure D). The lowest tier of the flow deck is the inert drainage tier. The inert drainage tier directs liquid to the feed tube during low flow conditions and forms a drainage channel to dry the tablets when there is no flow. As the flow increases, the liquid is channeled through the intermediate flow tier. This tier directs the increased flow to the chemical tablets and allows more tablets to contact the liquid. At higher flow rates, the liquid rises to the upper flow tier. The upper tier dissipates excess flow velocity and produces a consistent chemical dosage. The flow deck incorporates a retaining ring with locating ribs for the feed tubes. The locating ribs engage positioning slots in the feed tube to secure the tube in the proper installation position for the feeder's rated capacity.

FIGURE C



CONTINUOUS AND UNSPLICED

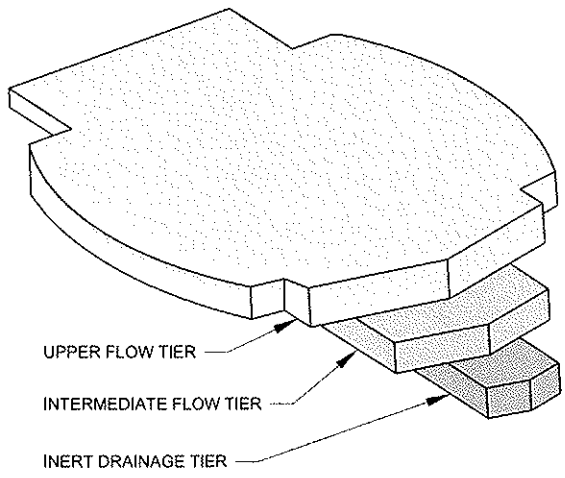
CLEARCHECK® FEED TUBE AND CAP

The LF Series tablet feeders are equipped with molded, chemical feed tubes with twist lock caps. Each feed tube and cap are constructed of NSF/ANSI Standard 61 listed PVC for durability and long life. The feed tube is manufactured with the translucent ClearCheck design. This design allows the operator or service provider to determine whether tablet refill is required simply by visual inspection without removing the tube from the feeder. The feed tube utilizes chemical tablets with the nominal weight and dimensions of 5 ounces, 2 5/8" diameter and 13/16" to 1" height. Slots molded directly into the bottom of the feed tube allow the chemical tablets to dry during intermittent or prolonged no flow periods. The twist lock cap fits securely inside the chemical feed tube to allow convenient installation of the tube and cap within a 4" Schedule 40 PVC riser pipe.

REMOTE REMOVAL SYSTEM

A remote removal system is available for direct burial installations to allow for safe removal, recharge and reinstallation of the feed tube from grade. The remote removal system consists of a top-threaded feed tube cap, one extension and one handle. For use, replace the standard cap with the top-threaded cap. The top-threaded cap locks into the feed tube, then the extension and handle are threaded onto the top of the new cap (See Figure E). Additional extensions are available for deeper installations and can be added or removed any time. The extension(s) and handle remain in place during system operation and standard feed tube filling instructions apply.

FIGURE D



THREE TIERED FLOW DECK

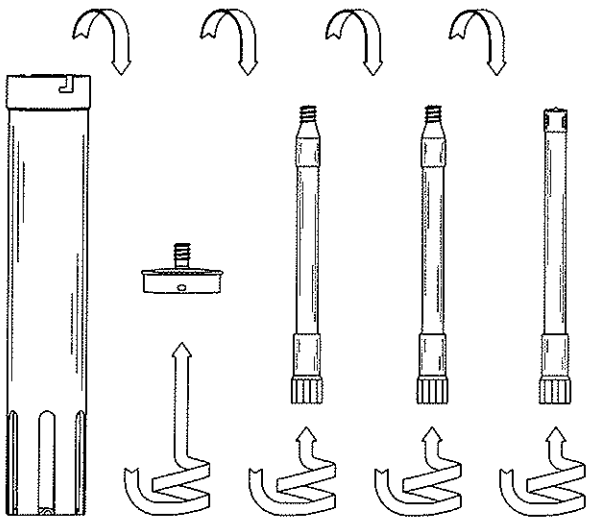
FILLING AND INSTALLING THE FEED TUBE

Before handling any chemical tablets, carefully read the product container label and the **CAUTION** section of these instructions. When filling the feed tube, always wear rubber gloves and safety goggles or a face shield for proper protection. Follow all handling instructions for the chemical tablets used. To fill the feed tube, remove it from the feeder. Rinse the feed tube and cap thoroughly with fresh water. Dry as required. Hold the tube, slotted end up, at a 30° to 45° angle and slide the chemical tablets into the open feed tube, one tablet at a time. Insure that each tablet lies flat, against the next and evenly on top of one another, in the feed tube (See Figure F). Use a gloved hand to retain the tablets inside the open end of the inverted tube until it has been evenly and completely filled. Carefully return the tube to the upright position. Replace the cap and slide the feed tube into the body of the feeder, slotted end down. The slots in the bottom of the feed tube must properly engage the locating ribs molded into the flow deck. Be sure the feed tube is fully engaged within the feeder and rests evenly on the flow deck. Utilize the Chemical Consumption Record on the back of this manual to track the chemical refill pattern.

BIO-SANITIZER® DISINFECTING TABLETS

the tablet feeder is to be used for the disinfection of water or wastewater, a 10 lb., 25 lb., 45 lb. or 100 lb. supply of Bio-Sanitizer disinfecting tablets is available from your local distributor. Bio-Sanitizer tablets insure dependable disinfection for water and wastewater treatment system flow and other applications where a predictable long-term source of chlorine is desirable. The tablets are manufactured from pure calcium hypochlorite and contain at least 70% available chlorine. Bio-Sanitizer disinfecting tablets are registered with the USEPA for water and wastewater treatment. The tablets incorporate beveled edges to enhance the chemical dissolution pattern, providing effective and economical bacteria killing power. Each tablet is $2\frac{5}{8}$" diameter, compressed to a $\frac{13}{16}$" thickness, has an approximate weight of 5 ounces and is white in color for easy identification. The chemical application rate of Bio-Sanitizer tablets remains consistent at peak flow factors as high as four.

FIGURE E



REMOTE REMOVAL HANDLES AND CAP

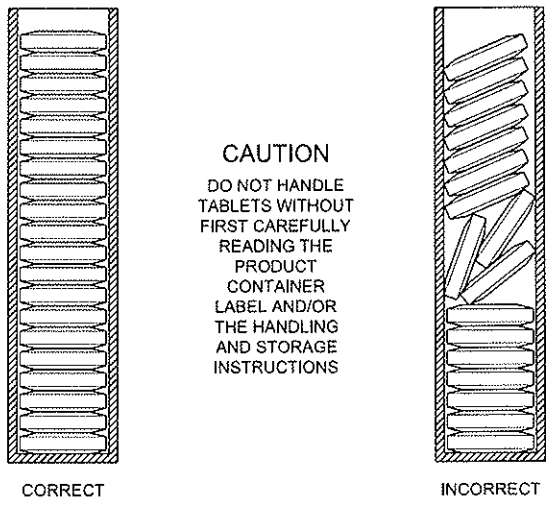
BLUE CRYSTAL® DISINFECTING TABLETS

the tablet feeder is to be used for the disinfection of residential wastewater, a 1.9 lb., 10 lb. or 100 lb. supply of Blue Crystal residential disinfecting tablets is available from your local distributor. Blue Crystal tablets are the first disinfectant that has been specifically developed for use in residential wastewater treatment applications. Formulated to maintain positive disinfection during the low, sustained, variable and intermittent flow rates that are common to residential wastewater treatment systems, Blue Crystal tablets are produced with a proprietary beveled edge design to enhance the chemical dissolution pattern. Each tablet is $2\frac{5}{8}$" diameter, compressed to a 1" thickness, has an approximate weight of 5 ounces and is white in color with blue crystals for easy identification. Containing a minimum of 70% available chlorine, Blue Crystal tablets are registered with the USEPA for wastewater treatment.

BIO-MAX® DECHLORINATION TABLETS

If the tablet feeder is to be used for the dechlorination of water or wastewater a 48 lb. supply of Bio-Max dechlorination tablets is available from your local distributor. Containing 92% sodium sulfite, the tablets are manufactured to neutralize both free and combined chlorine. Bio-Max tablets incorporate beveled edges to enhance the chemical dissolution pattern. Each tablet is $2\frac{5}{8}$" diameter, compressed to a $\frac{13}{16}$" thickness, weighs approximately 5 ounces and is green in color for easy identification. The tablets dissolve slowly, releasing controlled amounts of chemical for the instantaneous removal of residual chlorine from the water or wastewater flow. The chemical application rate of the tablets remains consistent at peak flow factors as high as four. Bio-Max tablets are formulated to remove chlorine residuals to non-detectable levels.

FIGURE F



TABLETS MUST LIE FLAT IN THE STACK

BIO-PERC® REMEDIATION TABLETS

If the tablet feeder is to be used for the bioaugmentation of wastewater, a 10 lb. supply of Bio-Perc biological remediation tablets is available from your local distributor. Bio-Perc tablets rejuvenate failing wastewater treatment systems by reducing or eliminating organic buildup in distribution lines and disposal processes. Bio-Perc tablets help sand filters and soil-based treatment systems recover their infiltrative capacity while preventing the failure of new installations. Each tablet is $2\frac{5}{8}$" diameter, compressed to a 1" thickness, has an approximate weight of 5 ounces and incorporates a beveled edge design to reduce wicking.

CAUTION: All chemicals and chemical feed systems should be handled with care. Chemicals and feed tubes should not be mixed with each other or any other products. Do not handle tablets or feed tubes without first carefully reading the product container label, MSDS information and the handling and storage instructions.

PLACING THE BIO-DYNAMIC® ON-LINE

Be sure the entire liquid stream from the facility being served flows through the tablet feeder. Confirm that the proper chemica tablets are being used in the feed tube and that the feed tube is firmly engaged into the retaining ring and locating ribs of the flov deck. After the system has been in operation for at least one hour, draw a sample of the treated effluent from the feeder outle or the contact chamber inlet to test the chemical application. For chlorination applications, testing can be done using a chlorin test kit, available from your Bio-Dynamic distributor, or a DPD Colorimetric test as outlined in the most recent edition of Standar Methods for the Examination of Water and Wastewater. Dechlorination applications may also require that a chlorine residual tes be performed. Multiple samples must be taken to insure that the system has reached equilibrium. Take samples at 15 minut intervals. When three or more consecutive samples produce the same results, the system has reached equilibrium. In direc burial installations, make sure the riser pipe extends at least 6" above grade and is covered securely by a tamper-proof pipe cap

OPERATIONAL ADJUSTMENT

LF Series feeders can be adjusted without taking the unit off-line. When fully inserted into the feeder body, the feed tube lock into locating ribs molded into the flow deck. This locked position provides the maximum chemical dose. Rotating the feed tub clockwise, one-quarter (1/4) turn from its fully locked position raises the feed tube approximately one-eighth inch (1/8"). By raisin the feed tube, the chemical delivery can be reduced. Please refer to the Operational Adjustment Chart at the bottom of this pag for routine guidance. If there are additional questions regarding operation, contact your local Bio-Dynamic distributor. For furthe reference, a red identification tag with the contact information of the manufacturer is attached to the feeder.

ROUTINE MAINTENANCE

LF Series feeders require very little maintenance other than periodic cleaning and refilling of the feed tubes. When performin maintenance, always wear rubber gloves and safety goggles or a face shield and follow the procedures outlined in the handlin instructions for the chemicals used in the feeder. Before refilling the feed tubes, rinse the tube and cap thoroughly with fresh wate Occasionally, a feed tube may need to be cleaned with a brush. A service brush for cleaning the feed tube and flow deck is availabl from your local Bio-Dynamic distributor. To use the brush, remove the extension handle from the top-threaded feed tube cap an screw the brush into the handle. When refilling the feed tube, check the inside of the feeder and rinse any residue with a lov pressure hose. Dry the feed tube with a clean cloth before reinserting chemical tablets. The liquid flow will normally prever accumulation of debris during routine operation. Debris that may become lodged within the feeder during a malfunction of th upstream treatment system can be removed with the cleaning brush or a gloved hand.

INTERMITTENT USAGE

During a period of intermittent use or extended period of non-use, feed tubes should be removed and stored in a well-ventilatec dry, secure location. Refer to the tablet container label and material safety data sheet for detailed safety, storage and/or disposa instructions for the chemical tablets. Reinstall the riser cap securely for the time period the system will be unattended.

OPERATIONAL ADJUSTMENT CHART

Condition	Possible Cause	Recommended Remedy
Insufficient Chemical Application	Feed tube empty	Refill chemical tablets
	Incorrect type of tablets used	Replace using properly approved tablets
	Feed tube not properly installed	Install the feed tube flat on flow deck
	Tablets jammed in the feed tube	Remove, clean and properly refill the feed tube
	Excess solids in effluent	Troubleshoot treatment plant
	Debris clogging bottom of the feed tube	Remove, clean and properly refill the feed tube
	Tablet feeder not level	Adjust mounting position
	Tablets more than one year old	Remove, clean and properly refill the feed tube
Overapplication of Chemical	Incorrect type of tablets used	Replace using properly approved tablets
	Blockage at outlet	Rinse feeder with fresh water to remove blockage
	Too many tablets immersed	Rotate the feed tube clockwise 90 degrees
	Excess hydraulic flow	Equalize flow prior to the tablet feeder
	Recirculation piping not properly adjusted	Increase percentage of recirculation flow
	Tablet feeder not level	Adjust mounting position

SYSTEM SAFETY

All installations not protected by a safety fence or locked grating should be equipped with a Schedule 40 PVC riser pipe with tamper-proof pipe cap. Only authorized personnel should have access to the tablet feeder and its components. Confined space entry equipment (Occupational Safety and Health Regulations OSHA 29, CFR1910.146) is not required for a properly installed Bio-Dynamic LF Series tablet feeder in a direct burial installation. Maintenance of the tablet feeder can be performed from grade. Rubber gloves and safety goggles or a face shield should always be worn when providing service to any chemical feed system. Toxic fumes present in wastewater and/or tablets may accumulate within the feeder and cause personal injury or death. All safety and handling procedures for chemical tablets must be followed completely. Water and wastewater treatment chemicals can be very dangerous. Thoroughly read chemical container label before use. Only trained personnel using the proper safety procedures and approved equipment should be allowed in the vicinity of a treatment system.

BIO-DYNAMIC® LIMITED WARRANTY

The Bio-Dynamic Model LF Series tablet feeders are backed by a comprehensive ten year limited warranty. The purchaser is protected from defects in material and workmanship, under normal use and service, for a period of ten years from the date of original purchase. The Bio-Dynamic distributor will provide a warranty registration card, as well as detailed warranty and exchange information, to each purchaser. This warranty is not effective unless the warranty registration card is returned to the factory within 30 days of purchase. If the tablet feeder or components require service or replacement, do not use or dismantle the unit. Contact your local, authorized Bio-Dynamic distributor to arrange for inspection, service or replacement of the system or component. After inspection, the distributor will return the tablet feeder or component, as required, to the factory and replace the necessary items according to the terms of the limited warranty.

CHEMICAL CONSUMPTION RECORD

For your reference, please document chemical consumption and maintenance on the following chart:

DATE	DESCRIPTION

norweco®

Engineering the future of water and wastewater treatment

DISTRIBUTED LOCALLY BY:

220 REPUBLIC STREET
NORWALK, OHIO, USA 44857-1156
TELEPHONE (419) 668-4471
FAX (419) 663-5440
www.norweco.com

APPENDIX 'C'

IRRIGATION PUMP & MOTOR

J-CLASS SandHandler

6" High Capacity Pumps

Ideal for farm, home, irrigation, industry, municipal and commercial applications, equipped with the power, performance and reliability you expect from Franklin Electric.

Flow ratings of 50, 75, 100 and 125 gpm with TDH up to 1200 ft.

Horsepower ranges from 1-1/2 to 40 hp.

Features:

- Heavy-duty stainless steel discharge head and motor bracket
- Stainless steel shaft, shell, intake screen and cable guard provides corrosion resistance and longer pump life
- Glass-filled Noryl®* impeller stage assemblies provide exceptional strength and durability
- Ceramic shaft sleeve and rubber discharge bearing minimize bearing wear and shaft misalignment
- 3" NPT tapping in heavy-duty stainless steel discharge head
- Modular motor bracket enabling 4" or 6" motor mount for 5-10 horsepower units
- One-year unconditional warranty against failure from sand locking in abrasive well conditions

* Noryl® is a registered trademark of G.E.

System Solutions

Franklin Electric
The Company You Trust Deep Down

Ordering Information

6" Pump Ends:

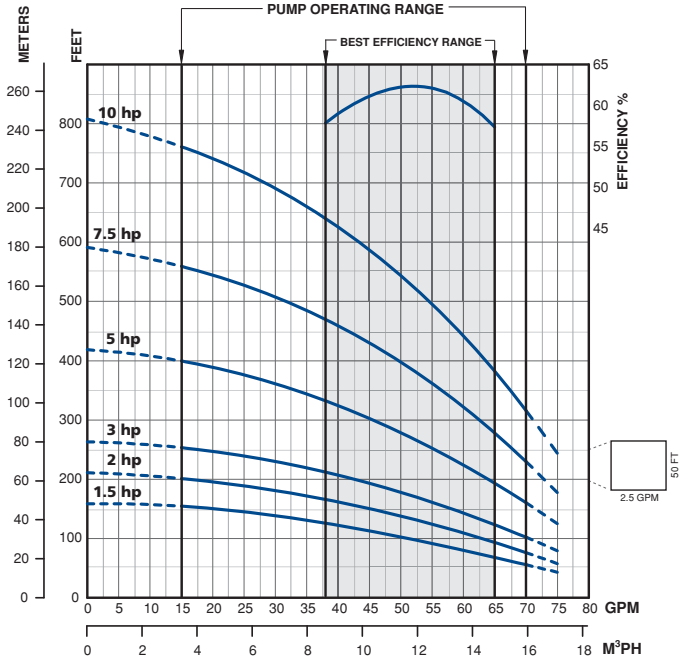
1.5 - 25 HP 6" PUMP ENDS							
GPM	HP	STAGES	MOTOR FIT	ORDERING INFO.		DIMENSIONS	WT.
				MODEL NO.	ORDER NO.	PEA	
50	1.5	3	4"	50JS15S6-PE	94815003	13.51	30
	2	4	4"	50JS2S6-PE	94815004	15.13	31
	3	5	4"	50JS3S6-PE	94815005	16.76	32
	5	8	4" & 6"	50JS5S6-PE	94815008	21.63	36
	7.5	11	4" & 6"	50JS75S6-PE	94815011	26.51	40
	10	15	4" & 6"	50JS10S6-PE	94815015	32.94	46
75	3	3	4"	75JS3S6-PE	94817503	13.51	30
	5	5	4" & 6"	75JS5S6-PE	94817505	16.76	32
	7.5	7	4" & 6"	75JS75S6-PE	94817507	20.01	35
	10	9	4" & 6"	75JS10S6-PE	94817509	23.26	38
	15	13	6"	75JS15S6-PE	94817513	29.76	43
	20	17	6"	75JS20S6-PE	94817517	36.19	48
	25	23	6"	75JS25S6-PE	94817523	46.00	54
100	5	3	4" & 6"	100JS5S6-PE	94810003	14.62	30
	7.5	5	4" & 6"	100JS7S6-PE	94810005	18.51	32
	10	6	4" & 6"	100JS10S6-PE	94810006	20.49	34
	15	9	6"	100JS15S6-PE	94810009	26.31	38
	20	13	6"	100JS20S6-PE	94810013	34.07	43
	25	16	6"	100JS25S6-PE	94810016	39.94	47
125	5	2	4" & 6"	125JS5S6-PE	94812502	12.94	29
	7.5	3	4" & 6"	125JS7S6-PE	94812503	15.05	30
	10	4	4" & 6"	125JS10S6-PE	94812504	17.13	31
	15	7	6"	125JS15S6-PE	94812507	23.37	35
	20	9	6"	125JS20S6-PE	94812509	27.54	38
	25	11	6"	125JS25S6-PE	94812511	31.70	40
	30	13	6"	125JS30S6-PE	94812513	35.87	43
	40	18	6"	125JS40S6-PE	94812518	46.27	48

Note: All dimensions are in inches. Discharge is 3" NPT. Maximum diameter across cable guard is 5.5" on all models. Weight in pounds.

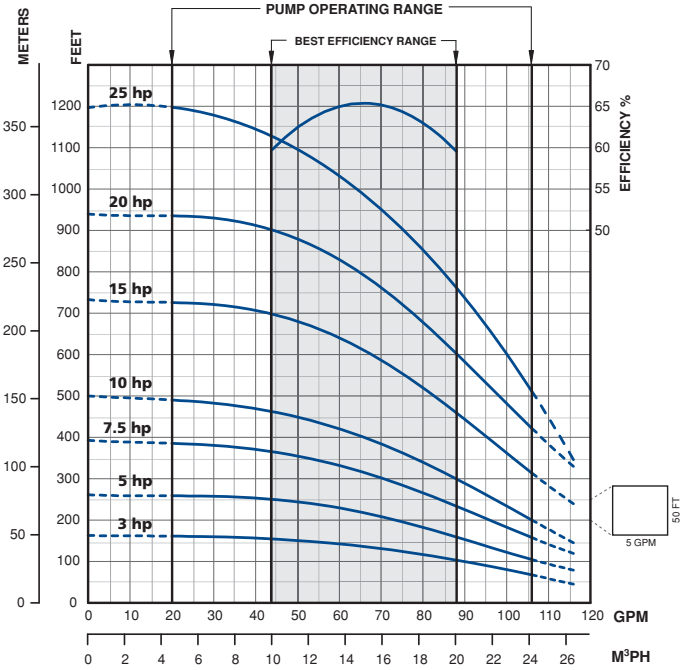
6" High Capacity Pumps

Perfomance Curves:

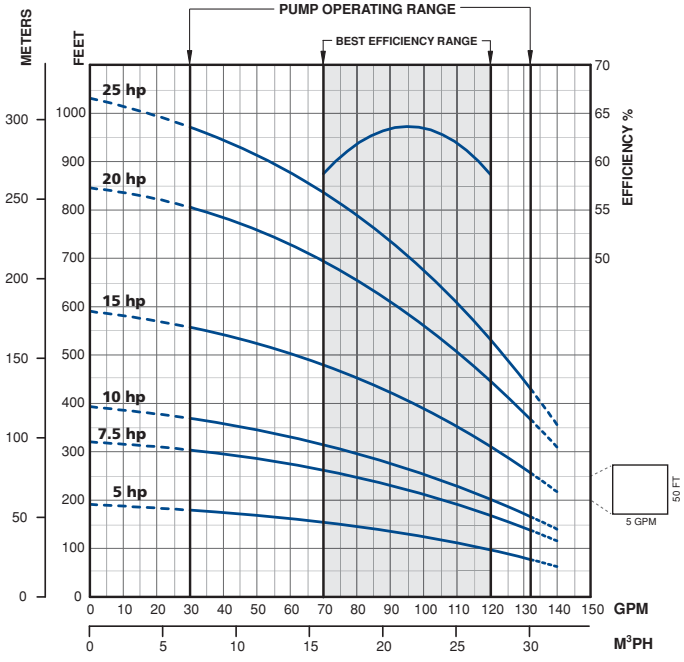
50 gpm:



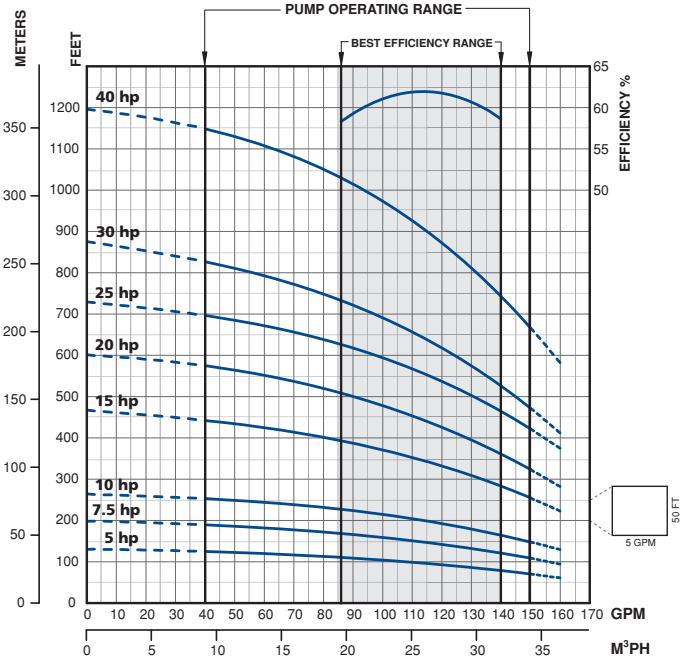
75 gpm:



100 gpm:



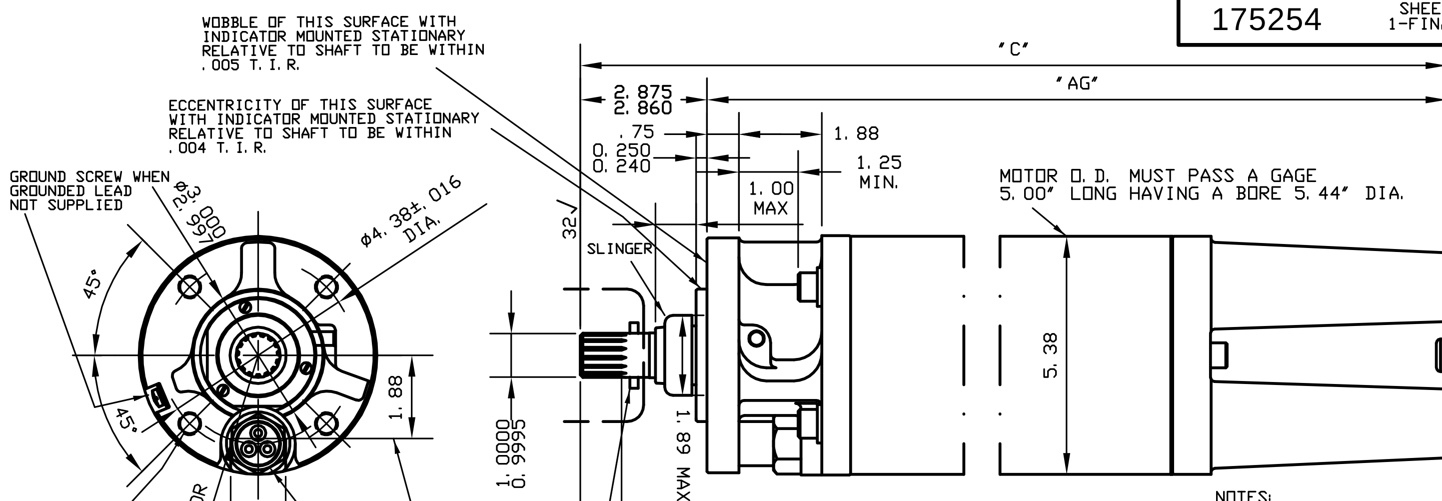
125 gpm:



Franklin Electric
The Company You Trust Deep Down

Franklin Electric
400 East Spring Street, Bluffton, IN 46714
Tel: 260.824.2900 • Fax: 260.824.2909
www.franklin-electric.com

MJ2004 09/09



175254	SHEET 1-FINAL

DO NOT SCALE PRINT

UNLESS OTHERWISE SPECIFIED TOLERANCE-DECIMAL		
BASIC DIM.	2 PLACES	3 PLACES
UNDER 6"	±.02	±.005
6" TO 24"	±.03	±.010
24" TO 72"	±.06	±.020
TOLERANCE-FRACTIONAL		
UNDER 6"	±1/64	ANGLE ±1/2°
6" TO 24"	±1/32	
24" TO 72"	±1/16	

PAR NO. ECN. NO.	FILM	NO.	CHANGE	DATE INITIALS
205934		23	1.875/2.860 WAS 2.875/2.869	CJC 4-2-07

NOTES:

1) SHAFT FREE END PLAY LIMITS .026MIN. - .050 MAX.
2) PHASE DESIGNATION OF LEADS FOR CW ROTATION (VIEWING OPP. SHAFT) ON 3 PHASE MOTORS
   PHASE 1 (T1) OR 'A' BLACK LEAD
   PHASE 2 (T2) OR 'B' WHITE, YELLOW OR BLACK LEAD
   PHASE 3 (T3) OR 'C' RED OR BLACK LEAD.
3) STANDARD WATER WELL MODELS INCLUDE 150 INCH REMOVABLE LEADS; NI-RESIST, 316 S.S. AND SPECIAL WATER WELL MODELS REQUIRE CABLES OR LEADS SOLD SEPARATELY.
4) 20,25 AND 30 HP 200 AND 230 VOLT; ALL 40,50 AND 60 3 PHASE; AND ALL 15 HP 1 PHASE USE #8 LEAD WIRE (.360 MAX. DIA.); ALL OTHERS USE #10 (.300 MAX. DIA.).
5) THIS SURFACE TO BE FLAT & SQUARE WITH SHAFT AXIS WITHIN .001 T.I.R.
6) SPLINE DATA - 15 TOOTH 16/32 DIAMETRAL PITCH FILLET ROOT SIDEFIT, CLASS 5 SPLINE PER ANSI B.92.1-1996 SHORT DEDENDUM INTERNAL SPLINE. SPLINE DATA ON DRAWING 151560.
7) ANY ADDITIONAL LABELS ADDED TO THE STATOR SHELL MUST CLEAR THE WELDS BY A MINIMUM OF 1/4 INCH.

* FOR METRIC DIMENSIONS IN MM MULTIPLY DIMENSION SHOWN BY 25.4

GR	HP	PH	HZ	AG	C	DOWN THRUST CAPACITY 60 CYCLE	DOWN THRUST CAPACITY 50 CYCLE	UP THRUST CAPACITY 60 CYCLE	UP THRUST CAPACITY 50 CYCLE
						CONTINUOUS		3 MIN. MAX.	
814	35	3	60/50	38.25	41.13	3500 LB.	15500 N.	300 LB.	1350 N.
813	17.5	3	60/50	29.28	32.16	3500 LB.	15500 N.	300 LB.	1350 N.
812	12.5	3	60/50	26.72	29.60	3500 LB.	15500 N.	300 LB.	1350 N.
811	OBSOLETE								
810	60	3	60/50	61.31	64.19	6000 LB.	27500 N.	300 LB.	1350 N.
809	50	3	60/50	55.31	58.19	6000 LB.	27500 N.	300 LB.	1350 N.
808	40	3	60/50	40.81	43.69	6000 LB.	27500 N.	300 LB.	1350 N.
807	30	3	60/50	35.69	38.56	3500 LB.	15500 N.	300 LB.	1350 N.
806	25	3	60/50	33.13	36.00	3500 LB.	15500 N.	300 LB.	1350 N.
	15	1	60						
805	20	3	60/50	30.56	33.44	3500 LB.	15500 N.	300 LB.	1350 N.
	10	1	60						
804	15	3	60/50	28.00	30.87	3500 LB.	15500 N.	300 LB.	1350 N.
	7 1/2	1	60			3500 LB.			
803	10	3	60/50	25.44	28.31	3500 LB.	15500 N.	300 LB.	1350 N.
	5	1	60			3500 LB.			
802	7 1/2	3	60/50	24.19	27.06	3500 LB.	15500 N.	300 LB.	1350 N.
801	5	3	60/50	22.88	25.75	3500 LB.	15500 N.	300 LB.	1350 N.

SIMILAR TO 175238		Franklin Electric Bluffton, Indiana 46714 USA
	6" REDESIGN	TITLE OUTLINE 1985 6" REDESIGN
NEXT ASSY.	FIRST USED ON	
APPLICATION		
DRAWN BY RC 2-4-85	CHECKED BY DLM 8-23-94	SIZE B · CODE IDENT. NO. 7980 · DWG. NO. 175254
APPROVED WLN	RELEASE DATE 4-10-85	SCALE · AutoCAD · SHEET 1 OF FINAL

175254 SHEET 1-FINAL

FRANKLIN ELECTRIC

2011 AIM MANUAL

SUBMERSIBLE MOTORS

Application • Installation • Maintenance

60 Hz, Single-Phase and Three-Phase Motors

System Solutions

Franklin Electric

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 WITHIN 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 INSTALACION 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 INSTALACION Y PUESTA EN MARCHA DE LOS EQUIPOS, ESTAN DISPONIBLES CON LOS DISTRIBUIDORES, FABRICANTES 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 PRACTIQUE NATACION.

Commitment to Quality

Franklin Electric is committed to provide customers with defect free products through our program of continuous improvement. Quality shall, in every case, take precedence over quantity.

Franklin Electric

SUBMERSIBLE MOTORS

60 Hz, Single-Phase and Three-Phase

Application • Installation • Maintenance Manual

The submersible motor is a reliable, efficient and trouble-free means of powering a pump. Its needs for a long operational 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
4. An appropriate pump load

All considerations of application, installation, and maintenance of submersible motors relating to these four areas are presented in this manual. Franklin Electric's web page, www.franklin-electric.com, should be checked for the latest updates.

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Storage

Franklin Electric submersible motors are a water-lubricated design. The fill solution consists of a mixture of deionized water and Propylene Glycol (a non-toxic antifreeze). The solution will prevent damage from freezing in temperatures to -40 °F (-40 °C); motors should be stored in areas that do not go below this temperature. The solution will partially freeze below 27 °F (-3 °C), but no damage occurs. Repeated freezing and thawing should be avoided to prevent possible loss of fill solution.

There may be an interchange of fill 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 100° to 130 °F, 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 to 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. Rapid cycling can also cause motor spline damage, bearing damage, and motor overheating. All these conditions can lead to reduced motor life.

The pump size, tank size and other controls should be selected to keep the starts per day as low as practical for longest life. The maximum number of starts per 24-hour period is shown in table 3.

Motors should run a minimum of one minute to dissipate heat build up from starting current. Six inch and larger motors should have a minimum of 15 minutes between starts or starting attempts.

Table 3 Number of Starts

MOTOR RATING		MAXIMUM STARTS PER 24 HR PERIOD	
HP	KW	SINGLE-PHASE	THREE-PHASE
Up to 0.75	Up to 0.55	300	300
1 thru 5.5	0.75 thru 4	100	300
7.5 thru 30	5.5 thru 22	50	100*
40 and over	30 and over	-	100

* Keeping starts per day within the recommended numbers provides the best system life. However, when used with a properly configured Reduced Voltage Starter (RVS) or Variable Frequency Drive (VFD), 7.5 thru 30 hp three-phase motors can be started up to 200 times per 24 hour period.

Mounting Position

Franklin submersible motors are designed primarily for operation in the vertical, shaft-up position.

During acceleration, the pump thrust increases as its output head increases. In cases where the pump head stays below its normal operating range during startup and full speed condition, the pump may create upward thrust. This creates upward thrust on the motor upthrust bearing. This is an acceptable operation for short periods at each start, but running continuously with upthrust will cause excessive wear on the upthrust bearing.

With certain additional restrictions as listed in this section and the Inline Booster Pump Systems sections of this manual, motors are also suitable for operation in positions from shaft-up to shaft-horizontal. As the mounting position becomes further from vertical and closer to horizontal, the probability of shortened thrust bearing life increases. For normal motor life expectancy with motor positions other than shaft-up, follow these recommendations:

1. Minimize the frequency of starts, preferably to fewer than **10** per 24-hour period. Six and eight inch motors should have a minimum of 20 minutes between starts or starting attempts
2. Do not use in systems which can run even for short periods at full speed without thrust toward the motor.

Transformer Capacity - 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 4 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.

Table 4 Transformer Capacity

MOTOR RATING		TOTAL EFFECTIVE KVA REQUIRED	SMALLEST KVA RATING-EACH TRANSFORMER	
HP	KW		OPEN WYE OR DELTA 2- TRANSFORMERS	CLOSED WYE OR DELTA 3- TRANSFORMERS
1.5	1.1	3	2	1
2	1.5	4	2	1.5
3	2.2	5	3	2
5	3.7	7.5	5	3
7.5	5.5	10	7.5	5
10	7.5	15	10	5
15	11	20	15	7.5
20	15	25	15	10
25	18.5	30	20	10
30	22	40	25	15
40	30	50	30	20
50	37	60	35	20
60	45	75	40	25
75	55	90	50	30
100	75	120	65	40
125	93	150	85	50
150	110	175	100	60
175	130	200	115	70
200	150	230	130	75

NOTE: Standard kVA ratings are shown. If power company experience and practice allows transformer loading higher than standard, higher loading values may be used to meet total effective kVA required, provided correct voltage and balance is maintained.

Effects of Torque

During 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-handed 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 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 10 lb-ft per motor horsepower is recommended (table 4A). It may be necessary to tack or strap weld pipe joints on high horsepower pumps, especially at shallower settings.

Table 4A Torque Required (Examples)

MOTOR RATING		MINIMUM SAFE TORQUE-LOAD
HP	KW	
1 hp & Less	0.75 kW & Less	10 lb-ft
20 hp	15 kW	200 lb-ft
75 hp	55 kW	750 lb-ft
200 hp	150 kW	2000 lb-ft

Use of Engine Driven Generators - Single-Phase or Three-Phase

Table 5 lists minimum generator sizes based on typical 80 °C rise continuous duty generators, with 35% maximum voltage dip during starting, for Franklin's three-wire motors, single- or three-phase.

This is a general chart. The generator manufacturer should 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 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 (self-excited) generators have an extra winding in the generator stator. The extra winding senses the output current to automatically adjust the output voltage.

Generators must be sized to deliver at least 65% of the rated voltage during starting to ensure adequate starting torque. Besides sizing, generator frequency is 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 if the generator is allowed to coast down with the motor running. This same condition occurs when the generator is allowed to run out of fuel.

Follow generator manufacturer's recommendations for de-rating at higher elevations or using natural gas.

Table 5 Engine Driven Generators

NOTE: This chart applies to 3-wire or 3-phase motors. For best starting of 2-wire motors, the minimum generator rating is 50% higher than shown.

MOTOR RATING		MINIMUM RATING OF GENERATOR			
		EXTERNALLY REGULATED		INTERNALLY REGULATED	
HP	KW	KW	KVA	KW	KVA
1/3	0.25	1.5	1.9	1.2	1.5
1/2	0.37	2	2.5	1.5	1.9
3/4	0.55	3	3.8	2	2.5
1	0.75	4	5.0	2.5	3.13
1.5	1.1	5	6.25	3	3.8
2	1.5	7.5	9.4	4	5
3	2.2	10	12.5	5	6.25
5	3.7	15	18.75	7.5	9.4
7.5	5.5	20	25.0	10	12.5
10	7.5	30	37.5	15	18.75
15	11	40	50	20	25
20	15	60	75	25	31
25	18.5	75	94	30	37.50
30	22	100	125	40	50
40	30	100	125	50	62.5
50	37	150	188	60	75
60	45	175	220	75	94
75	55	250	313	100	125
100	75	300	375	150	188
125	93	375	469	175	219
150	110	450	563	200	250
175	130	525	656	250	313
200	150	600	750	275	344

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.

Use of Check Valves

It is recommended that one or more check valves always be used in submersible pump installations. If the pump does not have a built-in check valve, a line check valve should be installed in the discharge line within 25 feet of the pump and below the draw down level of the water supply. For deeper settings, check valves should be installed per the manufacturer's recommendations. More than one check valve may be required, but more than the recommended number of check valves should not be used.

Swing type check valves are **not** acceptable and should never be used with submersible motors/pumps. Swing type check valves have a slower reaction time which can cause water hammer (see next page). Internal pump check valves or spring loaded check valves close quickly and help eliminate water hammer.

Check valves are used to hold pressure in the system when the pump stops. They also prevent backspin, water hammer and upthrust. Any of these can lead to early pump or motor failure.

NOTE: Only positive sealing check valves should be used in submersible installations. Although drilling the check valves or using drain-back check valves may prevent back spinning, they create upthrust and water hammer problems.

A. Backspin - With no check valve or a failed check valve, the water in the drop pipe and the water in the system can flow down the discharge pipe when the motor stops. This can cause the pump to rotate in a reverse direction. If the motor is started while it is backspinning, an excessive force is placed across the pump-motor assembly that can cause impeller damage, motor or pump shaft breakage, excessive bearing wear, etc.

B. Upthrust - With no check valve, a leaking check valve, or drilled check valve, the unit starts under

a zero head condition. This causes an uplifting or upthrust on the impeller-shaft assembly in the pump. This upward movement carries across the pump-motor coupling and creates an upthrust condition in the motor. Repeated upthrust can cause premature failure of both the pump and the motor.

C. **Water Hammer -** If the lowest check valve is more than 30 feet above the standing (lowest static) water level, or a lower check valve leaks and the check valve above holds, a 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 can often be heard or felt. When discovered, the system should be shut down and the pump installer contacted to correct the problem.

Wells – Large Diameter, Uncased, Top Feeding and Screened Sections

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

If the pump installation does not provide the minimum flow shown in table 6, a flow inducer sleeve (flow sleeve) must be used. The conditions requiring a flow sleeve are:

- Well diameter is too large to meet table 6 flow requirements.
- Pump is in an open body of water.
- Pump is in a rock well or below the well casing.
- The well is “top-feeding” (a.k.a. cascading)
- Pump is set in or below screens or perforations.

Water Temperature and Flow

Franklin Electric’s standard submersible motors, except Hi-Temp designs (see note below), are designed to operate up to maximum service factor horsepower in water up to 86 °F (30 °C). A flow of 0.25 ft/s for 4" motors rated 3 hp and higher, and 0.5 ft/s for 6" and 8" motors is required for proper cooling. Table 6 shows minimum flow rates, in gpm, for various well diameters and motor sizes.

If a standard motor is operated in water over 86 °F (30 °C), water flow past the motor must be increased to maintain safe motor operating temperatures. See HOT WATER APPLICATIONS on page 7.

NOTE: Franklin Electric offers a line of Hi-Temp motors designed to operate in water at higher temperatures or lower flow conditions. Consult factory for details.

Table 6 Required Cooling Flow

MINIMUM GPM REQUIRED FOR MOTOR COOLING IN WATER UP TO 86 °F (30 °C).			
CASING OR SLEEVE ID INCHES (MM)	4" MOTOR (3-10 HP) 0.25 FT/S GPM (L/M)	6" MOTOR 0.50 FT/S GPM (L/M)	8" MOTOR 0.50 FT/S GPM (L/M)
4 (102)	1.2 (4.5)	-	-
5 (127)	7 (26.5)	-	-
6 (152)	13 (49)	9 (34)	-
7 (178)	20 (76)	25 (95)	-
8 (203)	30 (114)	45 (170)	10 (40)
10 (254)	50 (189)	90 (340)	55 (210)
12 (305)	80 (303)	140 (530)	110 (420)
14 (356)	110 (416)	200 (760)	170 (645)
16 (406)	150 (568)	280 (1060)	245 (930)

0.25 ft/s = 7.62 cm/sec 0.50 ft/s = 15.24 cm/sec
1 inch = 2.54 cm

Flow Inducer Sleeve

If the flow rate is less than specified, then a flow inducer sleeve must be used. A flow sleeve is always required in an open body of water. FIG. 1 shows a typical flow inducer sleeve construction.

EXAMPLE: A 6" motor and pump that delivers 60 gpm will be installed in a 10" well.

From table 6, 90 gpm would be required to maintain proper cooling. In this case adding an 8" or smaller flow sleeve provides the required cooling.

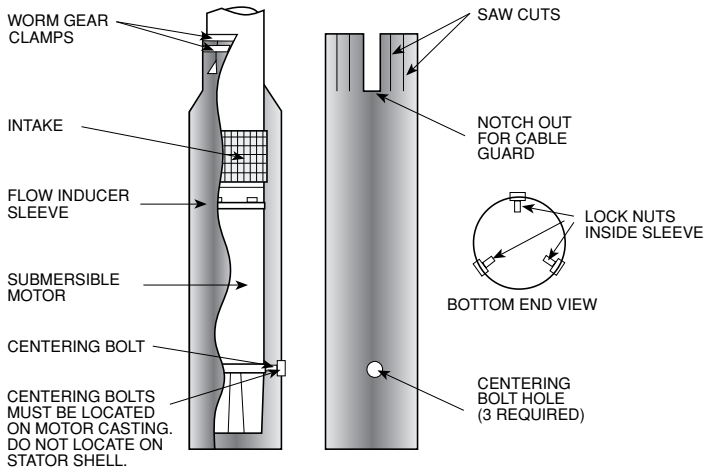

FIG. 1

Head Loss From Flow Past Motor

Table 7 lists the approximate head loss due to flow between an average length motor and smooth casing or flow inducer sleeve.

Table 7 Head Loss in Feet (Meters) at Various Flow Rates

MOTOR DIAMETER		4"	4"	4"	6"	6"	6"	8"	8"
CASING ID IN INCHES (MM)		4 (102)	5 (127)	6 (152)	6 (152)	7 (178)	8 (203)	8.1 (206)	10 (254)
Flow Rate in gpm (l/m)	25 (95)	0.3 (.09)							
	50 (189)	1.2 (.37)							
	100 (378)	4.7 (1.4)	0.3 (.09)		1.7 (.52)				
	150 (568)	10.2 (3.1)	0.6 (.18)	0.2 (.06)	3.7 (1.1)				
	200 (757)		1.1 (.34)	0.4 (.12)	6.3 (1.9)	0.5 (.15)		6.8 (2.1)	
	250 (946)		1.8 (.55)	0.7 (.21)	9.6 (2.9)	0.8 (.24)		10.4 (3.2)	
	300 (1136)		2.5 (.75)	1.0 (.30)	13.6 (4.1)	1.2 (.37)	0.2 (.06)	14.6 (4.5)	
	400 (1514)				23.7 (7.2)	2.0 (.61)	0.4 (.12)	24.6 (7.5)	
	500 (1893)					3.1 (.94)	0.7 (.21)	37.3 (11.4)	0.6 (0.2)
	600 (2271)					4.4 (1.3)	1.0 (.30)	52.2 (15.9)	0.8 (0.3)
	800 (3028)								1.5 (0.5)
	1000 (3785)								2.4 (0.7)

Hot Water Applications (Standard Motors)

Franklin Electric offers a line of Hi-Temp motors which are designed to operate in water with various temperatures up to 194 °F (90 °C) without increased flow. When a standard pump-motor operates in water hotter than 86 °F (30 °C), a flow rate of at least 3 ft/s is required. When selecting the motor to drive a pump in over 86 °F (30 °C) water, the motor horsepower must be de-rated per the following procedure.

1. Using table 7A, determine pump gpm required for different well or sleeve diameters. If necessary, add a flow sleeve to obtain at least 3 ft/s flow rate.

Table 7A Minimum gpm (l/m) Required for 3 ft/s (.91 m/sec) Flow Rate

CASING OR SLEEVE ID		4" HIGH THRUST MOTOR		6" MOTOR		8" MOTOR	
INCHES	(MM)	GPM	(L/M)	GPM	(L/M)	GPM	(L/M)
4	(102)	15	(57)				
5	(127)	80	(303)				
6	(152)	160	(606)	52	(197)		
7	(178)			150	(568)		
8	(203)			260	(984)	60	(227)
10	(254)			520	(1970)	330	(1250)
12	(305)					650	(2460)
14	(356)					1020	(3860)
16	(406)					1460	(5530)

Continued on next page

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

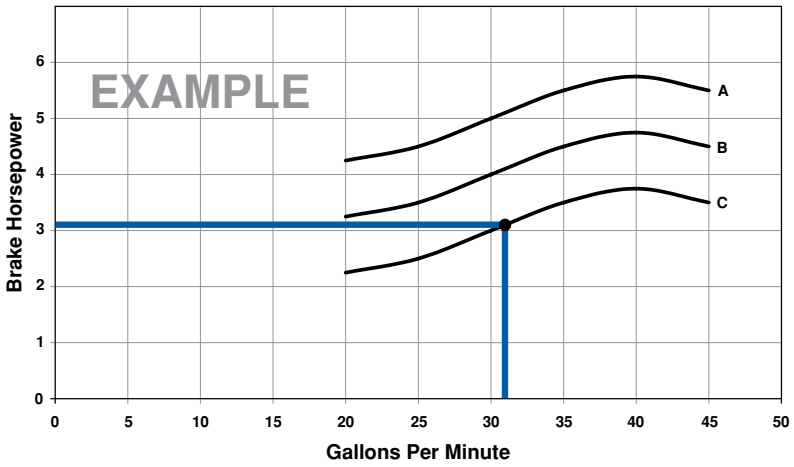

FIG. 2 MANUFACTURER'S PUMP CURVE

3. Multiply the pump horsepower required by the heat factor multiplier from table 8.

Table 8 Heat Factor Multiplier at 3 ft/s (.91 m/sec) Flow Rate

MAXIMUM WATER TEMPERATURE	1/3 - 5 HP .25 - 3.7 KW	7 1/2 - 30 HP 5.5 - 22 KW	OVER 30 HP OVER 22 KW
140 °F (60 °C)	1.25	1.62	2.00
131 °F (55 °C)	1.11	1.32	1.62
122 °F (50 °C)	1.00	1.14	1.32
113 °F (45 °C)	1.00	1.00	1.14
104 °F (40 °C)	1.00	1.00	1.00
95 °F (35 °C)	1.00	1.00	1.00

4. Select a rated hp motor on table 8A whose Service Factor Horsepower is at least the value calculated in Item 3.

Table 8A Service Factor Horsepower

HP	KW	SFHP	HP	KW	SFHP	HP	KW	SFHP	HP	KW	SFHP
1/3	0.25	0.58	3	2.2	3.45	25	18.5	28.75	100	75	115.00
1/2	0.37	0.80	5	3.7	5.75	30	22.0	34.50	125	93	143.75
3/4	0.55	1.12	7.5	5.5	8.62	40	30.0	46.00	150	110	172.50
1	0.75	1.40	10	7.5	11.50	50	37.0	57.50	175	130	201.25
1.5	1.10	1.95	15	11.0	17.25	60	45.0	69.00	200	150	230.00
2	1.50	2.50	20	15.0	23.00	75	55.0	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 table 7A, a 6" flow sleeve will be required to increase the flow rate to at least 3 ft/s.

Using table 8, the 1.62 heat factor multiplier is selected because the hp required is over 30 hp and water temperature is above 122 °F. Multiply 39 hp x 1.62 (multiplier), which equals 63.2 hp. This is the minimum rated service factor horsepower usable at 39 hp in 124 °F. Using table 8A, select a motor with a rated service factor horsepower above 63.2 hp. A 60 hp motor has a service factor horsepower of 69, so a 60 hp motor may be used.

Drawdown Seals

Allowable motor temperature is based on atmospheric pressure or higher surrounding the motor. “Drawdown seals,” which seal the well to the pump above its intake to maximize delivery, are not recommended, since the suction created can be lower than atmospheric pressure.

Grounding Control Boxes and Panels

The National Electrical Code requires that the control box or panel-grounding terminal always be connected to supply ground. 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 National Electrical Code, from the grounding terminal to the electrical supply ground.

WARNING: Failure to ground the control frame can result in a serious or fatal electrical shock hazard.

Grounding Surge Arrestors

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

Control Box, Pumptec Products and Panel Environment

Franklin Electric control boxes, Pumptec products and three-phase panels meet UL requirements for NEMA 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.

Control boxes, Pumptec products and three-phase panels should never be mounted in direct sunlight or high temperature locations. This will cause shortened capacitor life (where applicable) and unnecessary tripping of overload protectors. A ventilated enclosure painted white to reflect heat is recommended for an outdoor, high temperature location.

A damp well pit, or other humid location, accelerates component failure from corrosion.

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

Equipment Grounding

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.

The primary purpose of grounding the metal drop pipe and/or metal well casing in an installation is safety. It is done to limit the voltage between nonelectrical (exposed metal) parts of the system and ground, thus minimizing dangerous shock hazards. Using wire at least the size of the motor cable wires provides adequate current-carrying capability for any ground fault that might occur. It also provides a low resistance path to ground, ensuring that the current to ground will be large enough to trip any overcurrent device designed to detect faults (such as a ground fault circuit interrupter, or GFCI).

Normally, the ground wire to the motor would provide the primary path back to the power supply ground for any ground fault. There are conditions, however, where the ground wire connection could become compromised. One such example would be the case where the water in the well is abnormally corrosive or aggressive. In this example, a grounded metal drop pipe or casing would then become the primary path to ground. However, the many installations that now use plastic drop pipes and/or casings require further steps to be taken for safety purposes, so that the water column itself does not become the conductive path to ground.

When an installation has abnormally corrosive water AND the drop pipe or casing is plastic, Franklin Electric recommends the use of a GFCI with a 10 mA set-point. In this case, the motor ground wire should be routed through the current-sensing device along with the motor power leads. Wired this way, the GFCI will trip only when a ground fault has occurred AND the motor ground wire is no longer functional.

3-Wire Control Boxes

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

Control boxes contain starting capacitors, a starting relay, and, in some sizes, overload protectors, running capacitors and contactors.

Ratings through 1 hp may use either a Franklin Electric solid state QD or a potential (voltage) type starting relay, while larger ratings use potential relays.

Potential (Voltage) Relays

Potential relays have normally closed contacts. When 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 and not enough to open the contacts of the relay.

As the motor accelerates, the increasing voltage across the start winding (and the relay coil) opens the relay contacts. This opens the starting circuit and the motor continues to run on the main winding alone, or the main plus run capacitor circuit. After the motor is started the relay contacts remain open.

CAUTION: The control box and motor are two pieces of one assembly. Be certain that the control box and motor hp and voltage match. Since a motor is designed to operate with a control box from the same manufacturer, we can promise warranty coverage only when a Franklin control box is used with a Franklin motor.

2-Wire Motor Solid State Controls

BIAC Switch Operation

When power is applied the bi-metal switch contacts are closed, so the triac is conducting and energizes the start winding. As rpm increases, the voltage in the sensor coil generates heat in the bi-metal strip, causing the bi-metal strip to bend and open the switch circuit. This removes the starting winding and the motor continues to run on the main winding alone.

Approximately 5 seconds after power is removed from the motor, the bi-metal strip cools sufficiently to return to its closed position and the motor is ready for the next start cycle.

Rapid Cycling

The BIAC starting switch will reset within approximately 5 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 in 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 switch will have closed and the motor will operate.

CAUTION: Restarting the motor within 5 seconds after power is removed may cause the motor overload to trip.

A waterlogged tank will cause fast cycling. When a waterlogged 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 waterlogged 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.

QD Relays (Solid State)

There are two elements in the 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 main winding current passing 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 QD relay is an interaction between the triac, the reed switch and the motor windings. The solid state switch senses motor speed through the changing phase relationship between start winding current and line current. As the motor approaches running speed, the phase angle between the start current and the line current becomes 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 QD relay is ready for the next starting cycle.

2- or 3-Wire Cable, 60 Hz (Service Entrance to Motor - Maximum Length In Feet)

Table 11

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE												
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000
115	1/2	.37	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/2	.37	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	.55	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870		
	1	.75	250	400	630	990	1540	2380	2960	3610	4410	5360	6520		
	1.5	1.1	190	310	480	770	1200	1870	2320	2850	3500	4280	5240		
	2	1.5	150	250	390	620	970	1530	1910	2360	2930	3620	4480		
	3	2.2	**120**	190	300	470	750	1190	1490	1850	2320	2890	3610		
	5	3.7	0	0	**180**	280	450	710	890	1110	1390	1740	2170	2680	
	7.5	5.5	0	0	0	**200**	310	490	610	750	930	1140	1410	1720	
	10	7.5	0	0	0	0	**250**	390	490	600	750	930	1160	1430	1760
	15	11	0	0	0	0	**170**	**270**	340	430	530	660	820	1020	1260

Table 11A

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE												
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000
115	1/2	.37	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/2	.37	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	.55	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870	9380	
	1	.75	250	400	630	990	1540	2380	2960	3610	4410	5360	6520	7780	9350
	1.5	1.1	190	310	480	770	1200	1870	2320	2850	3500	4280	5240	6300	7620
	2	1.5	150	250	390	620	970	1530	1910	2360	2930	3620	4480	5470	6700
	3	2.2	**120**	190	300	470	750	1190	1490	1850	2320	2890	3610	4470	5550
	5	3.7	0	**110**	180	280	450	710	890	1110	1390	1740	2170	2680	3330
	7.5	5.5	0	0	**120**	200	310	490	610	750	930	1140	1410	1720	2100
	10	7.5	0	0	0	**160**	250	390	490	600	750	930	1160	1430	1760
	15	11	0	0	0	0	**170**	270	340	430	530	660	820	1020	1260

1 Foot = .3048 Meter

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors 60 °C or 75 °C in free air or water, not in magnetic enclosures, conduit or direct buried.

Lengths NOT in bold meet the NEC ampacity requirements for either individual conductors or jacketed 60 °C or 75 °C cable and can be in conduit or direct buried. Flat molded and web/ribbon cable are considered jacketed cable.

If any other cable is used, the NEC and local codes should be observed.

Cable lengths in tables 11 & 11A allow for a 5% voltage drop running at maximum nameplate amperes. If 3% voltage drop is desired, multiply table 11 and 11A lengths by 0.6 to get maximum cable length.

The portion of the total cable length, which is between the supply and single-phase control box with a line contactor, should not exceed 25% of total maximum allowable to ensure reliable contactor operation. Single-phase control boxes without line contactors may be connected at any point in the total cable length.

Tables 11 & 11A are based on copper wire. If aluminum wire is used, it must be two sizes larger than copper wire and oxidation inhibitors must be used on connections.

EXAMPLE: If tables 11 & 11A call for #12 copper wire, #10 aluminum wire would be required.

Contact Franklin Electric for 90 °C cable lengths. See pages 15, 49, and 50 for applications using 230 V motors on 208 V power systems.

Two or More Different Cable Sizes Can Be Used

Depending on the installation, any number of combinations of cable may be used.

For example, in a replacement/upgrade installation, the well already has 160 feet of buried #10 cable between the service entrance and the wellhead. A new 3 hp, 230-volt, single-phase motor is being installed to replace a smaller motor. The question is: Since there is already 160 feet of #10 AWG installed, what size cable is required in the well with a 3 hp, 230-volt, single-phase motor setting at 310 feet?

From tables 11 & 11A, a 3 hp motor can use up to 300 feet of #10 AWG cable.

The application has 160 feet of #10 AWG copper wire installed.

Using the formula below, 160 feet (actual) ÷ 300 feet (max allowable) is equal to 0.533. This means 53.3% (0.533 x 100) of the allowable voltage drop or loss, which is allowed between the service entrance and the motor, occurs in this wire. This leaves us 46.7% (1.00 - 0.533 = 0.467) of some other wire size to use in the remaining 310 feet “down hole” wire run.

The table shows #8 AWG copper wire is good for 470 feet. Using the formula again, 310 feet (used) ÷ 470 feet (allowed) = 0.660; adding this to the 0.533 determined earlier; 0.533 + 0.660 = 1.193. This combination is greater than 1.00, so the voltage drop will not meet US National Electrical Code recommendations.

Tables 11 & 11A show #6 AWG copper wire is good for 750 feet. Using the formula, 310 ÷ 750 = 0.413, and using these numbers, 0.533 + 0.413 = 0.946, we find this is less than 1.00 and will meet the NEC recommended voltage drop.

This works for two, three or more combinations of wire and it does not matter which size wire comes first in the installation.

$$\text{Formula: } \frac{\text{Actual Length}}{\text{Max Allowed}} + \frac{\text{Actual Length}}{\text{Max Allowed}} = 1.00$$

EXAMPLE: 3 hp, 230-Volt, Single-Phase Motor

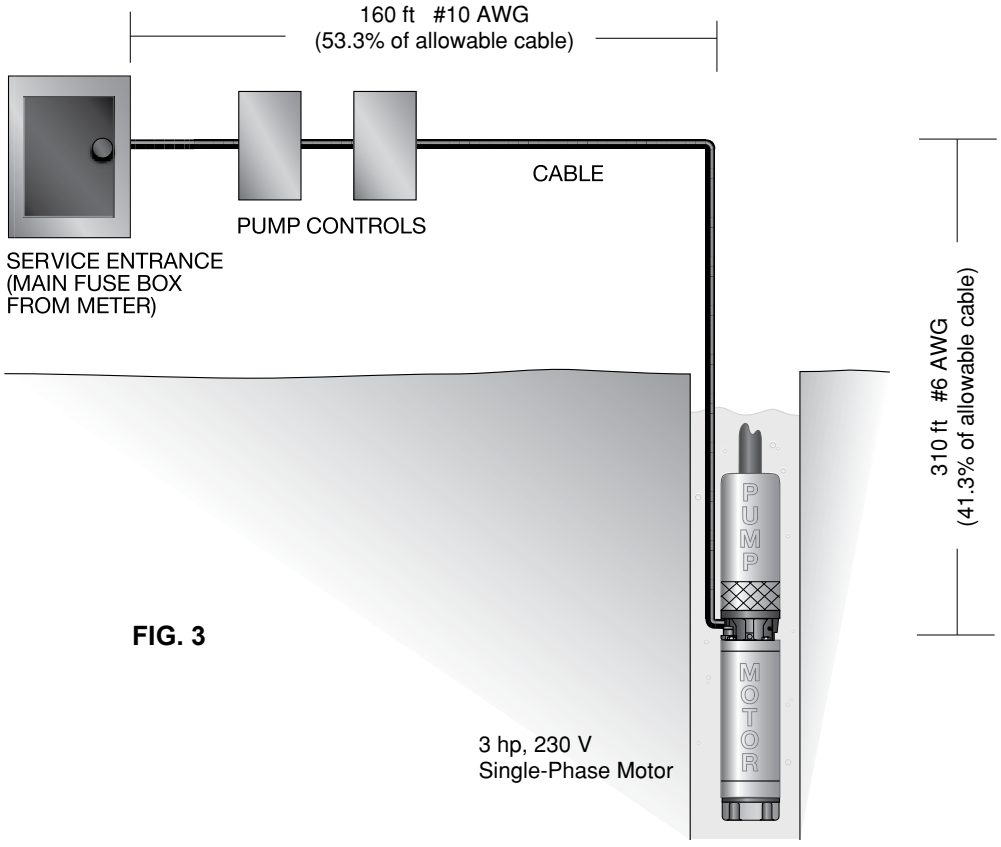

FIG. 3

Table 13 Single-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		WINDING (1) RES. IN OHMS	EFFICIENCY %		POWER FACTOR %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	(2) AMPS	WATTS	(2) AMPS	WATTS	M=MAIN RES. S=START RES.	S.F.	F.L.	S.F.	F.L.		
4" 2-WIRE	244504	1/2	0.37	115	60	1.6	10.0	670	12.0	960	1.0-1.3	62	56	73	58	64.4	R
	244505	1/2	0.37	230	60	1.6	5.0	670	6.0	960	4.2-5.2	62	56	73	58	32.2	R
	244507	3/4	0.55	230	60	1.5	6.8	940	8.0	1310	3.0-3.6	64	59	74	62	40.7	N
	244508	1	0.75	230	60	1.4	8.2	1210	10.4	1600	2.2-2.7	65	62	74	63	48.7	N
	244309	1.5	1.1	230	60	1.3	10.6	1770	13.1	2280	1.5-2.1	64	63	83	76	66.2	M
4" 3-WIRE	214504	1/2	0.37	115	60	1.6	Y10.0 B10.0 R0	670	Y12.0 B12.0 R0	960	M1.0-1.3 S4.1-5.1	62	56	73	58	50.5	M
	214505	1/2	0.37	230	60	1.6	Y5.0 B5.0 R0	670	Y6.0 B6.0 R0	960	M4.2-5.2 S16.7-20.5	62	56	73	58	23	M
	214507	3/4	0.55	230	60	1.5	Y6.8 B6.8 R0	940	Y8.0 B8.0 R0	1310	M3.0-3.6 S10.7-13.1	64	59	74	62	34.2	M
	214508	1	0.75	230	60	1.4	Y8.2 B8.2 R0	1210	10.4 10.4 R0	1600	M2.2-2.7 S9.9-12.1	65	62	74	63	41.8	L
4" 3-WIRE W/CRC CB	214505	1/2	0.37	230	60	1.6	Y3.6 B3.7 R2.0	655	Y4.3 B4.0 R2.0	890	M4.2-5.2 S16.7-20.5	67	57	90	81	23	M
	214507	3/4	0.55	230	60	1.5	Y4.9 B5.0 R3.2	925	Y5.7 B5.2 R3.1	1220	M3.0-3.6 S10.7-13.1	69	60	92	84	34.2	M
	214508	1	0.75	230	60	1.4	Y6.0 B5.7 R3.4	1160	Y7.1 B6.2 R3.3	1490	M2.2-2.7 S9.9-12.1	70	64	92	86	41.8	L
4" 3-WIRE	214508 W/1-1.5 CB	1	0.75	230	60	1.4	Y6.6 B6.6 R1.3	1130	Y8.0 B7.9 R1.3	1500	M2.2-2.7 S9.9-12.1	70	66	82	72	43	L
	224300	1.5	1.1	230	60	1.3	Y10.0 B9.9 R1.3	1620	Y11.5 B11.0 R1.3	2080	M1.7-2.1 S7.5-9.2	70	69	85	79	51.4	J
	224301	2	1.5	230	60	1.25	Y10.0 B9.3 R2.6	2025	Y13.2 B11.9 R2.6	2555	M1.8-2.3 S5.5-7.2	73	74	95	94	53.1	G
	224302 (3)	3	2.2	230	60	1.15	Y14.0 B11.2 R6.1	3000	Y17.0 B12.6 R6.0	3400	M1.1-1.4 S4.0-4.8	75	75	99	99	83.4	H
	224303 (4)	5	3.7	230	60	1.15	Y23.0 B15.9 R11.0	4830	Y27.5 B19.1 R10.8	5500	M.71-.82 S1.8-2.2	78	77	100	100	129	G
6"	226110 (5)	5	3.7	230	60	1.15	Y23.0 B14.3 R10.8	4910	Y27.5 B17.4 R10.5	5570	M.55-.68 S1.3-1.7	77	76	100	99	99	E
	226111	7.5	5.5	230	60	1.15	Y36.5 B34.4 R5.5	7300	Y42.1 B40.5 R5.4	8800	M.36-.50 S.88-1.1	73	74	91	90	165	F
	226112	10	7.5	230	60	1.15	Y44.0 B39.5 R9.3	9800	Y51.0 B47.5 R8.9	11300	M.27-.33 S.80-.99	76	77	96	96	204	E
	226113	15	11	230	60	1.15	Y62.0 B52.0 R17.5	13900	Y75.0 B62.5 R16.9	16200	M.17-.22 S.68-.93	79	80	97	98	303	E

(1) Main winding - yellow to black
Start winding - yellow to red

(2) Y = Yellow lead - line amps
B = Black lead - main winding amps
R = Red lead - start or auxiliary winding amps

(3) Control Boxes date coded 02C and older have **35 MFD** run capacitors. Current values should be Y14.0 @ FL and Y17.0 @ Max Load.
B12.2 B14.5
R4.7 R4.5

(4) Control Boxes date coded 01M and older have **60 MFD** run capacitors and the current values on a 4" motor will be Y23.0 @ FL - Y27.5 @ Max Load.
B19.1 B23.2
R8.0 R7.8

(5) Control Boxes date coded 01M and older have **60 MFD** run capacitors and the current values on a 6" motor will be Y23.0 @ FL -Y27.5 @ Max Load.
B18.2 B23.2
R8.0 R7.8

Performance is typical, not guaranteed, at specified voltages and specified capacitor values. Performance at voltage ratings not shown is similar, except amps vary inversely with voltage.

Table 14 Single-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
4" 2-WIRE	244504	1/2	0.37	115	35	20	30	30	15	30
	244505	1/2	0.37	230	20	10	15	15	8	15
	244507	3/4	0.55	230	25	15	20	20	10	20
	244508	1	0.75	230	30	20	25	25	11	25
	244309	1.5	1.1	230	35	20	30	35	15	30
4" 3-WIRE	214504	1/2	0.37	115	35	20	30	30	15	30
	214505	1/2	0.37	230	20	10	15	15	8	15
	214507	3/4	0.55	230	25	15	20	20	10	20
	214508	1	0.75	230	30	20	25	25	11	25
4" 3-WIRE W/CRC CB	214505	1/2	0.37	230	20	10	15	15	8	15
	214507	3/4	0.55	230	25	15	20	20	10	20
	214508	1	0.75	230	30	20	25	25	11	25
4" 3-WIRE	214508 W/ 1-1.5 CB	1	0.75	230	30	20	25	25	11	25
	224300	1.5	1.1	230	35	20	30	30	15	30
	224301	2	1.5	230	30	20	25	30	15	25
	224302	3	2.2	230	45	30	40	45	20	40
	224303	5	3.7	230	80	45	60	70	30	60
6"	226110	5	3.7	230	80	45	60	70	30	60
	226111	7.5	5.5	230	125	70	100	110	50	100
	226112	10	7.5	230	150	80	125	150	60	125
	226113	15	11	230	200	125	175	200	90	175

Auxiliary Running Capacitors

Added capacitors must be connected across “Red” and “Black” control box terminals, in parallel with any existing running capacitors. The additional capacitor(s) should be mounted in an auxiliary box. The values of additional running capacitors most likely to reduce noise are given below. The tabulation gives the **max.** S.F. amps normally in each lead with the added capacitor.

Although motor amps decrease when auxiliary run capacitance is added, the load on the motor does not. If a motor is overloaded with normal capacitance, it still will be overloaded with auxiliary run capacitance, even though motor amps may be within nameplate values.

Table 15 Auxiliary Capacitor Sizing

MOTOR RATING		NORMAL RUNNING CAPACITOR(S)	AUXILIARY RUNNING CAPACITORS FOR NOISE REDUCTION			MAXIMUM AMPS WITH RUN CAP		
HP	VOLTS	MFD	MFD	MIN. VOLTS	FRANKLIN PART	YELLOW	BLACK	RED
1/2	115	0	60(1)	370	TWO 155327101	8.4	7.0	4.0
1/2	230	0	15(1)	370	ONE 155328101	4.2	3.5	2.0
3/4		0	20(1)	370	ONE 155328103	5.8	5.0	2.5
1		0	25(1)	370	ONE EA. 155328101 155328102	7.1	5.6	3.4
1.5		10	20	370	ONE 155328103	9.3	7.5	4.4
2		20	10	370	ONE 155328102	11.2	9.2	3.8
3		45	NONE	370		17.0	12.6	6.0
5		80	NONE	370		27.5	19.1	10.8
7.5		45	45	370	ONE EA. 155327101 155328101	37.0	32.0	11.3
10		70	30	370	ONE 155327101	49.0	42.0	13.0
15		135	NONE			75.0	62.5	16.9

(1) Do not add running capacitors to 1/3 through 1 hp control boxes, which use solid state switches or QD relays. 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, a buck-boost transformer is often used to adjust voltage to match the motor. The most common usage on submersible motors is boosting a 208 volt supply to use a standard 230 volt single-phase submersible motor and control. While tables to give a wide range of voltage boost or buck are published by transformer manufacturers, the following table shows Franklin’s recommendations. The table, based on boosting the voltage 10%, shows the minimum rated transformer kVA needed and the common standard transformer kVA.

Table 15A 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	11.70	16.60
MINIMUM XFMR KVA	0.11	0.14	0.19	0.22	0.27	0.31	0.40	0.64	0.97	1.20	1.70
STANDARD XFMR KVA	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.75	1.00	1.50	2.00

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.

Table 16 Three-Phase 60 °C Cable, 60 Hz (Service Entrance to Motor) Maximum Length in Feet

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	710	1140	1800	2840	4420													
	3/4	0.55	510	810	1280	2030	3160													
	1	0.75	430	690	1080	1710	2670	4140	5140											
	1.5	1.1	310	500	790	1260	1960	3050	3780											
	2	1.5	240	390	610	970	1520	2360	2940	3610	4430	5420								
	3	2.2	180	290	470	740	1160	1810	2250	2760	3390	4130								
	5	3.7	**110**	170	280	440	690	1080	1350	1660	2040	2490	3050	3670	4440	5030				
	7.5	5.5	0	0	200	310	490	770	960	1180	1450	1770	2170	2600	3150	3560				
	10	7.5	0	0	0	**230**	370	570	720	880	1090	1330	1640	1970	2390	2720	3100	3480	3800	4420
	15	11	0	0	0	**160**	**250**	390	490	600	740	910	1110	1340	1630	1850	2100	2350	2570	2980
	20	15	0	0	0	0	**190**	**300**	380	460	570	700	860	1050	1270	1440	1650	1850	2020	2360
	25	18.5	0	0	0	0	0	**240**	**300**	**370**	460	570	700	840	1030	1170	1330	1500	1640	1900
	30	22	0	0	0	0	0	0	**250**	**310**	**380**	470	580	700	850	970	1110	1250	1360	1590
230 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	930	1490	2350	3700	5760	8910												
	3/4	0.55	670	1080	1700	2580	4190	6490	8060	9860										
	1	0.75	560	910	1430	2260	3520	5460	6780	8290										
	1.5	1.1	420	670	1060	1670	2610	4050	5030	6160	7530	9170								
	2	1.5	320	510	810	1280	2010	3130	3890	4770	5860	7170	8780							
	3	2.2	240	390	620	990	1540	2400	2980	3660	4480	5470	6690	8020	9680					
	5	3.7	**140**	230	370	590	920	1430	1790	2190	2690	3290	4030	4850	5870	6650	7560	8460	9220	
	7.5	5.5	0	**160**	260	420	650	1020	1270	1560	1920	2340	2870	3440	4160	4710	5340	5970	6500	7510
	10	7.5	0	0	**190**	310	490	760	950	1170	1440	1760	2160	2610	3160	3590	4100	4600	5020	5840
	15	11	0	0	0	**210**	330	520	650	800	980	1200	1470	1780	2150	2440	2780	3110	3400	3940
	20	15	0	0	0	0	**250**	400	500	610	760	930	1140	1380	1680	1910	2180	2450	2680	3120
	25	18.5	0	0	0	0	0	**320**	400	500	610	750	920	1120	1360	1540	1760	1980	2160	2520
	30	22	0	0	0	0	0	**260**	**330**	**410**	510	620	760	930	1130	1280	1470	1650	1800	2110
380 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	2690	4290	6730															
	3/4	0.55	2000	3190	5010	7860														
	1	0.75	1620	2580	4060	6390	9980													
	1.5	1.1	1230	1970	3100	4890	7630													
	2	1.5	870	1390	2180	3450	5400	8380												
	3	2.2	680	1090	1710	2690	4200	6500	8020	9830										
	5	3.7	400	640	1010	1590	2490	3870	4780	5870	7230	8830								
	7.5	5.5	270	440	690	1090	1710	2640	3260	4000	4930	6010	7290	8780						
	10	7.5	**200**	**320**	510	800	1250	1930	2380	2910	3570	4330	5230	6260	7390	8280	9340			
	15	11	0	0	**370**	590	920	1430	1770	2170	2690	3290	4000	4840	5770	6520	7430	8250	8990	
	20	15	0	0	0	**440**	700	1090	1350	1670	2060	2530	3090	3760	4500	5110	5840	6510	7120	8190
	25	18.5	0	0	0	**360**	570	880	1100	1350	1670	2050	2510	3040	3640	4130	4720	5250	5740	6590
	30	22	0	0	0	0	**470**	730	910	1120	1380	1700	2080	2520	3020	3430	3920	4360	4770	5490
	40	30	0	0	0	0	0	**530**	660	820	1010	1240	1520	1840	2200	2500	2850	3170	3470	3990
	50	37	0	0	0	0	0	0	**540**	**660**	820	1000	1220	1480	1770	2010	2290	2550	2780	3190
	60	45	0	0	0	0	0	0	0	**560**	**690**	850	1030	1250	1500	1700	1940	2150	2350	2700
	75	55	0	0	0	0	0	0	0	0	**570**	**700**	**860**	1050	1270	1440	1660	1850	2030	2350
	100	75	0	0	0	0	0	0	0	0	0	**510**	**630**	**760**	910	1030	1180	1310	1430	1650
	125	93	0	0	0	0	0	0	0	0	0	0	0	**620**	**740**	**840**	**950**	1060	1160	1330
	150	110	0	0	0	0	0	0	0	0	0	0	0	0	**620**	**700**	**790**	**880**	**960**	1090
	175	130	0	0	0	0	0	0	0	0	0	0	0	0	0	**650**	**750**	**840**	**920**	1070
	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**630**	**700**	**760**	**880**

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

Continued on next page

Table 17 Three-Phase 60 °C Cable (Continued)

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
460 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	3770	6020	9460															
	3/4	0.55	2730	4350	6850															
	1	0.75	2300	3670	5770	9070														
	1.5	1.1	1700	2710	4270	6730														
	2	1.5	1300	2070	3270	5150	8050													
	3	2.2	1000	1600	2520	3970	6200													
	5	3.7	590	950	1500	2360	3700	5750												
	7.5	5.5	420	680	1070	1690	2640	4100	5100	6260	7680									
	10	7.5	310	500	790	1250	1960	3050	3800	4680	5750	7050								
	15	11	0	**340**	540	850	1340	2090	2600	3200	3930	4810	5900	7110						
	20	15	0	0	**410**	650	1030	1610	2000	2470	3040	3730	4580	5530						
	25	18.5	0	0	0	**530**	830	1300	1620	1990	2450	3010	3700	4470	5430					
	30	22	0	0	0	**430**	680	1070	1330	1640	2030	2490	3060	3700	4500	5130	5860			
	40	30	0	0	0	0	**500**	790	980	1210	1490	1830	2250	2710	3290	3730	4250			
	50	37	0	0	0	0	0	**640**	800	980	1210	1480	1810	2190	2650	3010	3420	3830	4180	4850
	60	45	0	0	0	0	0	**540**	**670**	**830**	1020	1250	1540	1850	2240	2540	2890	3240	3540	4100
	75	55	0	0	0	0	0	0	0	**680**	**840**	1030	1260	1520	1850	2100	2400	2700	2950	3440
	100	75	0	0	0	0	0	0	0	0	**620**	**760**	**940**	1130	1380	1560	1790	2010	2190	2550
	125	93	0	0	0	0	0	0	0	0	0	0	**740**	**890**	**1000**	1220	1390	1560	1700	1960
	150	110	0	0	0	0	0	0	0	0	0	0	0	**760**	**920**	**1050**	**1190**	1340	1460	1690
	175	130	0	0	0	0	0	0	0	0	0	0	0	0	**810**	**930**	**1060**	**1190**	1300	1510
	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	**810**	**920**	**1030**	**1130**	1310
575 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	5900	9410																
	3/4	0.55	4270	6810																
	1	0.75	3630	5800	9120															
	1.5	1.1	2620	4180	6580															
	2	1.5	2030	3250	5110	8060														
	3	2.2	1580	2530	3980	6270														
	5	3.7	920	1480	2330	3680	5750													
	7.5	5.5	660	1060	1680	2650	4150													
	10	7.5	490	780	1240	1950	3060	4770	5940											
	15	11	**330**	530	850	1340	2090	3260	4060											
	20	15	0	**410**	650	1030	1610	2520	3140	3860	4760	5830								
	25	18.5	0	0	**520**	830	1300	2030	2530	3110	3840	4710								
	30	22	0	0	**430**	680	1070	1670	2080	2560	3160	3880	4770	5780	7030	8000				
	40	30	0	0	0	**500**	790	1240	1540	1900	2330	2860	3510	4230	5140	5830				
	50	37	0	0	0	0	**640**	1000	1250	1540	1890	2310	2840	3420	4140	4700	5340	5990	6530	7580
	60	45	0	0	0	0	0	**850**	1060	1300	1600	1960	2400	2890	3500	3970	4520	5070	5530	6410
	75	55	0	0	0	0	0	**690**	**860**	**1060**	1310	1600	1970	2380	2890	3290	3750	5220	4610	5370
	100	75	0	0	0	0	0	0	0	**790**	**970**	**1190**	1460	1770	2150	2440	2790	3140	3430	3990
	125	93	0	0	0	0	0	0	0	0	**770**	**950**	**1160**	1400	1690	1920	2180	2440	2650	3070
	150	110	0	0	0	0	0	0	0	0	0	**800**	**990**	**1190**	1440	1630	1860	2080	2270	2640
	175	130	0	0	0	0	0	0	0	0	0	0	**870**	**1050**	**1270**	**1450**	1650	1860	2030	2360
	200	150	0	0	0	0	0	0	0	0	0	0	0	**920**	**1110**	**1260**	**1440**	1620	1760	2050

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See 11 for additional details.

Continued on next page

Table 18 Three-Phase 60 °C Cable (Continued)

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	160	250	420	660	1030	1620	2020	2490	3060	3730	4570	5500	6660	7540				
	7.5	5.5	110	180	300	460	730	1150	1440	1770	2170	2650	3250	3900	4720	5340				
	10	7.5	**80**	130	210	340	550	850	1080	1320	1630	1990	2460	2950	3580	4080	4650	5220	5700	6630
	15	11	0	0	**140**	240	370	580	730	900	1110	1360	1660	2010	2440	2770	3150	3520	3850	4470
	20	15	0	0	0	**170**	280	450	570	690	850	1050	1290	1570	1900	2160	2470	2770	3030	3540
	25	18.5	0	0	0	**140**	**220**	360	450	550	690	850	1050	1260	1540	1750	1990	2250	2460	2850
	30	22	0	0	0	0	**180**	294	370	460	570	700	870	1050	1270	1450	1660	1870	2040	2380
230 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	210	340	550	880	1380	2140	2680	3280	4030	4930	6040	7270	8800	9970				
	7.5	5.5	150	240	390	630	970	1530	1900	2340	2880	3510	4300	5160	6240	7060	8010	8950	9750	
	10	7.5	**110**	180	280	460	730	1140	1420	1750	2160	2640	3240	3910	4740	5380	6150	6900	7530	8760
	15	11	0	0	**190**	310	490	780	970	1200	1470	1800	2200	2670	3220	3660	4170	4660	5100	5910
	20	15	0	0	**140**	230	370	600	750	910	1140	1390	1710	2070	2520	2860	3270	3670	4020	4680
	25	18.5	0	0	0	**190**	300	480	600	750	910	1120	1380	1680	2040	2310	2640	2970	3240	3780
	30	22	0	0	0	**150**	**240**	390	490	610	760	930	1140	1390	1690	1920	2200	2470	2700	3160
380 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	600	960	1510	2380	3730	5800	7170	8800										
	7.5	5.5	400	660	1030	1630	2560	3960	4890	6000	7390	9010								
	10	7.5	300	480	760	1200	1870	2890	3570	4360	5350	6490	7840	9390						
	15	11	210	340	550	880	1380	2140	2650	3250	4030	4930	6000	7260	8650	9780				
	20	15	**160**	260	410	660	1050	1630	2020	2500	3090	3790	4630	5640	6750	7660	4260	9760		
	25	18.5	0	**210**	330	540	850	1320	1650	2020	2500	3070	3760	4560	5460	6190	7080	7870	8610	9880
	30	22	0	0	**270**	430	700	1090	1360	1680	2070	2550	3120	3780	4530	5140	5880	6540	7150	8230
	40	30	0	0	0	**320**	510	790	990	1230	1510	1860	2280	2760	3300	3750	4270	4750	5200	5980
	50	37	0	0	0	**250**	**400**	630	810	990	1230	1500	1830	2220	2650	3010	3430	3820	4170	4780
	60	45	0	0	0	0	**340**	540	660	840	1030	1270	1540	1870	2250	2550	2910	3220	3520	4050
	75	55	0	0	0	0	0	**450**	550	690	855	1050	1290	1570	1900	2160	2490	2770	3040	3520
	100	75	0	0	0	0	0	0	**420**	**520**	640	760	940	1140	1360	1540	1770	1960	2140	2470
	125	93	0	0	0	0	0	0	0	**400**	**490**	**600**	730	930	1110	1260	1420	1590	1740	1990
	150	110	0	0	0	0	0	0	0	0	**420**	**510**	**620**	750	930	1050	1180	1320	1440	1630
	175	130	0	0	0	0	0	0	0	0	**360**	**440**	**540**	660	780	970	1120	1260	1380	1600
	200	150	0	0	0	0	0	0	0	0	0	0	**480**	**580**	**690**	790	940	1050	1140	1320
460 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	880	1420	2250	3540	5550	8620												
	7.5	5.5	630	1020	1600	2530	3960	6150	7650	9390										
	10	7.5	460	750	1180	1870	2940	4570	5700	7020	8620									
	15	11	310	510	810	1270	2010	3130	3900	4800	5890	7210	8850							
	20	15	**230**	380	610	970	1540	2410	3000	3700	4560	5590	6870	8290						
	25	18.5	**190**	310	490	790	1240	1950	2430	2980	3670	4510	5550	6700	8140					
	30	22	0	**250**	410	640	1020	1600	1990	2460	3040	3730	4590	5550	6750	7690	8790			
	40	30	0	0	**300**	480	750	1180	1470	1810	2230	2740	3370	4060	4930	5590	6370			
	50	37	0	0	0	**370**	590	960	1200	1470	1810	2220	2710	3280	3970	4510	5130	5740	6270	7270
	60	45	0	0	0	**320**	**500**	810	1000	1240	1530	1870	2310	2770	3360	3810	4330	4860	5310	6150
	75	55	0	0	0	0	**420**	660	810	1020	1260	1540	1890	2280	2770	3150	3600	4050	4420	5160
	100	75	0	0	0	0	0	**500**	**610**	760	930	1140	1410	1690	2070	2340	2680	3010	3280	3820
	125	93	0	0	0	0	0	0	**470**	**590**	**730**	880	1110	1330	1500	1830	2080	2340	2550	2940
	150	110	0	0	0	0	0	0	0	**510**	**630**	**770**	950	1140	1380	1570	1790	2000	2180	2530
	175	130	0	0	0	0	0	0	0	0	**550**	**680**	**830**	1000	1220	1390	1580	1780	1950	2270
	200	150	0	0	0	0	0	0	0	0	0	**590**	**730**	**880**	1070	1210	1380	1550	1690	1970
575 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	1380	2220	3490	5520	8620													
	7.5	5.5	990	1590	2520	3970	6220													
	10	7.5	730	1170	1860	2920	4590	7150	8910											
	15	11	490	790	1270	2010	3130	4890	6090											
	20	15	370	610	970	1540	2410	3780	4710	5790	7140	8740								
	25	18.5	**300**	490	780	1240	1950	3040	3790	4660	5760	7060								
	30	22	**240**	400	645	1020	1600	2500	3120	3840	4740	5820	7150	8670						
	40	30	0	**300**	480	750	1180	1860	2310	2850	3490	4290	5260	6340	7710	8740				
	50	37	0	0	**380**	590	960	1500	1870	2310	2830	3460	4260	5130	6210	7050	8010	8980	9790	
	60	45	0	0	0	**500**	**790**	1270	1590	1950	2400	2940	3600	4330	5250	5950	6780	7600	8290	9610
	75	55	0	0	0	**420**	**660**	1030	1290	1590	1960	2400	2950	3570	4330	4930	5620	6330	6910	8050
	100	75	0	0	0	0	**400**	**780**	960	1180	1450	1780	2190	2650	3220	3660	4180	4710	5140	5980
	125	93	0	0	0	0	0	**600**	**740**	920	1150	1420	1740	2100	2530	2880	3270	3660	3970	4600
	150	110	0	0	0	0	0	0	**650**	**800**	**990**	1210	1480	1780	2160	2450	2790	3120	3410	3950
	175	130	0	0	0	0	0	0	0	**700**	**860**	1060	1300	1570	1910	2170	2480	2780	3040	3540
	200	150	0	0	0	0	0	0	0	0	**760**	**930**	1140	1370	1670	1890	2160	2420	2640	3070

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

Table 19 Three-Phase 75 °C Cable, 60 Hz (Service Entrance to Motor) Maximum Length in Feet

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	710	1140	1800	2840	4420													
	3/4	0.55	510	810	1280	2030	3160													
	1	0.75	430	690	1080	1710	2670	4140	5140											
	1.5	1.1	310	500	790	1260	1960	3050	3780											
	2	1.5	240	390	610	970	1520	2360	2940	3610	4430	5420								
	3	2.2	180	290	470	740	1160	1810	2250	2760	3390	4130								
	5	3.7	**110**	170	280	440	690	1080	1350	1660	2040	2490	3050	3670	4440	5030				
	7.5	5.5	0	0	200	310	490	770	960	1180	1450	1770	2170	2600	3150	3560				
	10	7.5	0	0	**150**	230	370	570	720	880	1090	1330	1640	1970	2390	2720	3100	3480	3800	4420
	15	11	0	0	0	**160**	250	390	490	600	740	910	1110	1340	1630	1850	2100	2350	2570	2980
	20	15	0	0	0	0	**190**	300	380	460	570	700	860	1050	1270	1440	1650	1850	2020	2360
	25	18.5	0	0	0	0	0	**240**	300	370	460	570	700	840	1030	1170	1330	1500	1640	1900
	30	22	0	0	0	0	0	**200**	**250**	310	380	470	580	700	850	970	1110	1250	1360	1590
230 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	930	1490	2350	3700	5760	8910												
	3/4	0.55	670	1080	1700	2580	4190	6490	8060	9860										
	1	0.75	560	910	1430	2260	3520	5460	6780	8290										
	1.5	1.1	420	670	1060	1670	2610	4050	5030	6160	7530	9170								
	2	1.5	320	510	810	1280	2010	3130	3890	4770	5860	7170	8780							
	3	2.2	240	390	620	990	1540	2400	2980	3660	4480	5470	6690	8020	9680					
	5	3.7	**140**	230	370	590	920	1430	1790	2190	2690	3290	4030	4850	5870	6650	7560	8460	9220	
	7.5	5.5	0	**160**	260	420	650	1020	1270	1560	1920	2340	2870	3440	4160	4710	5340	5970	6500	7510
	10	7.5	0	0	**190**	310	490	760	950	1170	1440	1760	2160	2610	3160	3590	4100	4600	5020	5840
	15	11	0	0	0	**210**	330	520	650	800	980	1200	1470	1780	2150	2440	2780	3110	3400	3940
	20	15	0	0	0	**160**	**250**	400	500	610	760	930	1140	1380	1680	1910	2180	2450	2680	3120
	25	18.5	0	0	0	0	**200**	320	400	500	610	750	920	1120	1360	1540	1760	1980	2160	2520
	30	22	0	0	0	0	0	**260**	330	410	510	620	760	930	1130	1280	1470	1650	1800	2110
380 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	2690	4290	6730															
	3/4	0.55	2000	3190	5010	7860														
	1	0.75	1620	2580	4060	6390	9980													
	1.5	1.1	1230	1970	3100	4890	7630													
	2	1.5	870	1390	2180	3450	5400	8380												
	3	2.2	680	1090	1710	2690	4200	6500	8020	9830										
	5	3.7	400	640	1010	1590	2490	3870	4780	5870	7230	8830								
	7.5	5.5	270	440	690	1090	1710	2640	3260	4000	4930	6010	7290	8780						
	10	7.5	**200**	320	510	800	1250	1930	2380	2910	3570	4330	5230	6260	7390	8280	9340			
	15	11	0	0	370	590	920	1430	1770	2170	2690	3290	4000	4840	5770	6520	7430	8250	8990	
	20	15	0	0	**280**	440	700	1090	1350	1670	2060	2530	3090	3760	4500	5110	2840	6510	7120	8190
	25	18.5	0	0	0	**360**	570	880	1100	1350	1670	2050	2510	3040	3640	4130	4720	5250	5740	6590
	30	22	0	0	0	**290**	470	730	910	1120	1380	1700	2080	2520	3020	3430	3920	4360	4770	5490
	40	30	0	0	0	0	0	**530**	660	820	1010	1240	1520	1840	2200	2500	2850	3170	3470	3990
	50	37	0	0	0	0	0	**440**	**540**	660	820	1000	1220	1480	1770	2010	2290	2550	2780	3190
	60	45	0	0	0	0	0	**370**	**460**	**560**	690	850	1030	1250	1500	1700	1940	2150	2350	2700
	75	55	0	0	0	0	0	0	0	**460**	**570**	700	860	1050	1270	1440	1660	1850	2030	2350
	100	75	0	0	0	0	0	0	0	0	**420**	**510**	**630**	760	910	1030	1180	1310	1430	1650
	125	93	0	0	0	0	0	0	0	0	0	0	**510**	**620**	**740**	840	950	1060	1160	1330
	150	110	0	0	0	0	0	0	0	0	0	0	0	**520**	**620**	**700**	**790**	880	960	1090
	175	130	0	0	0	0	0	0	0	0	0	0	0	0	**560**	**650**	**750**	**840**	920	1070
	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	**550**	**630**	**700**	**760**	880

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

Continued on next page

Table 20 Three-Phase 75 °C Cable (Continued)

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
460 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	3770	6020	9460															
	3/4	0.55	2730	4350	6850															
	1	0.75	2300	3670	5770	9070														
	1.5	1.1	1700	2710	4270	6730														
	2	1.5	1300	2070	3270	5150	8050													
	3	2.2	1000	1600	2520	3970	6200													
	5	3.7	590	950	1500	2360	3700	5750												
	7.5	5.5	420	680	1070	1690	2640	4100	5100	6260	7680									
	10	7.5	310	500	790	1250	1960	3050	3800	4680	5750	7050								
	15	11	0	**340**	540	850	1340	2090	2600	3200	3930	4810	5900	7110						
	20	15	0	0	410	650	1030	1610	2000	2470	3040	3730	4580	5530						
	25	18.5	0	0	**330**	530	830	1300	1620	1990	2450	3010	3700	4470	5430					
	30	22	0	0	**270**	430	680	1070	1330	1640	2030	2490	3060	3700	4500	5130	5860			
	40	30	0	0	0	**320**	**500**	790	980	1210	1490	1830	2250	2710	3290	3730	4250			
	50	37	0	0	0	0	**410**	640	800	980	1210	1480	1810	2190	2650	3010	3420	3830	4180	4850
	60	45	0	0	0	0	0	**540**	**670**	830	1020	1250	1540	1850	2240	2540	2890	3240	3540	4100
	75	55	0	0	0	0	0	**440**	**550**	**680**	840	1030	1260	1520	1850	2100	2400	2700	2950	3440
	100	75	0	0	0	0	0	0	0	**500**	**620**	**760**	940	1130	1380	1560	1790	2010	2190	2550
	125	93	0	0	0	0	0	0	0	0	0	**600**	**740**	**890**	1000	1220	1390	1560	1700	1960
	150	110	0	0	0	0	0	0	0	0	0	0	**630**	**760**	**920**	1050	1190	1340	1460	1690
	175	130	0	0	0	0	0	0	0	0	0	0	0	**670**	**810**	**930**	1060	1190	1300	1510
	200	150	0	0	0	0	0	0	0	0	0	0	0	**590**	**710**	**810**	**920**	1030	1130	1310
575 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	5900	9410																
	3/4	0.55	4270	6810																
	1	0.75	3630	5800	9120															
	1.5	1.1	2620	4180	6580															
	2	1.5	2030	3250	5110	8060														
	3	2.2	1580	2530	3980	6270														
	5	3.7	920	1480	2330	3680	5750													
	7.5	5.5	660	1060	1680	2650	4150													
	10	7.5	490	780	1240	1950	3060	4770	5940											
	15	11	**330**	530	850	1340	2090	3260	4060											
	20	15	0	**410**	650	1030	1610	2520	3140	3860	4760	5830								
	25	18.5	0	0	520	830	1300	2030	2530	3110	3840	4710								
	30	22	0	0	**430**	680	1070	1670	2080	2560	3160	3880	4770	5780	7030	8000				
	40	30	0	0	0	**500**	790	1240	1540	1900	2330	2860	3510	4230	5140	5830				
	50	37	0	0	0	**410**	**640**	1000	1250	1540	1890	2310	2840	3420	4140	4700	5340	5990	6530	7580
	60	45	0	0	0	0	**540**	850	1060	1300	1600	1960	2400	2890	3500	3970	4520	5070	5530	6410
	75	55	0	0	0	0	0	**690**	860	1060	1310	1600	1970	2380	2890	3290	3750	5220	4610	5370
	100	75	0	0	0	0	0	0	**640**	**790**	970	1190	1460	1770	2150	2440	2790	3140	3430	3990
	125	93	0	0	0	0	0	0	0	**630**	**770**	**950**	1160	1400	1690	1920	2180	2440	2650	3070
	150	110	0	0	0	0	0	0	0	0	**660**	**800**	**990**	1190	1440	1630	1860	2080	2270	2640
	175	130	0	0	0	0	0	0	0	0	0	**700**	**870**	**1050**	1270	1450	1650	1860	2030	2360
	200	150	0	0	0	0	0	0	0	0	0	0	**760**	**920**	**1110**	1260	1440	1620	1760	2050

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

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APPLICATION
Three-Phase Motors

Table 21 Three-Phase 75 °C Cable (Continued)

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	160	250	420	660	1030	1620	2020	2490	3060	3730	4570	5500	6660	7540				
	7.5	5.5	110	180	300	460	730	1150	1440	1770	2170	2650	3250	3900	4720	5340				
	10	7.5	**80**	130	210	340	550	850	1080	1320	1630	1990	2460	2950	3580	4080	4650	5220	5700	6630
	15	11	0	0	140	240	370	580	730	900	1110	1360	1660	2010	2440	2770	3150	3520	3850	4470
	20	15	0	0	**120**	170	280	450	570	690	850	1050	1290	1570	1900	2160	2470	2770	3030	3540
	25	18.5	0	0	0	**140**	220	360	450	550	690	850	1050	1260	1540	1750	1990	2250	2460	2850
	30	22	0	0	0	**120**	**180**	294	370	460	570	700	870	1050	1270	1450	1660	1870	2040	2380
230 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	210	340	550	880	1380	2140	2680	3280	4030	4930	6040	7270	8800	9970				
	7.5	5.5	150	240	390	630	970	1530	1900	2340	2880	3510	4300	5160	6240	7060	8010	8950	9750	
	10	7.5	**110**	180	280	460	730	1140	1420	1750	2160	2640	3240	3910	4740	5380	6150	6900	7530	8760
	15	11	0	**130**	190	310	490	780	970	1200	1470	1800	2200	2670	3220	3660	4170	4660	5100	5910
	20	15	0	0	**140**	230	370	600	750	910	1140	1390	1710	2070	2520	2860	3270	3670	4020	4680
	25	18.5	0	0	**120**	190	300	480	600	750	910	1120	1380	1680	2040	2310	2640	2970	3240	3780
	30	22	0	0	0	**150**	240	390	490	610	760	930	1140	1390	1690	1920	2200	2470	2700	3160
380 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	600	960	1510	2380	3730	5800	7170	8800										
	7.5	5.5	400	660	1030	1630	2560	3960	4890	6000	7390	9010								
	10	7.5	300	480	760	1200	1870	2890	3570	4360	5350	6490	7840	9390						
	15	11	210	340	550	880	1380	2140	2650	3250	4030	4930	6000	7260	8650	9780				
	20	15	**160**	260	410	660	1050	1630	2020	2500	3090	3790	4630	5640	6750	7660	4260	9760		
	25	18.5	0	**210**	330	540	850	1320	1650	2020	2500	3070	3760	4560	5460	6190	7080	7870	8610	9880
	30	22	0	0	**270**	430	700	1090	1360	1680	2070	2550	3120	3780	4530	5140	5880	6540	7150	8230
	40	30	0	0	**210**	320	510	790	990	1230	1510	1860	2280	2760	3300	3750	4270	4750	5200	5980
	50	37	0	0	0	**250**	400	630	810	990	1230	1500	1830	2220	2650	3010	3430	3820	4170	4780
	60	45	0	0	0	0	**340**	540	660	840	1030	1270	1540	1870	2250	2550	2910	3220	3520	4050
	75	55	0	0	0	0	**290**	450	550	690	855	1050	1290	1570	1900	2160	2490	2770	3040	3520
	100	75	0	0	0	0	0	**340**	**420**	520	640	760	940	1140	1360	1540	1770	1960	2140	2470
	125	93	0	0	0	0	0	0	**340**	**400**	**490**	600	730	930	1110	1260	1420	1590	1740	1990
	150	110	0	0	0	0	0	0	0	**350**	**420**	**510**	620	750	930	1050	1180	1320	1440	1630
	175	130	0	0	0	0	0	0	0	0	**360**	**440**	**540**	660	780	970	1120	1260	1380	1600
	200	150	0	0	0	0	0	0	0	0	0	**410**	**480**	**580**	690	790	940	1050	1140	1320
460 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	880	1420	2250	3540	5550	8620												
	7.5	5.5	630	1020	1600	2530	3960	6150	7650	9390										
	10	7.5	460	750	1180	1870	2940	4570	5700	7020	8620									
	15	11	310	510	810	1270	2010	3130	3900	4800	5890	7210	8850							
	20	15	230	380	610	970	1540	2410	3000	3700	4560	5590	6870	8290						
	25	18.5	**190**	310	490	790	1240	1950	2430	2980	3670	4510	5550	6700	8140					
	30	22	0	**250**	410	640	1020	1600	1990	2460	3040	3730	4590	5550	6750	7690	8790			
	40	30	0	0	**300**	480	750	1180	1470	1810	2230	2740	3370	4060	4930	5590	6370			
	50	37	0	0	**250**	370	590	960	1200	1470	1810	2220	2710	3280	3970	4510	5130	5740	6270	7270
	60	45	0	0	0	**320**	500	810	1000	1240	1530	1870	2310	2770	3360	3810	4330	4860	5310	6150
	75	55	0	0	0	0	**420**	660	810	1020	1260	1540	1890	2280	2770	3150	3600	4050	4420	5160
	100	75	0	0	0	0	**310**	**500**	610	760	930	1140	1410	1690	2070	2340	2680	3010	3280	3820
	125	93	0	0	0	0	0	**390**	**470**	**590**	730	880	1110	1330	1500	1830	2080	2340	2550	2940
	150	110	0	0	0	0	0	0	**420**	**510**	**630**	770	950	1140	1380	1570	1790	2000	2180	2530
	175	130	0	0	0	0	0	0	0	**450**	**550**	**680**	830	1000	1220	1390	1580	1780	1950	2270
	200	150	0	0	0	0	0	0	0	0	**480**	**590**	**730**	880	1070	1210	1380	1550	1690	1970
575 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	1380	2220	3490	5520	8620													
	7.5	5.5	990	1590	2520	3970	6220													
	10	7.5	730	1170	1860	2920	4590	7150	8910											
	15	11	490	790	1270	2010	3130	4890	6090											
	20	15	370	610	970	1540	2410	3780	4710	5790	7140	8740								
	25	18.5	**300**	490	780	1240	1950	3040	3790	4660	5760	7060								
	30	22	**240**	400	645	1020	1600	2500	3120	3840	4740	5820	7150	8670						
	40	30	0	**300**	480	750	1180	1860	2310	2850	3490	4290	5260	6340	7710	8740				
	50	37	0	0	**380**	590	960	1500	1870	2310	2830	3460	4260	5130	6210	7050	8010	8980	9790	
	60	45	0	0	**330**	500	790	1270	1590	1950	2400	2940	3600	4330	5250	5950	6780	7600	8290	9610
	75	55	0	0	0	**420**	660	1030	1290	1590	1960	2400	2950	3570	4330	4930	5620	6330	6910	8050
	100	75	0	0	0	0	**400**	780	960	1180	1450	1780	2190	2650	3220	3660	4180	4710	5140	5980
	125	93	0	0	0	0	0	**600**	740	920	1150	1420	1740	2100	2530	2880	3270	3660	3970	4600
	150	110	0	0	0	0	0	**520**	**650**	800	990	1210	1480	1780	2160	2450	2790	3120	3410	3950
	175	130	0	0	0	0	0	0	**570**	**700**	860	1060	1300	1570	1910	2170	2480	2780	3040	3540
	200	150	0	0	0	0	0	0	**500**	**610**	**760**	930	1140	1370	1670	1890	2160	2420	2640	3070

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

Table 22 Three-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	WATTS	AMPS	WATTS		S.F.	F.L.		
4"	234501	1/2	0.37	200	60	1.6	2.8	585	3.4	860	6.6-8.4	70	64	17.5	N
	234511			230	60	1.6	2.4	585	2.9	860	9.5-10.9	70	64	15.2	N
	234541			380	60	1.6	1.4	585	2.1	860	23.2-28.6	70	64	9.2	N
	234521			460	60	1.6	1.2	585	1.5	860	38.4-44.1	70	64	7.6	N
	234531			575	60	1.6	1.0	585	1.2	860	58.0-71.0	70	64	6.1	N
	234502	3/4	0.55	200	60	1.5	3.6	810	4.4	1150	4.6-5.9	73	69	24.6	N
	234512			230	60	1.5	3.1	810	3.8	1150	6.8-7.8	73	69	21.4	N
	234542			380	60	1.5	1.9	810	2.5	1150	16.6-20.3	73	69	13	N
	234522			460	60	1.5	1.6	810	1.9	1150	27.2-30.9	73	69	10.7	N
	234532			575	60	1.5	1.3	810	1.6	1150	41.5-50.7	73	69	8.6	N
	234503	1	0.75	200	60	1.4	4.5	1070	5.4	1440	3.8-4.5	72	70	30.9	M
	234513			230	60	1.4	3.9	1070	4.7	1440	4.9-5.6	72	70	26.9	M
	234543			380	60	1.4	2.3	1070	2.8	1440	12.2-14.9	72	70	16.3	M
	234523			460	60	1.4	2	1070	2.4	1440	19.9-23.0	72	70	13.5	M
	234533			575	60	1.4	1.6	1070	1.9	1440	30.1-36.7	72	70	10.8	M
	234504	1.5	1.1	200	60	1.3	5.8	1460	6.8	1890	2.5-3.0	76	76	38.2	K
	234514			230	60	1.3	5	1460	5.9	1890	3.2-4.0	76	76	33.2	K
	234544			380	60	1.3	3	1460	3.6	1890	8.5-10.4	76	76	20.1	K
	234524			460	60	1.3	2.5	1460	3.1	1890	13.0-16.0	76	76	16.6	K
	234534			575	60	1.3	2	1460	2.4	1890	20.3-25.0	76	76	13.3	K
	234305	2	1.5	200	60	1.25	7.7	1960	9.3	2430	1.8-2.4	76	76	50.3	K
	234315			230	60	1.25	6.7	1960	8.1	2430	2.3-3.0	76	76	45.0	K
	234345			380	60	1.25	4.1	1960	4.9	2430	6.6-8.2	76	76	26.6	K
	234325			460	60	1.25	3.4	1960	4.1	2430	9.2-12.0	76	76	22.5	K
	234335			575	60	1.25	2.7	1960	3.2	2430	14.6-18.7	76	76	17.8	K
	234306	3	2.2	200	60	1.15	10.9	2920	12.5	3360	1.3-1.7	77	77	69.5	K
	234316			230	60	1.15	9.5	2920	10.9	3360	1.8-2.2	77	77	60.3	K
	234346			380	60	1.15	5.8	2920	6.6	3360	4.7-6.0	77	77	37.5	K
	234326			460	60	1.15	4.8	2920	5.5	3360	7.2-8.8	77	77	31.0	K
	234336			575	60	1.15	3.8	2920	4.4	3360	11.4-13.9	77	77	25.1	K
	234307	5	3.7	200	60	1.15	18.3	4800	20.5	5500	.68-.83	78	78	116	K
	234317			230	60	1.15	15.9	4800	17.8	5500	.91-1.1	78	78	102	K
	234347			380	60	1.15	9.6	4800	10.8	5500	2.6-3.2	78	78	60.2	K
	234327			460	60	1.15	8.0	4800	8.9	5500	3.6-4.4	78	78	53.7	K
	234337			575	60	1.15	6.4	4800	7.1	5500	5.6-6.9	78	78	41.8	K
	234308	7.5	5.5	200	60	1.15	26.5	7150	30.5	8200	.43-.53	78	78	177	K
	234318			230	60	1.15	23.0	7150	26.4	8200	.60-.73	78	78	152	K
	234348			380	60	1.15	13.9	7150	16.0	8200	1.6-2.0	78	78	92.7	K
	234328			460	60	1.15	11.5	7150	13.2	8200	2.3-2.8	78	78	83.8	K
	234338			575	60	1.15	9.2	7150	10.6	8200	3.6-4.5	78	78	64.6	K
	234549	10	7.5	380	60	1.15	19.3	10000	21.0	11400	1.2-1.6	75	75	140	L
	234595			460	60	1.15	15.9	10000	17.3	11400	1.8-2.3	75	75	116.0	L
	234598			575	60	1.15	12.5	10000	13.6	11400	2.8-3.5	75	75	92.8	L

Table 23 Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
4"	234501	1/2	0.37	200	10	5	8	10	4	15
	234511			230	8	4.5	6	8	4	15
	234541			380	5	2.5	4	5	2	15
	234521			460	4	2.25	3	4	2	15
	234531			575	3	1.8	3	3	1.4	15
	234502	3/4	0.55	200	15	7	10	12	5	15
	234512			230	10	5.6	8	10	5	15
	234542			380	6	3.5	5	6	3	15
	234522			460	5	2.8	4	5	3	15
	234532			575	4	2.5	4	4	1.8	15
	234503	1	0.75	200	15	8	15	15	6	15
	234513			230	15	7	10	12	6	15
	234543			380	8	4.5	8	8	4	15
	234523			460	6	3.5	5	6	3	15
	234533			575	5	2.8	4	5	2.5	15
	234504	1.5	1.1	200	20	12	15	20	8	15
	234514			230	15	9	15	15	8	15
	234544			380	10	5.6	8	10	4	15
	234524			460	8	4.5	8	8	4	15
	234534			575	6	3.5	5	6	3	15
	234305	2	1.5	200	25	15	20	25	11	20
	234315			230	25	12	20	25	10	20
	234345			380	15	8	15	15	6	15
	234325			460	15	6	10	11	5	15
	234335			575	10	5	8	10	4	15
	234306	3	2.2	200	35	20	30	35	15	30
	234316			230	30	17.5	25	30	12	25
	234346			380	20	12	15	20	8	15
	234326			460	15	9	15	15	6	15
	234336			575	15	7	10	11	5	15
	234307	5	3.7	200	60	35	50	60	25	50
	234317			230	50	30	40	45	20	40
	234347			380	30	17.5	25	30	12	25
	234327			460	25	15	20	25	10	20
	234337			575	20	12	20	20	8	20
	234308	7.5	5.5	200	90	50	70	80	35	70
	234318			230	80	45	60	70	30	60
	234348			380	45	25	40	40	20	40
	234328			460	40	25	30	35	15	30
	234338			575	30	17.5	25	30	12	25
	234349	10	7.5	380	70	40	60	60	25	60
	234329			460	60	30	45	50	25	45
	234339			575	45	25	35	40	20	35
	234549			380	70	35	60	60	25	60
	234595			460	60	30	45	50	25	45
	234598			575	45	25	35	40	20	35

Table 24 Three-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	WATTS	AMPS	WATTS		S.F.	F.L.		
6" STD.	236650	5	3.7	200	60	1.15	17.5	4700	20.0	5400	.77-.93	79	79	99	H
	236600			230	60	1.15	15	4700	17.6	5400	1.0-1.2	79	79	86	H
	236660			380	60	1.15	9.1	4700	10.7	5400	2.6-3.2	79	79	52	H
	236610			460	60	1.15	7.5	4700	8.8	5400	3.9-4.8	79	79	43	H
	236620			575	60	1.15	6	4700	7.1	5400	6.3-7.7	79	79	34	H
	236651	7.5	5.5	200	60	1.15	25.1	7000	28.3	8000	.43-.53	80	80	150	H
	236601			230	60	1.15	21.8	7000	24.6	8000	.64-.78	80	80	130	H
	236661			380	60	1.15	13.4	7000	15	8000	1.6-2.1	80	80	79	H
	236611			460	60	1.15	10.9	7000	12.3	8000	2.4-2.9	80	80	65	H
	236621			575	60	1.15	8.7	7000	9.8	8000	3.7-4.6	80	80	52	H
	236652	10	7.5	200	60	1.15	32.7	9400	37	10800	.37-.45	79	79	198	H
	236602			230	60	1.15	28.4	9400	32.2	10800	.47-.57	79	79	172	H
	236662			380	60	1.15	17.6	9400	19.6	10800	1.2-1.5	79	79	104	H
	236612			460	60	1.15	14.2	9400	16.1	10800	1.9-2.4	79	79	86	H
	236622			575	60	1.15	11.4	9400	12.9	10800	3.0-3.7	79	79	69	H
	236653	15	11	200	60	1.15	47.8	13700	54.4	15800	.24-.29	81	81	306	H
	236603			230	60	1.15	41.6	13700	47.4	15800	.28-.35	81	81	266	H
	236663			380	60	1.15	25.8	13700	28.9	15800	.77-.95	81	81	161	H
	236613			460	60	1.15	20.8	13700	23.7	15800	1.1-1.4	81	81	133	H
	236623			575	60	1.15	16.6	13700	19	15800	1.8-2.3	81	81	106	H
	236654	20	15	200	60	1.15	61.9	18100	69.7	20900	.16-.20	82	82	416	J
	236604			230	60	1.15	53.8	18100	60.6	20900	.22-.26	82	82	362	J
	236664			380	60	1.15	33	18100	37.3	20900	.55-.68	82	82	219	J
	236614			460	60	1.15	26.9	18100	30.3	20900	.8-1.0	82	82	181	J
	236624			575	60	1.15	21.5	18100	24.2	20900	1.3-1.6	82	82	145	J
	236655	25	18.5	200	60	1.15	77.1	22500	86.3	25700	.12-.15	83	83	552	J
	236605			230	60	1.15	67	22500	75	25700	.15-.19	83	83	480	J
	236665			380	60	1.15	41	22500	46	25700	.46-.56	83	83	291	J
	236615			460	60	1.15	33.5	22500	37.5	25700	.63-.77	83	83	240	J
	236625			575	60	1.15	26.8	22500	30	25700	1.0-1.3	83	83	192	J
	236656	30	22	200	60	1.15	90.9	26900	104	31100	.09-.11	83	83	653	J
	236606			230	60	1.15	79	26900	90.4	31100	.14-.17	83	83	568	J
	236666			380	60	1.15	48.8	26900	55.4	31100	.35-.43	83	83	317	J
	236616			460	60	1.15	39.5	26900	45.2	31100	.52-.64	83	83	284	J
	236626			575	60	1.15	31.6	26900	36.2	31100	.78-.95	83	83	227	J
	236667	40	30	380	60	1.15	66.5	35600	74.6	42400	.26-.33	83	83	481	J
	236617			460	60	1.15	54.9	35600	61.6	42400	.34-.42	83	83	397	J
	236627			575	60	1.15	42.8	35600	49.6	42400	.52-.64	83	83	318	H
	236668	50	37	380	60	1.15	83.5	45100	95	52200	.21-.25	82	83	501	H
	236618			460	60	1.15	67.7	45100	77	52200	.25-.32	82	83	414	H
	236628			575	60	1.15	54.2	45100	61.6	52200	.40-.49	82	83	331	H
	276668			380	60	1.15	82.4	45100	94.5	52200	.21 - .25	82	83	501	H
	276618			460	60	1.15	68.1	45100	78.1	52200	.25 - .32	82	83	414	H
	276628			575	60	1.15	54.5	45100	62.5	52200	.40 - .49	82	83	331	H
	236669	60	45	380	60	1.15	98.7	53500	111	61700	.15-.18	84	84	627	H
	236619			460	60	1.15	80.5	53500	91	61700	.22-.27	84	84	518	H
	236629			575	60	1.15	64.4	53500	72.8	61700	.35-.39	84	84	414	H
	276669			380	60	1.15	98.1	53500	111.8	61700	.15 - .18	84	84	627	H
	276619			460	60	1.15	81.0	53500	92.3	61700	.22 - .27	84	84	518	H
	276629			575	60	1.15	64.8	53500	73.9	61700	.35 - .39	84	84	414	H

Model numbers above are for 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. Six-lead individual phase resistance = table X 1.5.

Table 25 6" Three-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	WATTS	AMPS	WATTS		S.F.	F.L.		
6" HI-TEMP 90 °C	276650	5	3.7	200	60	1.15	17.2	5200	19.8	5800	.53 - .65	73	72	124	K
	276600			230	60	1.15	15.0	5200	17.2	5800	.68 - .84	73	72	108	K
	276660			380	60	1.15	9.1	5200	10.4	5800	2.0 - 2.4	73	72	66.0	K
	276610			460	60	1.15	7.5	5200	8.6	5800	2.8 - 3.4	73	72	54.0	K
	276620			575	60	1.15	6.0	5200	6.9	5800	4.7 - 5.7	73	72	43.0	K
	276651	7.5	5.5	200	60	1.15	24.8	7400	28.3	8400	.30 - .37	77	76	193	K
	276601			230	60	1.15	21.6	7400	24.6	8400	.41 - .50	77	76	168	K
	276661			380	60	1.15	13.1	7400	14.9	8400	1.1 - 1.4	77	76	102	K
	276611			460	60	1.15	10.8	7400	12.3	8400	1.7 - 2.0	77	76	84.0	K
	276621			575	60	1.15	8.6	7400	9.9	8400	2.6 - 3.2	77	76	67.0	K
	276652	10	7.5	200	60	1.15	32.0	9400	36.3	10700	.21 - .26	80	79	274	L
	276602			230	60	1.15	27.8	9400	31.6	10700	.28 - .35	80	79	238	L
	276662			380	60	1.15	16.8	9400	19.2	10700	.80 - .98	80	79	144	L
	276612			460	60	1.15	13.9	9400	15.8	10700	1.2 - 1.4	80	79	119	L
	276622			575	60	1.15	11.1	9400	12.7	10700	1.8 - 2.2	80	79	95.0	L
	276653	15	11	200	60	1.15	48.5	14000	54.5	15900	.15 - .19	81	80	407	L
	276603			230	60	1.15	42.2	14000	47.4	15900	.19 - .24	81	80	354	L
	276663			380	60	1.15	25.5	14000	28.7	15900	.52 - .65	81	80	214	L
	276613			460	60	1.15	21.1	14000	23.7	15900	.78 - .96	81	80	177	L
	276623			575	60	1.15	16.9	14000	19.0	15900	1.2 - 1.4	81	80	142	L
	276654	20	15	200	60	1.15	64.9	18600	73.6	21300	.10 - .12	80	80	481	K
	276604			230	60	1.15	56.4	18600	64.0	21300	.14 - .18	80	80	418	K
	276664			380	60	1.15	34.1	18600	38.8	21300	.41 - .51	80	80	253	K
	276614			460	60	1.15	28.2	18600	32.0	21300	.58 - .72	80	80	209	K
	276624			575	60	1.15	22.6	18600	25.6	21300	.93 - 1.15	80	80	167	K
	276655	25	18.5	200	60	1.15	80.0	22600	90.6	25800	.09 - .11	83	82	665	L
	276605			230	60	1.15	69.6	22600	78.8	25800	.11 - .14	83	82	578	L
	276665			380	60	1.15	42.1	22600	47.7	25800	.27 - .34	83	82	350	L
	276615			460	60	1.15	34.8	22600	39.4	25800	.41 - .51	83	82	289	L
	276625			575	60	1.15	27.8	22600	31.6	25800	.70 - .86	83	82	231	L
	276656	30	22	200	60	1.15	95.0	28000	108.6	31900	.07 - .09	81	80	736	K
	276606			230	60	1.15	82.6	28000	94.4	31900	.09 - .12	81	80	640	K
	276666			380	60	1.15	50.0	28000	57.2	31900	.23 - .29	81	80	387	K
	276616			460	60	1.15	41.3	28000	47.2	31900	.34 - .42	81	80	320	K
	276626			575	60	1.15	33.0	28000	37.8	31900	.52 - .65	81	80	256	K
	276667	40	30	380	60	1.15	67.2	35900	76.0	42400	.18 - .23	84	83	545	L
	276617			460	60	1.15	55.4	35900	62.8	42400	.23 - .29	84	83	450	L
	276627			575	60	1.15	45.2	35900	50.2	42400	.34 - .43	84	83	360	L

Model numbers above are for 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. Six-lead individual phase resistance = table X 1.5.

Table 26 Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX		RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
			HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
6" STD. & HI-TEMP	236650	276650	5	3.7	200	60	35	45	50	25	45
	236600	276600			230	45	30	40	45	20	40
	236660	276660			380	30	17.5	25	30	12	25
	236610	276610			460	25	15	20	25	10	20
	236620	276620			575	20	12	15	20	8	15
	236651	276651	7.5	5.5	200	80	45	70	80	35	70
	236601	276601			230	70	40	60	70	30	60
	236661	276661			380	45	25	35	40	20	35
	236611	276611			460	35	20	30	35	15	30
	236621	276621			575	30	17.5	25	25	11	25
	236652	276652	10	7.5	200	100	60	90	100	45	90
	236602	276602			230	90	50	80	90	40	80
	236662	276662			380	60	35	45	50	25	45
	236612	276612			460	45	25	40	45	20	40
	236622	276622			575	35	20	30	35	15	30
	236653	276653	15	11	200	150	90	125	150	60	125
	236603	276603			230	150	80	110	125	60	110
	236663	276663			380	80	50	70	80	35	70
	236613	276613			460	70	40	60	60	30	60
	236623	276623			575	60	30	45	50	25	45
	236654	276654	20	15	200	200	110	175	175	80	175
	236604	276604			230	175	100	150	175	70	150
	236664	276664			380	100	60	90	100	45	90
	236614	276614			460	90	50	70	80	35	70
	236624	276624			575	70	40	60	70	30	60
	236655	276655	25	18.5	200	250	150	200	225	100	200
	236605	276605			230	225	125	175	200	90	175
	236665	276665			380	125	80	110	125	50	110
	236615	276615			460	110	60	90	100	45	90
	236625	276625			575	90	50	70	80	35	70
	236656	276656	30	22	200	300	175	250	300	125	250
	236606	276606			230	250	150	225	250	100	200
	236666	276666			380	150	90	125	150	60	125
	236616	276616			460	125	70	110	125	50	100
	236626	276626			575	100	60	90	100	40	80
	236667	276667	40	30	380	200	125	175	200	90	175
	236617	276617			460	175	100	150	175	70	150
	236627	276627			575	150	80	110	125	60	110
	236668	276668	50	37	380	250	150	225	250	110	225
	236618	276618			460	225	125	175	200	90	175
	236628	276628			575	175	100	150	175	70	150
	236669	276669	60	45	380	300	175	250	300	125	250
	236619	276619			460	250	150	225	250	100	225
	236629	276629			575	200	125	175	200	80	175

Table 27 Three-Phase Motor Specifications (60 Hz) 3525 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	KILOWATTS	AMPS	KILOWATTS		S.F.	F.L.		
8" STD.	239660	40	30	380	60	1.15	64	35	72	40	.16-.20	86	86	479	J
	239600			460	60	1.15	53	35	60	40	.24-.30	86	86	396	J
	239610			575	60	1.15	42	35	48	40	.39-.49	86	86	317	J
	239661	50	37	380	60	1.15	79	43	88	49	.12-.16	87	87	656	K
	239601			460	60	1.15	64	43	73	49	.18-.22	87	87	542	K
	239611			575	60	1.15	51	43	59	49	.28-.34	87	87	434	K
	239662	60	45	380	60	1.15	92	52	104	60	.09-.11	88	87	797	K
	239602			460	60	1.15	76	52	86	60	.14-.17	88	87	658	K
	239612			575	60	1.15	61	52	69	60	.22-.28	88	87	526	K
	239663	75	55	380	60	1.15	114	64	130	73.5	.06-.09	88	88	1046	L
	239603			460	60	1.15	94	64	107	73.5	.10-.13	88	88	864	L
	239613			575	60	1.15	76	64	86	73.5	.16-.21	88	88	691	L
	239664	100	75	380	60	1.15	153	85	172	97.5	.05-.06	89	89	1466	L
	239604			460	60	1.15	126	85	142	97.5	.07-.09	89	89	1211	L
	239614			575	60	1.15	101	85	114	97.5	.11-.13	89	89	969	L
	239165	125	93	380	60	1.15	202	109	228	125	.03-.04	87	86	1596	K
	239105			460	60	1.15	167	109	188	125	.05-.07	87	86	1318	K
	239115			575	60	1.15	134	109	151	125	.08-.11	87	86	1054	K
	239166	150	110	380	60	1.15	235	128	266	146	.02-.03	88	87	1961	K
	239106			460	60	1.15	194	128	219	146	.04-.05	88	87	1620	K
	239116			575	60	1.15	155	128	176	146	.06-.08	88	87	1296	K
	239167	175	130	380	60	1.15	265	150	302	173	.02-.04	88	88	1991	J
	239107			460	60	1.15	219	150	249	173	.04-.05	88	88	1645	J
	239117			575	60	1.15	175	150	200	173	.06-.08	88	88	1316	J
	239168	200	150	380	60	1.15	298	169	342	194	.02-.03	88	88	2270	J
	239108			460	60	1.15	246	169	282	194	.03-.05	88	88	1875	J
	239118			575	60	1.15	197	169	226	194	.05-.07	88	88	1500	J

Table 27A 8" Three-Phase Motor Specifications (60 Hz) 3525 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	KILOWATTS	AMPS	KILOWATTS		S.F.	F.L.		
8" HI-TEMP	279160	40	30	380	60	1.15	69.6	38	78.7	43	.11 - .14	79	78	616	M
	279100			460	60	1.15	57.5	38	65.0	43	.16 - .19	79	78	509	M
	279110			575	60	1.15	46.0	38	52.0	43	.25 - .31	79	78	407	M
	279161	50	37	380	60	1.15	84.3	47	95.4	53	.07 - .09	81	80	832	M
	279101			460	60	1.15	69.6	47	78.8	53	.11 - .14	81	80	687	M
	279111			575	60	1.15	55.7	47	63.0	53	.18 - .22	81	80	550	M
	279162	60	45	380	60	1.15	98.4	55	112	62	.06 - .07	83	82	1081	N
	279102			460	60	1.15	81.3	55	92.1	62	.09 - .11	83	82	893	N
	279112			575	60	1.15	65.0	55	73.7	62	.13 - .16	83	82	715	N
	279163	75	56	380	60	1.15	125	68	141	77	.05 - .06	83	82	1175	L
	279103			460	60	1.15	100	68	114	77	.07 - .09	83	82	922	L
	279113			575	60	1.15	80	68	92	77	.11 - .14	83	82	738	L
	279164	100	75	380	60	1.15	159	88	181	100	.04 - .05	86	85	1508	M
	279104			460	60	1.15	131	88	149	100	.05 - .07	86	85	1246	M
	279114			575	60	1.15	105	88	119	100	.08 - .10	86	85	997	M
	279165	125	93	380	60	1.15	195	109	223	125	.03 - .04	86	85	1793	L
	279105			460	60	1.15	161	109	184	125	.04 - .06	86	85	1481	L
	279115			575	60	1.15	129	109	148	125	.07 - .09	86	85	1185	L
	279166	150	110	380	60	1.15	235	133	269	151	.02 - .03	85	84	2012	K
	279106			460	60	1.15	194	133	222	151	.03 - .05	85	84	1662	K
	279116			575	60	1.15	155	133	178	151	.05 - .07	85	84	1330	K

Model numbers above are for 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. Six-lead individual phase resistance = table X 1.5.

Table 28 Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
8" STD.	239660	40	30	380	200	125	175	200	80	175
	239600			460	175	100	150	175	70	150
	239610			575	150	80	110	125	60	110
	239661	50	37	380	250	150	200	225	100	200
	239601			460	200	125	175	200	80	175
	239611			575	175	90	150	150	70	150
	239662	60	45	380	300	175	250	300	125	250
	239602			460	250	150	200	225	100	200
	239612			575	200	110	175	175	80	175
	239663	75	55	380	350	200	300	350	150	300
	239603			460	300	175	250	300	125	250
	239613			575	250	150	200	225	100	200
	239664	100	75	380	500	275	400	450	200	400
	239604			460	400	225	350	400	175	350
	239614			575	350	200	300	300	125	300
	239165	125	93	380	700	400	600	600	250	600
	239105			460	500	300	450	500	225	450
	239115			575	450	250	350	400	175	350
	239166	150	110	380	800	450	600	700	300	600
	239106			460	600	350	500	600	250	500
	239116			575	500	300	400	450	200	400
	239167	175	130	380	800	500	700	800	350	700
	239107			460	700	400	600	700	300	600
	239117			575	600	350	450	600	225	450
	239168	200	150	380	1000	600	800	1000	400	800
	239108			460	800	450	700	800	350	700
	239118			575	600	350	500	600	250	500

Table 28A 8" Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
8" HI-TEMP	279160	40	30	380	225	125	175	200	90	175
	279100			460	175	110	150	175	70	150
	279110			575	150	90	125	125	60	125
	279161	50	37	380	250	150	225	225	110	225
	279101			460	200	125	175	200	90	175
	279111			575	175	100	150	150	70	150
	279162	60	45	380	300	175	250	300	125	250
	279102			460	275	150	225	250	100	225
	279112			575	200	125	175	175	80	175
	279163	75	56	380	400	200	350	350	150	350
	279103			460	300	175	275	300	125	275
	279113			575	275	150	225	225	100	225
	279164	100	75	380	500	300	450	450	200	450
	279104			460	400	250	350	400	175	350
	279114			575	350	200	300	300	125	300
	279165	125	93	380	700	400	600	600	250	600
	279105			460	500	300	450	500	225	450
	279115			575	450	250	350	400	175	350
	279166	150	110	380	800	450	600	700	300	600
	279106			460	600	350	500	600	250	500
	279116			575	500	300	400	450	200	400

Overload Protection of Three-Phase Submersible Motors Class 10 Protection Required

The characteristics of submersible motors are different than standard motors and special overload protection is required.

If the motor is locked, the overload protection must trip within 10 seconds to protect the motor windings. Subtrol/SubMonitor, a Franklin-approved adjustable overload relay, or a Franklin-approved fixed heater must be used.

Fixed heater overloads must be the ambient-compensated quick-trip type to maintain protection at high and low air temperatures.

All heaters and amp settings shown are based on total line amps. When determining amperage settings or making heater selections for a six-lead motor with a Wye-Delta starter, divide motor amps by 1.732.

Pages 29, 30 and 31 list the correct selection and settings for some manufacturers. Approval for other manufacturers' types not listed may be requested by calling Franklin's Submersible Service Hotline at 800-348-2420.

Refer to notes on page 30.

Table 29 - 60 Hz 4" Motors

HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
				FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
1/2	0.37	200	00	K31	L380A	3.2	3.4
		230	00	K28	L343A	2.7	2.9
		380	00	K22	L211A	1.7	1.8
		460	00	-	L174A	1.4	1.5
		575	00	-	-	1.2	1.3
3/4	0.55	200	00	K34	L510A	4.1	4.4
		230	00	K32	L420A	3.5	3.8
		380	00	K27	L282A	2.3	2.5
		460	00	K23	L211A	1.8	1.9
		575	00	K21	L193A	1.5	1.6
1	0.75	200	00	K37	L618A	5.0	5.4
		230	00	K36	L561A	4.4	4.7
		380	00	K28	L310A	2.6	2.8
		460	00	K26	L282A	2.2	2.4
		575	00	K23	L211A	1.8	1.9
1.5	1.1	200	00	K42	L750A	6.3	6.8
		230	00	K39	L680A	5.5	5.9
		380	00	K32	L420A	3.3	3.6
		460	00	K29	L343A	2.8	3.0
		575	00	K26	L282A	2.2	2.4
2	1.5	200	0	K50	L111B	8.6	9.3
		230	0	K49	L910A	7.5	8.1
		380	0	K36	L561A	4.6	4.9
		460	00	K33	L463A	3.8	4.1
		575	00	K29	L380A	3.0	3.2
3	2.2	200	0	K55	L147B	11.6	12.5
		230	0	K52	L122B	10.1	10.9
		380	0	K41	L750A	6.1	6.6
		460	0	K37	L618A	5.1	5.5
		575	0	K34	L510A	4.1	4.4
5	3.7	200	1	K62	L241B	19.1	20.5
		230	1	K61	L199B	16.6	17.8
		380	0	K52	L122B	10.0	10.8
		460	0	K49	L100B	8.3	8.9
		575	0	K42	L825A	6.6	7.1
7.5	5.5	200	1	K68	L332B	28.4	30.5
		230	1	K67	L293B	24.6	26.4
		380	1	K58	L181B	14.9	16.0
		460	1	K55	L147B	12.3	13.2
		575	1	K52	L122B	9.9	10.6
10	7.5	380	1	K62	L241B	19.5	21.0
		460	1	K60	L199B	16.1	17.3
		575	1	K56	L165B	12.9	13.6

Table 30 - 60 Hz 6" Standard & Hi-Temp Motors

HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
				FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
5	3.7	200	1	K61	L220B	17.6	19.1
		230	1	K61	L199B	15.4	16.6
		380	0	K52	L122B	9.4	10.1
		460	0	K49	L100B	7.7	8.3
		575	0	K42	L825A	6.1	6.6
7.5	5.5	200	1	K67	L322B	26.3	28.3
		230	1	K64	L293B	22.9	24.6
		380	1	K57	L165B	13.9	14.9
		460	1	K54	L147B	11.4	12.3
		575	1	K52	L111B	9.1	9.8
10	7.5	200	2(1)	K72	L426B	34.4	37.0
		230	2(1)	K70	L390B	29.9	32.2
		380	1	K61	L220B	18.1	19.5
		460	1	K58	L181B	15.0	16.1
		575	1	K55	L147B	12.0	12.9
15	11	200	3(1)	K76	L650B	50.7	54.5
		230	2	K75	L520B	44.1	47.4
		380	2(1)	K68	L322B	26.7	28.7
		460	2(1)	K64	L265B	22.0	23.7
		575	2(1)	K61	L220B	17.7	19.0
20	15	200	3	K78	L787B	64.8	69.7
		230	3(1)	K77	L710B	56.4	60.6
		380	2	K72	L426B	34.1	36.7
		460	2	K69	L352B	28.2	30.3
		575	2	K64	L393B	22.7	24.4
25	18.5	200	3	K86	L107C	80.3	86.3
		230	3	K83	L866B	69.8	75.0
		380	2	K74	L520B	42.2	45.4
		460	2	K72	L426B	34.9	37.5
		575	2	K69	L352B	27.9	30.0
30	22	200	4(1)	K88	L126C	96.7	104.0
		230	3	K87	L107C	84.1	90.4
		380	3(1)	K76	L650B	50.9	54.7
		460	3(1)	K74	L520B	42.0	45.2
		575	3(1)	K72	L390B	33.7	36.2
40	30	380	3	K83	L866B	69.8	75.0
		460	3	K77	L710B	57.7	62.0
		575	3	K74	L593B	46.1	49.6
50	37	380	3	K87	L107C	86.7	93.2
		460	3	K83	L950B	71.6	77.0
		575	3	K77	L710B	57.3	61.6
60	45	380	4(1)	K89	L126C	102.5	110.2
		460	4(1)	K87	L107C	84.6	91.0
		575	4(1)	K78	L866B	67.7	72.8

Footnotes for Tables 29, 30, and 31

NOTE 1: Furnas intermediate sizes between NEMA starter sizes apply where (1) is shown in tables, size 1.75 replacing 2, 2.5 replacing 3, 3.5 replacing 4, and 4.5 replacing 5. Heaters were selected from Catalog 294, table 332 and table 632 (starter size 00, size B). Size 4 starters are heater type 4 (JG). Starters using these heater tables include classes 14, 17 and 18 (inNOVA), classes 36 and 37 (reduced voltage), and classes 87, 88 and 89 (pump and motor control centers). 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. Heater selections for class 16 starters (Magnetic Definite Purpose) will be furnished upon request.

NOTE 2: General Electric heaters are type CR123 usable only on type CR124 overload relays and were selected from Catalog GEP-126OJ, page 184. 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. Relay adjustment should be set at the specified SET amps. 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 or 6 starters are all used with current transformers per manufacturer standards. Adjustable relays may or may not use current transformers depending on design.

Table 31 - 60 Hz 8" Motors

MOTOR MODEL PREFIX	HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
					FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
239660	40	30	380	3	K78	L866B	68	73
239600			460	3	K77	L710B	56	60
239610			575	3	K73	L520B	45	48
239661	50	37	380	3	K86	L107C	81	87
239601			460	3	K78	L866B	68	73
239611			575	3	K77	L710B	56	60
239662	60	45	380	4(1)	K89	L126C	101	108
239602			460	4(1)	K86	L107C	83	89
239612			575	4(1)	K78	L787B	64	69
239663	75	55	380	4	K92	L142C	121	130
239603			460	4(1)	K89	L126C	100	107
239613			575	4(1)	K85	L950C	79	85
239664	100	75	380	5(1)	K28	L100B	168	181
239604			460	4	K92	L155C	134	144
239614			575	4	K90	L142C	108	116
239165	125	93	380	5	K32	L135B	207	223
239105			460	5(1)	K29	L111B	176	189
239115			575	5(1)	K26	L825A	140	150
239166	150	110	380	5	-	L147B	248	267
239106			460	5(1)	K32	L122B	206	221
239116			575	5(1)	K28	L100B	165	177
239167	175	130	380	6	K26	-	270	290
239107			460	5	K33	L147B	233	250
239117			575	5	K31	L111B	186	200
239168	200	150	380	6	K27	-	316	340
239108			460	5	K33	L165B	266	286
239118			575	5	K32	L135B	213	229

Table 31A - 60 Hz 8" Hi-Temp 75°C Motors

MOTOR MODEL PREFIX	HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
					FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
279160	40	30	380	3	K83	L866B	73	79
279100			460	3	K77	L710B	60	65
279110			575	3	K74	L593B	48	52
279161	50	37	380	3	K87	L107C	89	95
279101			460	3	K83	L866B	73	79
279111			575	3	K77	L710B	59	63
279162	60	45	380	4(1)	K89	L126C	104	112
279102			460	4(1)	K87	L107C	86	92
279112			575	4(1)	K78	L866B	69	74
279163	75	56	380	4	K92	L155C	131	141
279103			460	4(1)	K89	L126C	106	114
279113			575	4(1)	K87	L950C	86	92
279164	100	75	380	5(1)	K28	L100B	168	181
279104			460	5(1)	K26	L825A	139	149
279114			575	4	K90	L142C	111	119
279165	125	93	380	5	K32	L135B	207	223
279105			460	5(1)	K29	L111B	171	184
279115			575	5(1)	K26	L825A	138	148
279166	150	110	380	5	-	L147B	250	269
279106			460	5(1)	K32	L122B	206	222
279116			575	5(1)	K28	L100B	166	178

Note: 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.

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.

Recommended Adjustable Overload Relays

Advance Controls: MDR3 Overload

AEG Series: B17S, B27S, B27-2

ABB Type: RVH 40, RVH65, RVP160, T25DU, T25CT, TA25DU

AGUT: MT03, R1K1, R1L0, R1L3, TE set Class 5

Allen Bradley: Bulletin 193, SMP-Class 10 only

Automatic Switch Types: DQ, LR1-D, LR1-F, LR2 Class 10

Benshaw: RSD6 (Class 10) Soft Start

Bharita C-H: MC 305 ANA 3

Clipsal: 6CTR, 6MTR

Cutler-Hammer: C316F, C316P, C316S, C310-set at 6 sec max, Advantage Class10

Fanal Types: K7 or K7D through K400

Franklin Electric: Subtrol-Plus, SubMonitor

Fuji Types: TR-OQ, TR-OQH, TR-2NQ, TR- 3NQ, TR-4NQ, TR-6NQ, RCa 3737-ICQ & ICQH

Furnas Types: US15 48AG & 48BG, 958L, ESP100-Class 10 only, 3RB10-Class 10

General Electric: CR4G, CR7G, RT*1, RT*2, RTF3, RT*4, CR324X-Class 10 only

Kasuga: RU Set Operating Time Code = 10 & time setting 6 sec max

Klockner-Moeller Types: ZOO, Z1, Z4, PKZM1, PKZM3 & PKZ2

Lovato: RC9, RC22, RC80, RF9, RF25 & RF95

Matsushita: FKT-15N, 15GN, 15E, 15GE, FT-15N, FHT-15N

Mitsubishi: ET, TH-K12ABKP, TH-K20KF, TH-K20KP, TH-K20TAKF, TH-K60KF, TH-K60TAKF

Omron: K2CM Set Operating Timing Code = 10 & time setting 6 sec max, SE-KP24E time setting 6 sec max

Riken: PM1, PM3

Samwha: EOCRS Set for Class 5, EOCR-ST, EOCR-SE, EOCR-AT time setting 6 sec max

Siemens Types: 3UA50, -52, -54, -55, -58, -59, -60, -61, -62, -66, -68, -70, 3VUI3, 3VE, 3UB (Class 5)

Sprecher and Schuh Types: CT, CT1, CTA 1, CT3K, CT3-12 thru CT3-42, KTA3, CEF1 & CET3 set at 6 sec max, CEP 7 Class 10, CT4, 6, & 7, CT3, KT7

Square D/Telemecanique: Class 9065 Types: TD, TE, TF, TG, TJ, TK, TR, TJE &TJF (Class 10), LR1-D, LR1-F, LR2 Class 10, Types 18A, 32A, SS-Class 10, SR-Class 10 and 63-A-LB Series. Integral 18,32,63, GV2-L, GV2-M, GV2-P, GV3-M (1.6-10 amp only) LR9D, SF Class 10, ST Class 10, LT6 (Class 5 or 10), LRD (Class 10), Motor Logic (Class10)

Toshiba Type: 2E RC820, set at 8 sec max.

WEG: RW2

Westinghouse Types: FT13, FT23, FT33, FT43, K7D, K27D, K67D, Advantage (Class 10), MOR, IQ500 (Class 5)

Westmaster: OLWROO and OLWTOO suffix D thru P

SUBMERSIBLE PUMP
Installation Check List

1. Motor Inspection

- ☐ A. Verify that the model, hp or kW, voltage, phase and hertz on the motor nameplate match the installation requirements.
- ☐ B. Check that the motor lead assembly is not damaged.
- ☐ C. Measure insulation resistance using a 500 or 1000 volt DC megohmmeter from each lead wire to the motor frame. Resistance should be at least 200 megohms without drop cable.
- ☐ D. Keep a record of motor model number, hp or kW, voltage, and serial number (S/N). (S/N is stamped in shell above the nameplate. A typical example, S/N 07A18 01-0123)

2. Pump Inspection

- ☐ A. Check that the pump rating matches the motor.
- ☐ B. Check for pump damage and 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, debris and uneven paint thickness.
- ☐ B. Pumps and motors over 5 hp should be assembled in the vertical position to prevent stress on pump brackets and shafts. Assemble the pump and motor together so their mounting faces are in contact and then tighten assembly bolts or nuts evenly to manufacturer specifications.
- ☐ 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 wires during assembly or installation.

4. Power Supply and Controls

- ☐ A. Verify that the power supply voltage, Hertz, and kVA capacity match motor requirements.
- ☐ B. Verify control box hp and voltage matches motor (3-wire only).
- ☐ 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. Motors 5 hp 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 Drop Cable

- ☐ A. Use submersible cable sized in accordance with local regulations and the cable charts. See pages 11 and 16-21. Ground motor per national and local codes.
- ☐ B. Include a ground wire to the motor and surge protection, connected to the power supply ground if required by codes. Always ground any pump operated outside a drilled well.

7. Motor Cooling

- ☐ A. Ensure at all times that the installation provides adequate motor cooling; see page 6 for details.

SUBMERSIBLE PUMP
Installation Check List

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 padding between cable and any metal straps.
- ☐ C. A check valve in the delivery pipe is recommended. More than one check valve may be required, depending on valve rating and pump setting; see page 5 for details.
- ☐ D. Assemble all pipe joints as tightly as practical, to prevent unscrewing from motor torque. Torque should be 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. Pump should be at least 10 feet (3 meters) from the bottom of the well to allow for sediment build up.
- ☐ F. Check insulation resistance as pump/motor assembly is lowered into the well. Resistance may drop gradually as more cable enters the water, but any sudden drop indicates possible cable, splice or motor lead damage; see page 45.

9. After Installation

- ☐ A. Check all electrical and water line connections and parts before starting the pump.
- ☐ 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. Rotation may be reversed (with power off) by interchanging any two motor lead connections to the power supply.
- ☐ C. Check three-phase motors for current balance within 5% of average, using motor manufacturer instructions Imbalance over 5% will cause higher motor temperatures and may cause overload trip, vibration, and reduced life.
- ☐ D. Verify that starting, running and stopping cause no significant vibration or hydraulic shocks.
- ☐ E. After at least 15 minutes running time, verify that pump output, electrical input, pumping level, and other characteristics are stable and as specified.

Date _____ Filled In By _____

Notes _____

_____

_____

_____

_____

_____

Franklin Electric

SUBMERSIBLE MOTOR INSTALLATION RECORD
Form 2207 - Page 1

RMA Number

KEY DEALER #

DISTRIBUTOR	INSTALLER	END USER
Name:	Name:	Name:
City:	City:	City:
State: Zip:	State: Zip:	State: Zip:

Well ID or GPS: _____ _____ _____ Water Temperature: _____ ☐ °F ☐ °C

Application/Water Use (e.g. potable water, irrigation, municipal, fountain, etc.): _____

Date Installed (mm/yy): _____ Date Failed (mm/yy): _____ Motor Position Shaft-Up: ☐ Yes ☐ No

Operating Cycle: ON Time Per Start _____ ☐ Hrs. ☐ Mins. Time OFF Between Stop & Restart _____ ☐ Hrs. ☐ Mins.

MOTOR

Model: _____ Serial Number: _____ Date Code (if updated): _____

MOTOR OVERLOAD

System Typical Operating Current: _____ Amps @ _____ Volts

Overload: ☐ FE SubMonitor Input Amps _____ D3 Attached ☐ Yes ☐ No Fault Settings Attached ☐ Yes ☐ No

☐ Other Manufacturer Model: _____ Dial Set at: _____ or Heater# _____

NEMA Class: ☐ 10 ☐ 20 ☐ 30 Ambient Compensated: ☐ Yes ☐ No

Power to Motor by: ☐ Full Volt Starter ☐ VFD ☐ Soft Starter VFD or Soft Starter Mfr. & Model: _____

PUMP

Manufacturer: _____

Model: _____

Stages: _____

Design Rating: _____ gpm @ _____ ft TDH

Horsepower Required by Pump End: _____

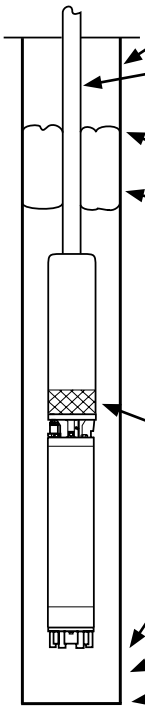
Actual Pump Delivery: _____ gpm @ _____ psi

What Controls When System Runs & Stops:

_____

(e.g. pressure, level, flow, manual on/off, timer, time clock etc.)

WELL DATA (All measurements from well head down.)



Casing Diameter _____ in

Drop Pipe Diameter _____ in

Number of Sticks of Drop Pipe _____

Static Water Level _____ ft

Drawdown (pumping) Water Level _____ ft

Spring Assist Check Valves:
(Measured from Well Head Down)

#1 _____ #2 _____ #3 _____ #4 _____ ft

☐ Solid ☐ Drilled Poppet ☐ Break-Off Plug

Pump Inlet Setting _____ ft

Flow Sleeve ☐ No ☐ Yes, Dia. _____ in

Case Ends _____ ft

☐ Well Screen ☐ Perforated Casing

#1 from ____ to ____ ft & #2 from ____ to ____ ft

Well Depth _____ ft

YOUR NAME / DATE

_____ / _____

Franklin Electric

SUBMERSIBLE MOTOR INSTALLATION RECORD
Form 2207 - Page 2

RMA Number

TRANSFORMERS

Number of Transformers: ☐ Two ☐ Three Transformers Supply Motor Only: ☐ Yes ☐ No ☐ Unsure

Transformer #1: _____ kVA Transformer #2: _____ kVA Transformer #3: _____ kVA

POWER CABLES & GROUND WIRE

1 **Service Entrance to Pump Control Panel:**

Length: _____ ft. & Gauge: _____ AWG/MCM

Material: ☐ Copper ☐ Aluminum Construction: ☐ Jacketed ☐ Individual Conductors ☐ Web ☐ Twisted

Temperature Rating of Cable: ☐ 60C ☐ 75C ☐ 90C ☐ 125C or Insulation Type: _____ (e.g. THHN)

2 **Pump Control Panel to Motor:**

Length: _____ ft. & Gauge: _____ AWG/MCM

Material: ☐ Copper ☐ Aluminum Construction: ☐ Jacketed ☐ Individual Conductors ☐ Web ☐ Twisted

Temperature Rating of Cable: ☐ 60C ☐ 75C ☐ 90C ☐ 125C or Insulation Type: _____ (e.g. THHN)

3 **Ground Wire Size:** From Control Panel to Motor: _____ AWG/MCM

Control Grounded to (mark all that apply):

☐ Well Head ☐ Metal Casing ☐ Motor ☐ Driven Rod ☐ Power Supply

INCOMING VOLTAGE

No Load L1-L2 _____ L2-L3 _____ L1-L3 _____

Full Load L1-L2 _____ L2-L3 _____ L1-L3 _____

RUNNING AMPS & CURRENT BALANCE

Full Load L1 _____ L2 _____ L3 _____

% Unbalance: _____

CONTROL PANEL

1 **Pump Panel Manufacturer/Fabricator:** _____

2 **Short Circuit Protection - Fuses or Circuit Breaker**

Option #1 - Fuse

Manufacturer: _____ Model: _____ Rating: _____ Amps

Type: ☐ Time-Delay ☐ Standard

Option #2 - Circuit Breaker

Manufacturer: _____ Model: _____ Rating: _____ Amps Setting: _____

3 **Starter - Full Voltage, Reduced Voltage, Soft-Starter or VFD (Variable Frequency Drive)**

Option #1 - Full Voltage

Manufacturer: _____ Model: _____ Size: _____ Contacts: ☐ NEMA ☐ IEC

Option #2 - Reduced Voltage

Manufacturer: _____ Model: _____ Ramp Time to Full Voltage: _____ sec.

Option #3 - Soft-Starter or VFD

Manufacturer: _____ Model: _____ Max. Continuous Amp Output Rating: _____

Min. Setting: _____ Hz & GPM: _____ Max. Setting: _____ Hz & GPM: _____

Start Ramp Time to 30 Hz: _____ sec. Stop Mode: ☐ Power Off Coast ☐ 30-0 Hz Ramp _____ sec.

Special Output Filter Purchased: ☐ Yes ☐ No

Output Filter Manufacturer: _____ Model: _____ % Reactance: _____

4 **Surge Arrestor:** ☐ No ☐ Yes, Manufacturer: _____ Model: _____

Franklin Electric

SUBMERSIBLE MOTOR
Booster Installation Record

RMA Number

Date _____ /_____/_____ Filled In By _____

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 _____
Is this a "HERO" system (10.0 - 10.5 PH)? ☐ Yes ☐ No

MOTOR

Model No. _____ Serial No. _____ Date Code _____
Horsepower _____ Voltage _____ ☐ Single-Phase ☐ Three-Phase Diameter _____ in.
Slinger Removed? ☐ Yes ☐ No Check Valve Plug Removed? ☐ Yes ☐ No
Motor Fill Solution ☐ Standard ☐ DI Water Model No. _____ Serial No. _____ Date Code _____

PUMP

Manufacturer _____ Model _____ Serial No. _____
Stages _____ Diameter _____ Flow Rate Of _____ gpm At _____TDH
Booster Case Internal Diameter _____ Material _____

CONTROLS AND PROTECTIVE DEVICES

SubMonitor? ☐ Yes ☐ No If Yes, Warranty Registration No._____
If Yes, Overload Set? ☐ Yes ☐ No _____ Set At _____
Underload Sets? ☐ Yes ☐ No _____ Set At _____
VFD or Reduced Voltage Starter? ☐ Yes ☐ No If Yes, Type _____
Mfr. _____Setting _____% Full Voltage In _____sec
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 Delay ____ sec
Inlet Flow Control ☐ Yes ☐ No If Yes, Mfr._____ Model _____ Setting _____ gpm Delay ____ sec
Outlet Pressure Control ☐ Yes ☐ No If Yes, Mfr._____ Model _____ Setting _____ psi Delay ____ sec
Outlet Flow Control ☐ Yes ☐ No If Yes, Mfr._____ Model _____ Setting _____ gpm Delay ____ sec
Water Temperature Control ☐ Yes ☐ No If Yes, Mfr._____ Model _____ Delay ____ sec
Set At _____ °F or _____ °C Located _____

Franklin Electric

SUBMERSIBLE MOTOR
Booster Installation Record

INSULATION CHECK

Initial Megs: Motor & Lead Only Black (T1/U1)_____ Yellow (T2/V1)_____ Red (T3/W1)_____

Installed Megs: Motor, Lead, & Cable Black (T1/U1)_____ Yellow (T2/V1)_____ Red (T3/W1)_____

VOLTAGE TO MOTOR

Non-Operating: B-Y (T1/U1 - T2/V1)_____ Y-R (T2/V1 - T3/W1)_____ R-B (T3/W1 - T1/U1)_____

At Rated Flow of _____gpm B-Y (T1/U1 - T2/V1)_____ Y-R (T2/V1 - T3/W1)_____ R-B (T3/W1 - T1/U1)_____

At Open Flow _____gpm B-Y (T1/U1 - T2/V1)_____ Y-R (T2/V1 - T3/W1)_____ R-B (T3/W1 - T1/U1)_____

AMPS TO MOTOR

At Rated Flow of _____gpm Black (T1/U1)_____ Yellow (T2/V1)_____ Red (T3/W1)_____

At Open Flow _____gpm Black (T1/U1)_____ Yellow (T2/V1)_____ Red (T3/W1)_____

At Shut Off* Black (T1/U1)_____ Yellow (T2/V1)_____ Red (T3/W1)_____

*Do **NOT** run at Shut Off more than two (2) minutes.

Inlet Pressure _____psi Outlet Pressure _____psi Water Temperature _____ °F or _____ °C

If you have any questions or problems, call the Franklin Electric Toll-Free Hot Line: 1-800-348-2420

Comments: _____

_____

_____

_____

PLEASE SKETCH THE SYSTEM

Franklin Electric

SubMonitor Three-Phase Protection

Applications

SubMonitor is designed to protect 3-phase pumps/motors with service factor amp ratings (SFA) from 5 to 350 A (approx. 3 to 200 hp). Current, voltage, and motor temperature are monitored using all three legs and allows the user to set up the SubMonitor quickly and easily.

Protects Against

- Under/Overload
- Under/Overvoltage
- Current Unbalance
- Overheated Motor
  (if equipped with Subtrol Heat Sensor)
- False Start (Chattering)
- Phase Reversal

Power Factor Correction

In some installations, power supply limitations make it necessary or desirable to increase the power factor of a submersible 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 32 kVAR Required 60 Hz

MOTOR		KVAR REQUIRED FOR PF OF:		
HP	KW	0.90	0.95	1.00
5	3.7	1.2	2.1	4.0
7.5	5.5	1.7	3.1	6.0
10	7.5	1.5	3.3	7.0
15	11	2.2	4.7	10.0
20	15	1.7	5.0	12.0
25	18.5	2.1	6.2	15.0
30	22	2.5	7.4	18.0
40	30	4.5	11.0	24.0
50	37	7.1	15.0	32.0
60	45	8.4	18.0	38.0
75	55	6.3	18.0	43.0
100	75	11.0	27.0	60.0
125	93	17.0	36.0	77.0
150	110	20.0	42.0	90.0
175	130	9.6	36.0	93.0
200	150	16.0	46.0	110.0

Values listed are total required (not per phase).

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 in series in the control circuit.

Line Voltage Control

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

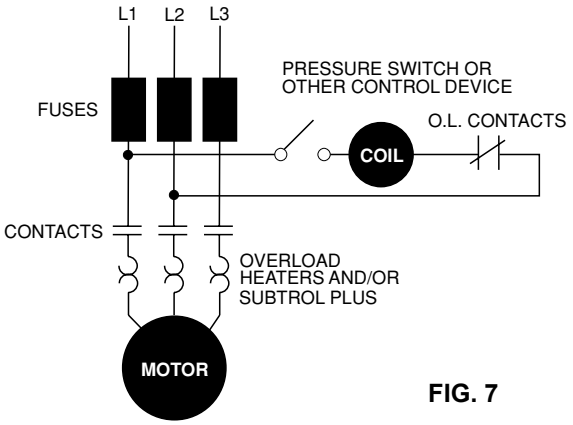


FIG. 7

Low Voltage Transformer Control

This control is 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.

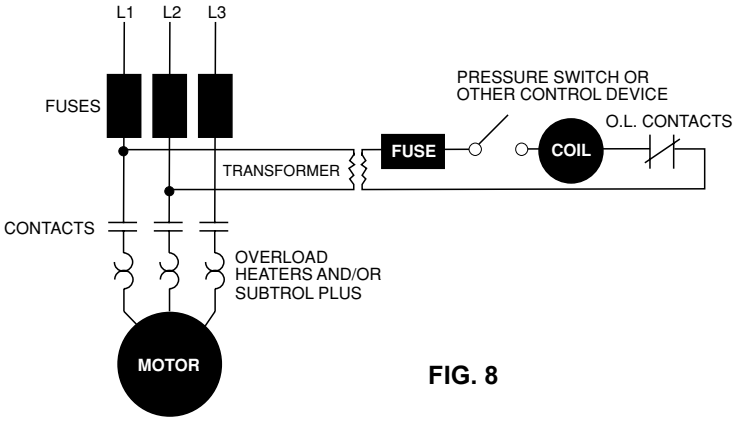


FIG. 8

External Voltage Controls

Control of a power circuit by a lower 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.

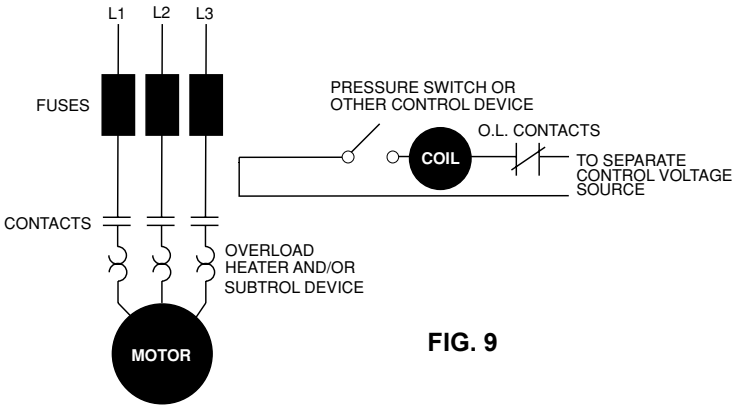


FIG. 9

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 rating should be no smaller than listed in table 4 for supply power to the motor alone.

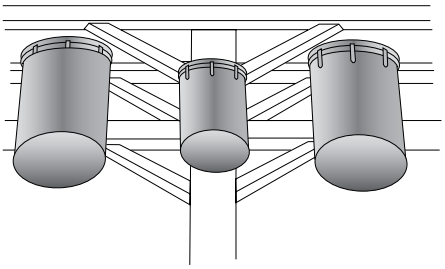


FIG. 10
FULL THREE-PHASE

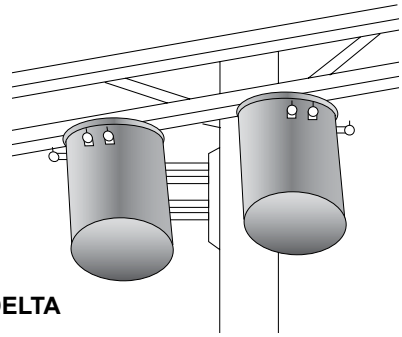


FIG. 11
OPEN DELTA

Checking and Correcting Rotation and Current Unbalance

1. Establish correct motor rotation by running the motor in both directions. Normal rotation is CCW viewing the shaft end. Rotation can be changed by interchanging any two of the three motor leads. The rotation that gives the most water flow is typically 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 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 amps 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. Multiply the result by 100 to determine percent of unbalance.
4. Current unbalance should not exceed 5% at max amp 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 side” of the system. 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.

Phase designation of leads for CCW rotation viewing shaft end.

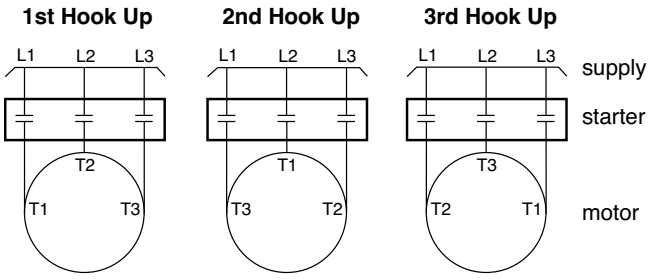
To reverse rotation, interchange any two leads.

Phase 1 or “A” - Black, T1, or U1

Phase 2 or “B” - Yellow, T2, or V1

Phase 3 or “C” - Red, T3, or W1

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



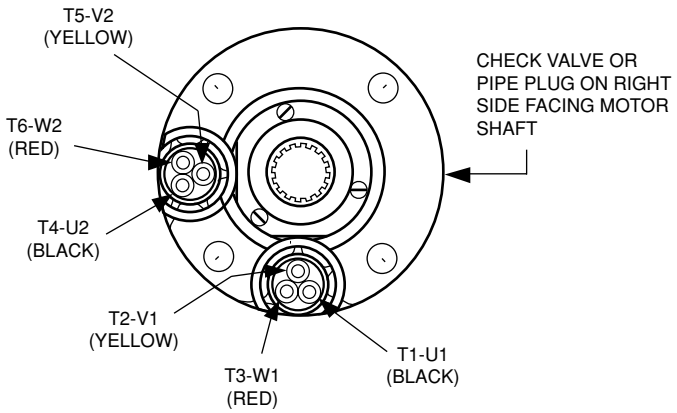
EXAMPLE:

T1 = 51 amps	T3 = 50 amps	T2 = 50 amps
T2 = 46 amps	T1 = 49 amps	T3 = 48 amps
+ T3 = 53 amps	+ T2 = 51 amps	+ T1 = 52 amps
Total = 150 amps	Total = 150 amps	Total = 150 amps
$\frac{150}{3}$ = 50 amps	$\frac{150}{3}$ = 50 amps	$\frac{150}{3}$ = 50 amps
50 - 46 = 4 amps	50 - 49 = 1 amp	50 - 48 = 2 amps
$\frac{4}{50}$ = 0.08 or 8%	$\frac{1}{50}$ = 0.02 or 2%	$\frac{2}{50}$ = 0.04 or 4%

Three-Phase Motor Lead Identification

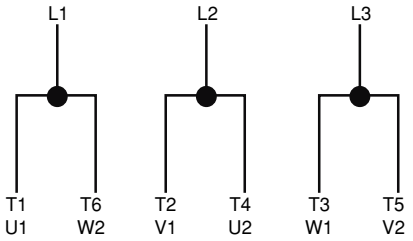
WARNING: When installing 6-lead motors extra care must be used to ensure lead identification at the surface. Leads must be marked and connected per diagram. Motor leads are not connected red to red, yellow to yellow, etc.

Line Connections — Six-Lead Motors

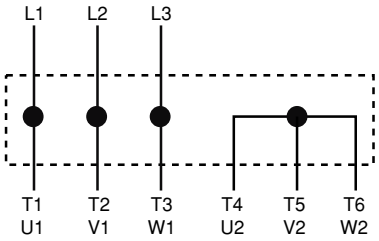


90° Lead Spacing

Connections for across-the-line starting, running, and any reduced voltage starting except WYE-DELTA type starters.



WYE-DELTA starters connect the motor as shown below during starting, then change to the running connection shown at the left.



Each motor lead is numbered with two markers, one near each end. To reverse rotation, interchange any two line connections.

Phase Converters

There are a number of different types of phase converters available. Each generates three-phase power from a single-phase power line.

In all phase converters, the voltage balance is critical to current balance. Although 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 3 ft/s flow past the motor. 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. SubMonitor may be used with electro mechanical type phase converters, however special connections are required. Consult SubMonitor Manual for connections of receiver and lightning arrestor.
5. SubMonitor will not work with electronic solid state phase converters.
6. Current unbalance must not exceed 10%.

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 a half second or less. The motor current goes from zero to locked rotor amps, then drops to running amps at full speed. This may dim lights, cause momentary voltage dips to other electrical equipment, and shock power distribution transformers.

In some cases the power companies may require reduced-voltage starters to limit this voltage dip. There are also times when reduced-voltage starters may be desirable to reduce motor starting torque thus reducing the stress on shafts, couplings, and discharge piping. Reduced-voltage starters also slow the rapid acceleration of the water on start-up to help control upthrust and water hammer.

Reduced-voltage starters may not be required if the maximum recommended cable length is used. With maximum recommended cable length there is a 5% voltage drop in the cable at running amps, resulting in about 20% reduction in starting current and about 36% reduction in starting torque compared to having rated voltage at the motor. This may be enough reduction in starting current so that reduced-voltage starters are not required.

Three-Lead Motors: Autotransformer or solid-state reduced-voltage starters may be used for soft-starting standard three-phase motors.

When autotransformer starters are used, the motor should be supplied with at least 55% of rated voltage to ensure adequate starting torque. Most autotransformer starters have 65% and 80% 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 the 80% taps may be used. When the cable length is more than 50% of allowable, the 80% tap should be used.

Six-Lead Motors: 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 compatible with Franklin Electric submersible motors and should not be used.

Wye-Delta starters of the open-transition type, which momentarily interrupt power during the starting cycle, are not recommended. Closed-transition starters have no interruption of power during the start cycle and can be used with satisfactory results.

Reduced-voltage starters have adjustable settings for acceleration ramp time, typically preset at 30 seconds. They must be adjusted so the motor is at full voltage within THREE SECONDS MAXIMUM to prevent excessive radial and thrust bearing wear.

If Subtrol-Plus or SubMonitor is used the acceleration time must be set to TWO SECONDS MAXIMUM due to the 3 second reaction time of the Subtrol-Plus or SubMonitor.

Solid-state starters AKA soft starts may not be compatible with Subtrol-Plus/SubMonitor. However, in some cases a bypass contactor has been used. Consult the factory for details.

During shutdown, Franklin Electric's recommendation is for the power to be removed, allowing the pump/motor to coast down. Stopping the motor by ramping down the voltage is possible, but should be limited to three (3) seconds maximum.

Inline Booster Pump Systems

Franklin Electric offers three different types of motors for non-vertical applications.

1. The **Booster** motors are specifically designed for booster applications. They are the **"Best Choice" for sealed Reverse Osmosis applications.** These motors are the result of two years of focused development and bring additional value and durability to booster module systems. These motors are only available to OEMs or Distributors who have demonstrated capability in Booster Module systems design and operation and adhere to Franklin's Application Manual requirements.

2. The **Hi-Temp** motors have many of the internal design features of the Booster motor. It's additional length allows for higher temperature handling and the Sand Fighter sealing system provides greater abrasion resistance. One or both of these conditions are often experienced in open atmosphere applications such as lakes, ponds, etc.

3. The **Standard Vertical Water Well** (40-125 hp) motors can be adapted to non-vertical applications when applied per the below guidelines. However, they will be more sensitive to application variances than the other two designs.

All of the above motors must be applied per the guidelines listed below. In addition, for all applications where the motor is applied in a sealed system, a Submersible Motor Booster Installation Record (Form 3655) or its equivalent must be completed at startup and received by Franklin Electric within 60 days. A sealed system is one where the motor and pump intake are mounted in a sleeve and the water feeding the pump intake is not open to the atmosphere.

Continued on next page

Inline Booster Pump Systems (continued)

Design And Operational Requirements

1. **Non-Vertical Operation:** Vertical Shaft-up (0°) to Horizontal (90°) operation is acceptable as long as the pump transmits "down-thrust" to the motor within 3 seconds after start-up and continuously during operation. However, it is best practice to provide a positive slope whenever it is possible, even if it is only a few degrees.

2. **Motor, Sleeve, and Pump Support System:** The booster sleeve ID must be sized according to the motor cooling and pump NPSHR requirements. The support system must support the motor's weight, prevent motor rotation and keep the motor and pump aligned. The support system must also allow for thermal axial expansion of the motor without creating binding forces.

3. **Motor Support Points:** A minimum of two support points are required on the motor. One in the motor/pump flange connection area and one in the bottom end of the motor area. The motor castings, not the shell area, are recommended as support points. If the support is a full length support and/or has bands in the shell area, they must not restrict heat transfer or deform the shell.

4. **Motor Support Material and Design:** The support system shall not create any areas of cavitation or other areas of reduced flow less than the minimum rate required by this manual. They should also be designed to minimize turbulence and vibration and provide stable alignment. The support materials and locations must not inhibit the heat transfer away from the motor.

5. **Motor and Pump Alignment:** The maximum allowable misalignment between the motor, pump, and pump discharge is 0.025 inch per 12 inches of length (2 mm per 1000 mm of length). This must be measured in both directions along the assembly using the motor/pump flange connection as the starting point. The booster sleeve and support system must be rigid enough to maintain this alignment during assembly, shipping, operation and maintenance.

6. The best motor lubrication and heat resistance is obtained with the factory based propylene glycol fill solution. Only when an application MUST HAVE deionized (DI) water should the factory fill solution be replaced. When a deionized water fill is required, the motor must be derated as indicated on the below chart. The exchange of the motor fill solution to DI water must be done by an approved Franklin service shop or representative using a vacuum fill system per Franklin's Motor Service Manual instruction. The motor shell then must be permanently stamped with a D closely behind the Serial Number.

   The maximum pressure that can be applied to the motor internal components during the removal of the factory fill solution is 7 psi (0.5 bar.)

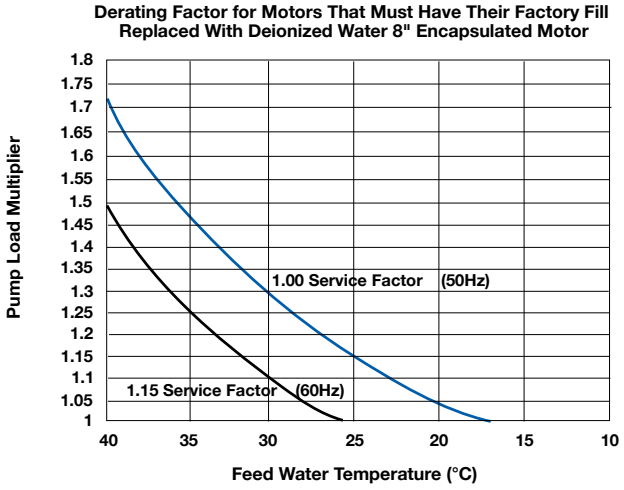


FIG. 12

First: Determine maximum Feed Water Temperature that will be experienced in this application. If the feed water exceeds the maximum ambient of the motor, both the DI water derating and a hot water application derating must be applied.

Second: Determine the Pump Load Multiplier from the appropriate Service Factor curve. (Typical 1.15 Service Factor is for 60 Hz ratings &1.00 Service Factor for 50 Hz ratings).

Third: Multiply the Pump Load Requirement times the pump load multiplier number indicated on the vertical axis to determine the Minimum Motor Nameplate Rating.

Fourth: Select a motor with a nameplate equal or higher than the above calculated value.

7. **Motor Alterations - Sand Slinger & Check Valve Plug:** On 6" and 8" motors, the rubber sand slinger located on the shaft must be removed. If a pipe plug is covering the check valve, it must be removed. The special Booster motor already has these modifications.

8. **Frequency of Starts:** Fewer than 10 starts per 24-hour period are recommended. Allow at least 20 minutes between shutdown and start-up of the motor.

Continued on next page

Inline Booster Pump Systems (continued)

9. **Controls-Soft Starters and VFDs:** Reduced voltage starters and variable speed drives (inverter drives) may be used with Franklin three-phase submersible motors to reduce starting current, upthrust, and mechanical stress during start-up. The guidelines for their use with submersible motors are different than with normal air cooled motor applications. Refer to the Franklin Electric Application, Installation and Maintenance (AIM) Manual Reduced Voltage Starters section or Variable Speed Submersible Pump Operation, Inverter Drives sections for specific details including required filtering.

10. **Motor Overload Protection:** Submersible motors require properly sized ambient compensated Class 10 quick-trip overloads per Franklin's AIM Manual guidelines to protect the motor. Class 20 or higher overloads are NOT acceptable. Franklin's SubMonitor is strongly recommended for all large submersibles since it is capable of sensing motor heat without any additional wiring to the motor. Applications using Soft Starters with a SubMonitor require a start-up bypass - consult the factory for details. SubMonitor can not be used in applications using a VFD control.

11. **Motor Surge Protection:** Properly sized, grounded and dedicated motor surge arrestors must be installed in the supply line of the booster module as close to the motor as possible. This is required on all systems including those using soft-starters and variable speed drives (inverter drives).

12. **Wiring:** Franklin's lead assemblies are only sized for submerged operation in water to the motor nameplate maximum ambient temperature and may overheat and cause failure or serious injury if operated in air. Any wiring not submerged must meet applicable national and local wiring codes and Franklin Cable Chart tables 16-21. (Notice: wire size, wire rating and insulation temperature rating must be known when determining its suitability to operate in air or conduit. Typically, for a given size and rating, as the insulation temperature rating increases its ability to operate in air or conduit also increases.)

13. **Check Valves:** Spring-loaded check valves must be used on start-up to minimize motor upthrusting, water hammer, or in multiple booster (parallel) applications to prevent reverse flow.

14. **Pressure Relief Valves:** A pressure relief valve is required and must be selected to ensure that, as the pump approaches shut-off, it never reaches the point that the motor will not have adequate cooling flow past it.

15. **System Purge (Can Flooding):** An air bleeder valve must be installed on the booster sleeve so that flooding may be accomplished prior to booster start-up. Once flooding is complete, the booster should be started and brought up to operating pressure as quickly as possible to minimize the duration of an upthrust condition. At no time should air be allowed to gather in the booster sleeve because this will prevent proper cooling of the motor and permanently damage it.

16. **System Flush – Must Not Spin Pump:** Applications may utilize a low flow flushing operation. Flow through the booster sleeve must not spin the pump impellers and the motor shaft. If spinning takes place, the bearing system will be permanently damaged and the motor life shortened. Consult the booster pump manufacturer for maximum flow rate through the pump when the motor is not energized.

Table 38 Franklin Cable chart (See 12. Wiring)

CABLE TEMP. RATING (°C)	MOTOR NAMEPLATE RATED AMPS FULL LOAD	#10 AWG		#8 AWG		#6 AWG		#4 AWG		#2 AWG	
		IN AIR	IN CONDUIT	IN AIR	IN CONDUIT	IN AIR	IN CONDUIT	IN AIR	IN CONDUIT	IN AIR	IN CONDUIT
75	3-LEAD (DOL)	40A	28A	56A	40A	76A	52A	100A	68A	136A	92A
	6-LEAD (Y-Δ)	69A	48A	97A	69A	132A	90A	173A	118A	236A	159A
90	3-LEAD (DOL)	44A	32A	64A	44A	84A	60A	112A	76A	152A	104A
	6-LEAD (Y-Δ)	76A	55A	111A	76A	145A	104A	194A	132A	263A	180A
125	3-LEAD (DOL)	66A	46A	77A	53A	109A	75A	153A	105A	195A	134A
	6-LEAD (Y-Δ)	114A	80A	133A	91A	188A	130A	265A	181A	337A	232A

Based on 30 °C maximum ambient with cable length of 100 feet or less.

Continued on next page

Inline Booster Pump Systems (continued)

17. **Open Atmosphere Booster Pump Systems:** When an open booster is placed in a lake, tank, etc. that is open to atmospheric pressure, the water level must provide sufficient head pressure to allow the pump to operate above its NPSHR requirement at all times and all seasons. Adequate inlet pressure must be provided prior to booster start-up.

Four Continuous Monitoring System Requirements for Sealed Booster Systems.

1. **Water Temperature:** Feed water on each booster must be continuously monitored and not allowed to exceed the motor nameplate maximum ambient temperature at any time. IF THE INLET TEMPERATURE EXCEEDS THE MOTOR NAMEPLATE MAXIMUM AMBIENT TEMPERATURE, THE SYSTEM MUST SHUTDOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE. If feed water temperatures are expected to be above the allowable temperature, the motor must be derated. See Franklin's AIM Manual Hot Water Applications section for derating guidelines. (The high temperature feed water derating is in addition to the exchange to DI water derating if the motor factory fill solution was exchanged to DI water.)

2. **Inlet Pressure:** The inlet pressure on each booster module must be continuously monitored. It must always be positive and higher than the NPSHR (Net Positive Suction Head Requirement) of the pump. A minimum of 20 PSIG (1.38 Bar) is required at all times, except for 10 seconds or less when the motor is starting and the system is coming up to pressure. Even during these 10 seconds the pressure must remain positive and be higher than the NPSHR (Net Positive Suction Head Requirement) of the pump.

   PSIG is the actual value displayed on a pressure gauge in the system piping. PSIG is the pressure above the atmospheric conditions. If at any time these pressure requirements are not being met, the motor must be de-energized immediately to prevent permanent damage to the motor. Once the motor is damaged, it is usually not immediately noticeable, but progresses and results in a premature motor failure weeks or months after the damage occurred.

   Motors that will be exposed to pressure in excess of 500 psi (34.47 Bar) must undergo special high pressure testing. Consult factory for details and availability.

3. **Discharge Flow:** The flow rate for each pump must not be allowed to drop below the motor minimum cooling flow requirement. IF THE MOTOR MINIMUM COOLING FLOW REQUIREMENT IS NOT BEING MET FOR MORE THAN 10 SECONDS, THE SYSTEM MUST BE SHUT DOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE.

4. **Discharge Pressure:** The discharge pressure must be monitored to ensure that a downthrust load toward the motor is present within 3 seconds after start-up and continuously during operation. IF THE MOTOR DISCHARGE PRESSURE IS NOT ADEQUATE TO MEET THIS REQUIREMENT, THE SYSTEM MUST BE SHUT DOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE.

Variable Frequency Drive Submersible Motor Requirements

Franklin Electric's three-phase, encapsulated submersible motors can be used with variable frequency drives (VFD) when applied within the guidelines below.

All three-phase, encapsulated submersible motors must have the VFD sized based on the motor's nameplate maximum amps, not horsepower. The continuous rated amps of the VFD must be equal to or greater than the motor's nameplate maximum amps or warranty will be void.

Franklin Electric's single-phase, 2- and 3-wire, encapsulated submersible motors can only be used with the appropriate Franklin constant pressure controller.

Franklin Electric's submersible motor Application Installation Maintenance (AIM) manual should be checked for the latest guidelines and can be found online at www.franklin-electric.com.

WARNING: There is a potential shock hazard from contact with and/or touching the insulated cables connected to the variable frequency drive output anytime the motor has energy applied.

Output Filter Requirement Test:

NOTICE: An incoming power supply or line-side filter for the drive does not replace the need for additional output filters.

An output filter is required if the answer is yes to one or both of the items below:
#1 - Is the VFD's pulse width modulation (PWM) voltage rise-time (dV/dt) more than 500 Volts per micro-second (500 V/µ-second)?

#2 - Is the motor nameplate voltage more than 379 Volts and is the cable from drive-to-motor more than 50 ft (15.2 m)?

NOTICE:
More than 99% of the drives applied on water well submersible motors will require the purchase of additional output filtering based on question #1.

Output filters can be expensive. However, when needed, it is required for the motor to be considered for warranty. Make sure this item is not overlooked when quoting a job.

PWM dV/dt value can be defined as: the rate at which voltage is changing with time or how fast the voltage is accelerating. This information can be supplied by the drive manufacturer or the manufacturer's drive specification sheet. The dV/dt value cannot be measured with typical field equipment, even when using a true-RMS voltage/amperage multi-meter.

Franklin Electric has a line of VFDs that are specifically designed for Franklin application systems. These VFDs are used in the MonoDrive and SubDrive constant pressure systems. Franklin drive systems have the required additional output filtering installed; however, the SubDrive HPX does not.

Types of Output Filters:

A resistor-inductor-capacitor (RLC) filter has both a high pass filter & a low pass filter section and are considered the best practice, but a high pass reactor filter is also acceptable.

Filters should be recommended by the drive manufacturer; for the correct recommendations provide them with answers to all five of the items below.

REQUIRED ITEMS FOR PROPER VFD FILTER SIZING:
(1) VFD model (2) Carrier frequency setting (3) Motor nameplate voltage (4) Motor nameplate max amps (5) Cable length from the drive output terminals to the motor

Input Current & Motor Overload Protection:

- Motor input current should be set at the system's typical operating current when running at nameplate rated voltage and frequency (Hz).
- Motor overload protection should be set to trip at 115% of the system's typical operating current.
- Motor overload protection must trip equal to or faster than NEMA Class 10 motor overload curve requirements.

Motor Maximum Load Limits:

- The system must never operate in excess of the motor nameplate maximum amps.
- On 50 Hz motors, nameplate amps are maximum amps as these motors have a 1.0 service factor.

Variable Frequency Drive Submersible Motor Requirements

Motor Operating Hertz, Cooling Requirements & Underload Settings:

- Standard practice for large VFD installations is to limit the operation to 60 Hz max. Operating at greater than 60 Hz requires special system design considerations.
- The motor must never operate below 30 Hz. This is the minimum speed required to provide correct bearing lubrication.
- The motor's operating speed must always operate so the minimum water flow requirements of 0.5 ft/sec for 6-inch & 8-inch motors and 0.25 ft/sec for 4-inch motors is supplied.
- The motor underload protection is normally set to trip at 80% of the system's typical operating current. However, the underload trip point must be selected so that minimum flow requirements are always met.

Starting & Stopping Ramp Settings:

- The motor must reach or pass the 30 Hz operating speed within 1 second of the motor being energized. If this does not occur, the motor bearings will be damaged and the motor life reduced.
- The best stopping method is to turn power off followed by a natural coast to stop.
- A controlled stop from 30 Hz to 0 Hz is allowed if the time does not exceed 1 second.

Drive Carrier Frequency:

- The carrier frequency is set in the field. The drive typically has a selectable range between 2k and 12k Hz. The higher the carrier wave frequency setting, the greater the voltage spikes; the lower the carrier wave frequency setting, the rougher/poorer the shape of the power curve.
- The carrier frequency should be set within the range of 4k to 5k Hz for encapsulated submersible motors.

Application Function Setting:

- If the VFD has a setting of centrifugal pump or propeller fan it should be used.
- Centrifugal pumps and fans have similar load characteristics.

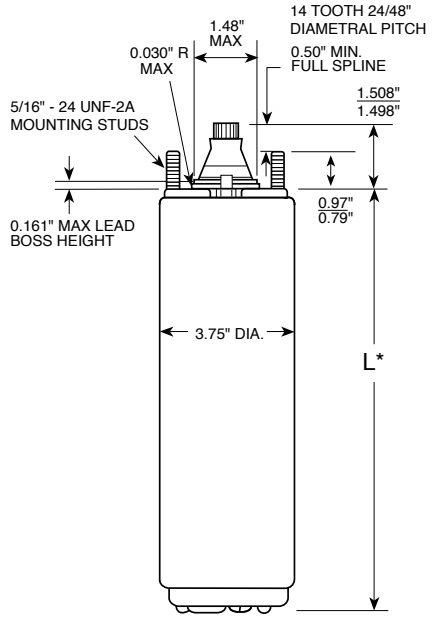
VFD Frequency of Starts:

- Keeping the starts per day within the recommended numbers shown in the frequency of starts section of the AIM manual provides the best system life. However, since in-rush current is typically reduced when used with a properly configured VFD, large 3-phase submersible motors can be started more frequently. In all cases a minimum of 7 minutes must be allowed between a power off and the next restart attempt or consecutive restart attempts.

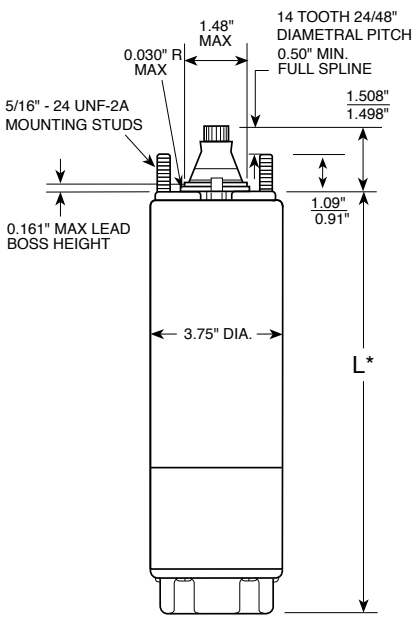
NEMA MG1 Above Ground Motor Standard Comments:

- Franklin Electric encapsulated submersible motors are not declared inverter duty motors by NEMA MG1 standards. The reason is NEMA MG1 standard part 31 does not include a section covering encapsulated winding designs.
- Franklin submersible motors can be used with VFDs without problems or warranty concerns providing Franklin's Application Installation Maintenance (AIM) manual guidelines are followed. See Franklin's on-line AIM manual for the latest guidelines.

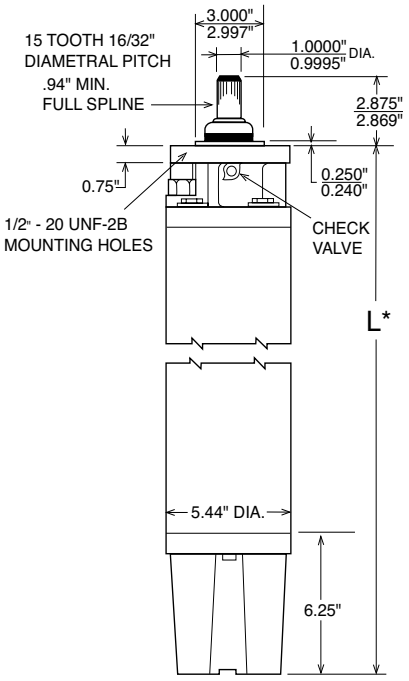
4" Super Stainless — Dimensions
(Standard Water Well)



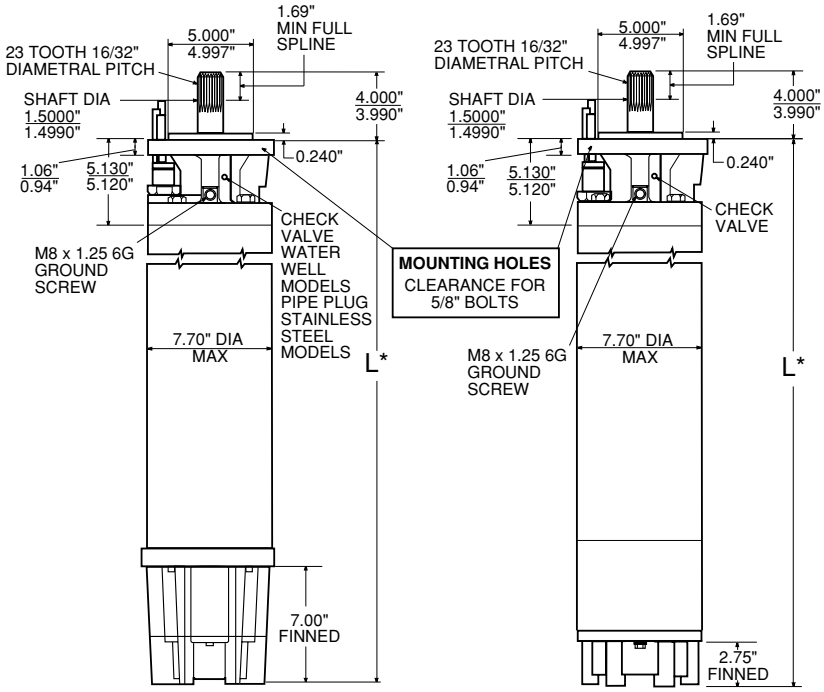
4" High Thrust — Dimensions
(Standard Water Well)



6" — Dimensions
(Standard Water Well)



8" — Dimensions
(Standard Water Well)



*** Motor lengths and shipping weights are available on Franklin Electric's web site (www.franklin-electric.com) or by calling Franklin's submersible hotline (800-348-2420).**

Tightening Motor Lead Connector Jam Nut

4" Motors with Jam Nut:
15 to 20 ft-lb (20 to 27 Nm)

4" Motors with 2 Screw Clamp Plate:
35 to 45 in-lb (4.0 to 5.1 Nm)

6" Motors:
40 to 50 ft-lb (54 to 68 Nm)

8" Motors with 1-3/16" to 1-5/8" Jam Nut:
50 to 60 ft-lb (68 to 81 Nm)

8" Motors with 4 Screw Clamp Plate:
Apply increasing torque to the screws equally in a criss-cross pattern until 80 to 90 in-lb (9.0 to 10.2 Nm) is reached.

Jam nut tightening torques recommended for field assembly are shown. Rubber compression set within the first few hours after assembly may reduce the jam nut torque. This is a normal condition which does not indicate reduced seal effectiveness. Retightening is not required, but is permissible and recommended if original torque was questionable.

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 removal may prevent proper resealing of the old lead.

All motors returned for warranty consideration must have the lead returned with the motor.

Pump to Motor Coupling

Assemble coupling with non-toxic FDA approved waterproof grease such as Mobile FM102, Texaco CYGNUS2661, or approved equivalent. This prevents abrasives from entering the spline area and prolongs spline life.

Pump to Motor Assembly

After assembling the motor to the pump, torque mounting fasteners to the following:

4" Pump and Motor: 10 lb-ft (14 Nm)

6" Pump and Motor: 50 lb-ft (68 Nm)

8" Pump and Motor: 120 lb-ft (163 Nm)

Shaft Height and Free End Play

Table 42

MOTOR	NORMAL SHAFT HEIGHT		DIMENSION SHAFT HEIGHT		FREE END PLAY	
					MIN.	MAX.
4"	1 1/2"	38.1 mm	1.508" / 1.498"	38.30 / 38.05 mm	0.010" 0.25 mm	0.045" 1.14 mm
6"	2 7/8"	73.0 mm	2.875" / 2.869"	73.02 / 72.88 mm	0.030" 0.76 mm	0.050" 1.27 mm
8" TYPE 1	4"	101.6 mm	4.000" / 3.990"	101.60 / 101.35 mm	0.008" 0.20 mm	0.032" 0.81 mm
8" TYPE 2.1	4"	101.6 mm	4.000" / 3.990"	101.60 / 101.35 mm	0.030" 0.76 mm	0.080" 2.03 mm

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

Submersible Leads and Cables

A common question is why motor leads are smaller than specified in Franklin's cable charts.

The leads are considered a part of the motor and actually are a connection between the large supply wire and the motor winding. The motor leads are short and there is virtually no voltage drop across the lead.

In addition, the lead assemblies **operate under water**, while at least part of the supply cable must **operate in air.** Lead assemblies running under water operate cooler.

CAUTION: Lead assemblies on submersible motors are suitable only for use in water and may overheat and cause failure if operated in air.

System Troubleshooting

Motor Does Not Start

POSSIBLE CAUSE	CHECKING PROCEDURES	CORRECTIVE ACTION
A. No power or incorrect voltage.	Check voltage at line terminals. The 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 breakers.	Replace with proper fuse or reset circuit breakers.
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 pages 48-56.	Repair or replace.
E. Defective wiring.	Check for loose or corroded connections or defective wiring	Correct faulty wiring or connections.
F. Bound pump.	Check for misalignment between pump and motor or a sand bound pump. Amp readings will be 3 to 6 times higher than normal until the overload trips	Pull pump and correct problem. Run new installation until the water clears
G. Defective cable or motor.	For detailed procedure, see pages 46 & 47.	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.	Check air charge	Clean or replace.
D. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.

System Troubleshooting

Motor Runs Continuously

POSSIBLE CAUSE	CHECKING PROCEDURES	CORRECTIVE ACTION
A. Pressure switch.	Check switch for welded contacts. Check switch adjustments.	Clean contacts, replace switch, or adjust setting.
B. Low water level in 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 the fault.	Pull pump and replace worn parts.
E. Loose coupling or broken motor shaft.	Check for loose coupling or damaged shaft.	Replace worn or damaged parts.
F. Pump screen blocked.	Check for clogged intake screen.	Clean screen and reset pump depth.
G. Check valve stuck closed.	Check operation of check valve.	Replace if defective.
H. Control box malfunction.	See pages 47-55 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 raise control box temperature causing protectors to trip. The box must not be hot to touch.	Shade box, provide ventilation or move box away from source.
C. Defective control box.	For detailed procedures, see pages 47-55.	Repair or replace.
D. Defective motor or cable.	For detailed procedures, see pages 45 & 46.	Repair or replace.
E. Worn pump or motor.	Check running current, see tables 13, 22, 24 & 27.	Replace pump and/or motor.

Table 45 Preliminary Tests - All Sizes Single- and Three-Phase

TEST	PROCEDURE	WHAT IT MEANS
Insulation Resistance	1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter. 2. Use a megohmmeter or set the scale lever to R X 100K on an ohmmeter. Zero the meter. 3. Connect one meter 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 meter lead to ground.	1. If the ohms value is normal (table 46), the motor is not grounded and the cable insulation is not damaged. 2. If the ohms 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.
Winding Resistance	1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter. 2. 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" the ohmmeter. 3. On 3-wire motors measure the resistance of yellow to black (main winding) and yellow to red (start winding). On 2-wire motors: measure the resistance from line-to-line. Three-phase motors: measure the resistance line-to-line for all three combinations.	1. If all ohms values are normal (tables 13, 22, 24 & 27), the motor windings are neither shorted nor open, and the cable colors are correct 2. If any one 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 ohms values are greater than normal and some less on single-phase motors, the leads are mixed. See page 46 to verify cable colors.

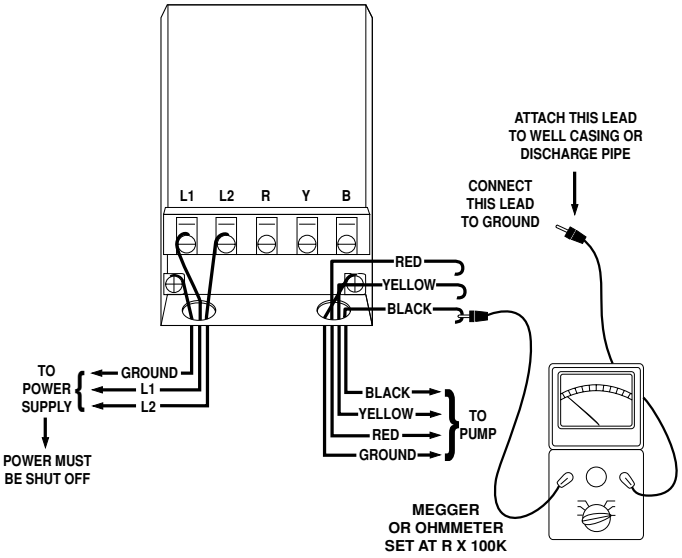


FIG. 13

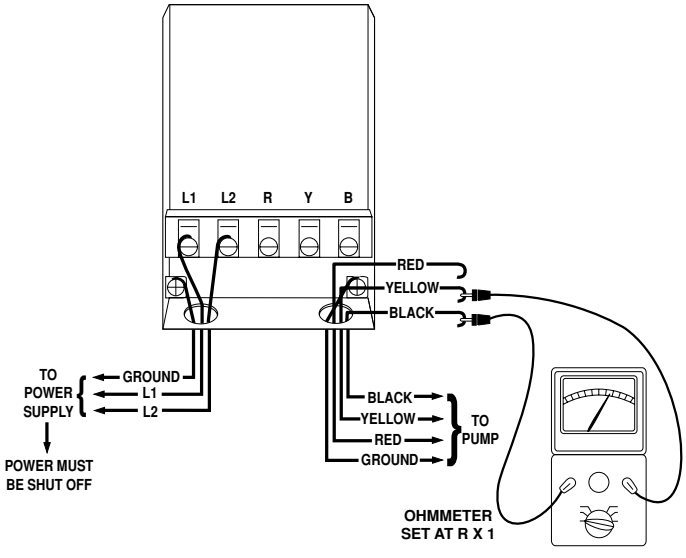


FIG. 14

Insulation Resistance Readings

Table 46 Normal ohm and Megohm Values Between All Leads and Ground

CONDITION OF MOTOR AND LEADS	OHMS VALUE	MEGOHM VALUE
A new motor (without drop cable).	200,000,000 (or more)	200.0 (or more)
A used motor which can be reinstalled in well.	10,000,000 (or more)	10.0 (or more)
MOTOR IN WELL. READINGS ARE FOR DROP CABLE PLUS MOTOR.		
New motor.	2,000,000 (or more)	2.0 (or more)
Motor in good condition.	500,000 - 2,000,000	0.50 - 2.0
Insulation damage, locate and repair.	Less than 500,000	Less than .50

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

The table above is based on readings taken with a megohm meter with a 500 VDC output. Readings may vary using a lower voltage ohmmeter, consult Franklin Electric if readings are in question.

Resistance of Drop Cable (ohms)

The values below are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher. To determine the actual resistance of the 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.

Winding Resistance Measuring

The winding resistance measured at the motor should fall within the values in tables 13, 22, 24 & 27. When measured through the drop cable, the resistance of the drop cable must be subtracted from the ohmmeter readings to get the winding resistance of the motor. See table below.

Table 46A DC Resistance in ohms per 100 ft of Wire (Two conductors) @ 50 °F

AWG OR MCM WIRE SIZE (COPPER)	14	12	10	8	6	4	3	2
OHMS	0.544	0.338	0.214	0.135	0.082	0.052	0.041	0.032

1	1/0	2/0	3/0	4/0	250	300	350	400	500	600	700
0.026	0.021	0.017	0.013	0.010	0.0088	0.0073	0.0063	0.0056	0.0044	0.0037	0.0032

Identification Of Cables When Color Code Is Unknown (Single-Phase 3-Wire Units)

If the colors on the individual drop cables cannot be found 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:

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

Single-Phase Control Boxes

Checking and Repairing Procedures (Power On)

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

A. VOLTAGE MEASUREMENTS

Step 1. Motor Off

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

Step 2. Motor Running

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. Excessive voltage drop can be caused by loose connections, bad contacts, ground faults, or inadequate power supply.
3. Relay chatter is caused by low voltage or ground faults.

B. CURRENT (AMP) MEASUREMENTS

1. Measure current on all motor leads.
2. Amp Reading: Current in red lead should momentarily be high, then drop within one second to values in table 13. This verifies relay or solid state relay operation. Current in black and yellow leads should not exceed values in table 13.
3. Relay or switch failures will cause red lead current to remain high and overload tripping.
4. Open run capacitor(s) will cause amps to be higher than normal in the black and yellow motor leads and lower than normal in the red motor lead.
5. A bound pump will cause locked rotor amps and overloading tripping.
6. Low amps may be caused by pump running at shutoff, worn pump, or stripped splines.
7. 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 QD switches should be regarded as indicative and not as conclusive. For example, a capacitor may test good (not open, not shorted) but may have lost some of its capacitance and may no longer be able to perform its function.

Ohmmeter Tests

QD, Solid State Control Box (Power Off)

A. START CAPACITOR AND RUN CAPACITOR IF APPLICABLE (CRC)

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. Q.D. (BLUE) RELAY

Step 1. Triac Test

1. Meter setting: R x 1,000.
2. Connections: Cap and B terminal.
3. Correct meter reading: Infinity for all models.

Step 2. Coil Test

1. Meter Setting: R x 1.
2. Connections: L1 and B.
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:
   0.7-1.8 (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.

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: Less 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. POTENTIAL (VOLTAGE) RELAY

Step 1. Coil Test

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.

Step 2. Contact Test

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

D. CONTACTOR

Step 1. Coil

1. Meter setting: R x 100
2. Connections: Coil terminals
3. Correct meter reading:
   1.8-14.0 (180 to 1,400 ohms)

Step 2. Contacts

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

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

Table 49 QD Control Box Parts 60 Hz

HP	VOLTS	CONTROL BOX MODEL NUMBER	QD (BLUE) RELAY	START CAPACITOR	MFD	VOLTS	RUN CAPACITOR	MFD	VOLTS
1/3	115	280 102 4915	223 415 905	275 464 125	159-191	110			
	230	280 103 4915	223 415 901	275 464 126	43-53	220			
1/2	115	280 104 4915	223 415 906	275 464 201	250-300	125			
	230	280 105 4915	223 415 902	275 464 105	59-71	220			
	230	282 405 5015 (CRC)	223 415 912	275 464 126	43-53	220	156 362 101	15	370
3/4	230	280 107 4915	223 415 903	275 464 118	86-103	220			
	230	282 407 5015 (CRC)	223 415 913	275 464 105	59-71	220	156 362 102	23	370
1	230	280 108 4915	223 415 904	275 464 113	105-126	220			
	230	282 408 5015 (CRC)	223 415 914	275 464 118	86-103	220	156 362 102	23	370

Table 49A QD Capacitor Replacement Kits

CAPACITOR NUMBER	KIT
275 464 105	305 207 905
275 464 113	305 207 913
275 464 118	305 207 918
275 464 125	305 207 925
275 464 126	305 207 926
275 464 201	305 207 951
156 362 101	305 203 907
156 362 102	305 203 908

Table 49B Overload Kits 60 Hz

HP	VOLTS	KIT (1)
1/3	115	305 100 901
1/3	230	305 100 902
1/2	115	305 100 903
1/2	230	305 100 904
3/4	230	305 100 905
1	230	305 100 906

(1) For Control Boxes with model numbers that end with 4915.

Table 49C QD Relay Replacement Kits

QD RELAY NUMBER	KIT
223 415 901	305 101 901
223 415 902	305 101 902
223 415 903	305 101 903
223 415 904	305 101 904
223 415 905	305 101 905
223 415 906	305 101 906
223 415 912 (CRC)	305 105 901
223 415 913 (CRC)	305 105 902
223 415 914 (CRC)	305 105 903

FOOTNOTES:

(1) Control boxes supplied with QD Relays are designed to operate on 230-volt systems. For 208-volt systems or where line voltage is between 200 volts and 210 volts use the next larger cable size, or use a boost transformer to raise the voltage.

(2) Voltage relays kits for 115-volts (305 102 901) and 230-volts (305 102 902) will replace current, voltage or QD Relays, and solid state switches.

Table 50 Integral Horsepower Control Box Parts 60 Hz

MOTOR SIZE	MOTOR RATING HP	CONTROL BOX (1) MODEL NO.	CAPACITORS				OVERLOAD (2) PART NO.	RELAY (3) PART NO.	CONTACTOR (2) PART NO.
			PART NO. (2)	MFD.	VOLTS	QTY.			
4"	1 - 1.5 STANDARD	282 300 8110 (See Note 5)	275 464 113 S 155 328 102 R	105-126 10	220 370	1 1	275 411 107	155 031 102	
		282 300 8110 (See Note 5)	275 464 113 S 155 328 101 R	105-126 15	220 370	1 1	275 411 114 S 275 411 113 M	155 031 102	
		282 300 8610	275 464 113 S 155 328 101 R	105-126 15	220 370	1 1	None (See Note 4)	155 031 102	
4"	2 STANDARD	282 301 8110	275 464 113 S 155 328 103 R	105-126 20	220 370	1 1	275 411 117 S 275 411 113 M	155 031 102	
4"	2 DELUXE	282 301 8310	275 464 113 S 155 328 103 R	105-126 20	220 370	1 1	275 411 117 S 275 411 113 M	155 031 102	155 325 102 L
4"	3 STANDARD	282 302 8110	275 463 123 S 155 327 109 R	208-250 45	220 370	1 1	275 411 118 S 275 411 115 M	155 031 102	
4"	3 DELUXE	282 302 8310	275 463 123 S 155 327 109 R	208-250 45	220 370	1 1	275 411 118 S 275 411 115 M	155 031 102	155 325 102 L
4" & 6"	5 STANDARD	282 113 8110	275 468 119 S 155 327 114 R	270-324 40	330 370	1 2	275 411 119 S 275 406 102 M	155 031 601	
4" & 6"	5 DELUXE	282 113 9310	275 468 119 S 155 327 114 R	270-324 40	330 370	1 2	275 411 119 S 275 406 102 M	155 031 601	155 326 101 L
6"	7.5 STANDARD	282 201 9210	275 468 119 S 275 468 118 S 155 327 109 R	270-324 216-259 45	330 330 370	1 1 1	275 411 102 S 275 406 122 M	155 031 601	
6"	7.5 DELUXE	282 201 9310	275 468 119 S 275 468 118 S 155 327 109 R	270-324 216-259 45	330 330 370	1 1 1	275 411 102 S 275 406 121 M	155 031 601	155 326 102 L
6"	10 STANDARD	282 202 9210	275 468 119 S 275468 120 S 155 327 102 R	270-324 350-420 35	330 330 370	1 1 2	275 406 103 S 155 409 101 M	155 031 601	
6"	10 STANDARD	282 202 9230	275 463 120 S 275 468 118 S 275 468 119 S 155 327 102 R	130-154 216-259 270-324 35	330 330 330 370	1 1 1 2	275 406 103 S 155 409 101 M	155 031 601	
6"	10 DELUXE	282 202 9310	275 468 119 S 275468 120 S 155 327 102 R	270-324 350-420 35	330 330 370	1 1 2	275 406 103 S 155 409 101 M	155 031 601	155 326 102 L
6"	10 DELUXE	282 202 9330	275 463 120 S 275 468 118 S 275 468 119 S 155 327 102 R	130-154 216-259 270-324 35	330 330 330 370	1 1 1 2	275 406 103 S 155 409 101 M	155 031 601	155 326 102 L
6"	15 DELUXE	282 203 9310	275 468 120 S 155 327 109 R	350-420 45	330 370	2 3	275 406 103 S 155 409 102 M	155 031 601	155 429 101 L
6"	15 DELUXE	282 203 9330	275 463 122 S 275 468 119 S 155 327 109 R	161-193 270-324 45	330 330 370	1 2 3	275 406 103 S 155 409 102 M	155 031 601	155 429 101 L
6"	15 X-LARGE	282 203 9621	275 468 120 S 155 327 109 R	350-420 45	330 370	2 3	275 406 103 S 155 409 102 M	155 031 601 2 required	155 429 101 L

FOOTNOTES:

(1) Lightning arrestors 150 814 902 are suitable for all control boxes.

(2) S = Start, M = Main, L = Line, R = Run
Deluxe = Control box with line contactor.

(3) For 208-volt systems or where line voltage is between 200 volts and 210 volts, a low voltage relay is required. On 3 hp and smaller control boxes use relay part 155 031 103 in place of 155 031 102 and use the next larger cable size than specified in the 230-volt table. On 5 hp and larger use relay 155 031 602 in place of 155 031 601 and next larger wire. Boost transformers per page 15 are an alternative to special relays and cable.

(4) Control box model 282 300 8610 is designed for use with motors having internal overload protectors. If used with a 1.5 hp motor manufactured prior to date code 06H18, Overload/Capacitor Kit 305 388 901 is required.

(5) Control box model 282 300 8110 with date code 11C19 (March 2011) and newer contain 15 MFD run capacitor and both start and run overloads. This box is designed for use with any Franklin 1.5 hp motor.

Table 51 Integral hp Capacitor Replacement Kits

CAPACITOR NUMBER	KIT
275 463 120	305 206 920
275 463 122	305 206 922
275 463 123	305 206 923
275 464 113	305 207 913
275 468 118	305 208 918
275 468 119	305 208 919
275 468 120	305 208 920
155 327 101	305 203 901
155 327 102	305 203 902
155 327 109	305 203 909
155 327 114	305 203 914
155 328 101	305 204 901
155 328 102	305 204 902
155 328 103	305 204 903

Table 51A Integral hp Overload Replacement Kits

OVERLOAD NUMBER	KIT
275 406 102	305 214 902
275 406 103	305 214 903
275 406 121	305 214 921
275 406 122	305 214 922
275 411 102	305 215 902
275 411 107	305 215 907
275 411 108	305 215 908
275 411 113	305 215 913
275 411 114	305 215 914
275 411 115	305 215 915
275 411 117	305 215 917
275 411 118	305 215 918
275 411 119	305 215 919

Table 51B Integral hp Voltage Relay Replacement Kits

RELAY NUMBER	KIT
155 031 102	305 213 902
155 031 103	305 213 903
155 031 601	305 213 961
155 031 602	305 213 962

Table 51C Integral hp Contactor Replacement Kits

CONTACTOR	KIT
155 325 102	305 226 902
155 326 101	305 347 903
155 326 102	305 347 902
155 429 101	305 347 901

FOOTNOTES:

(1) The following kit number changes were made for number consistency purposes only. Parts in the kit did not change.

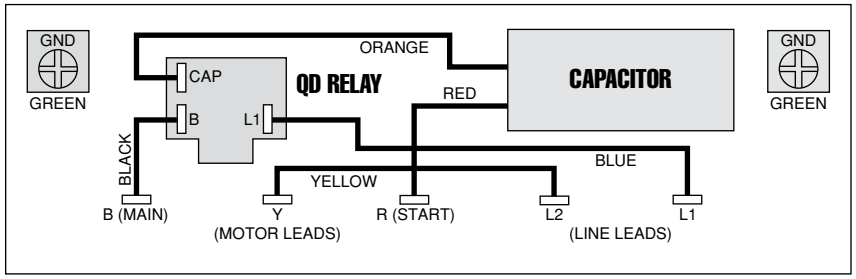
305 206 922 was 305 206 912

305 206 923 was 305 206 911

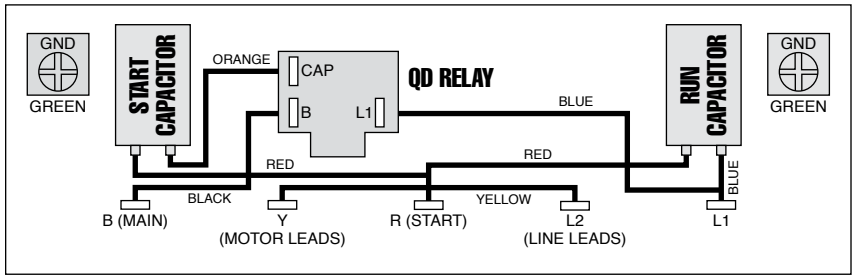
305 213 962 was 305 213 904

305 226 902 was 305 226 901

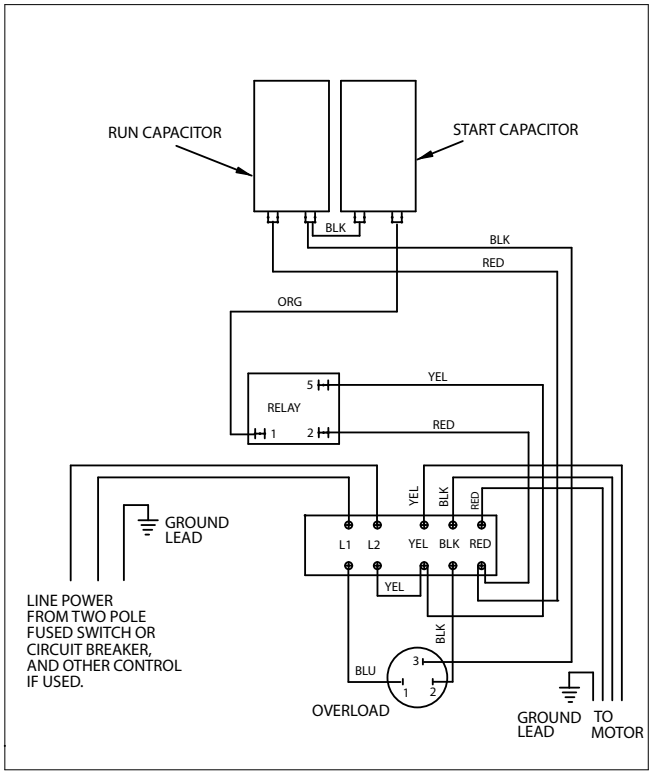
Control Box Wiring Diagrams



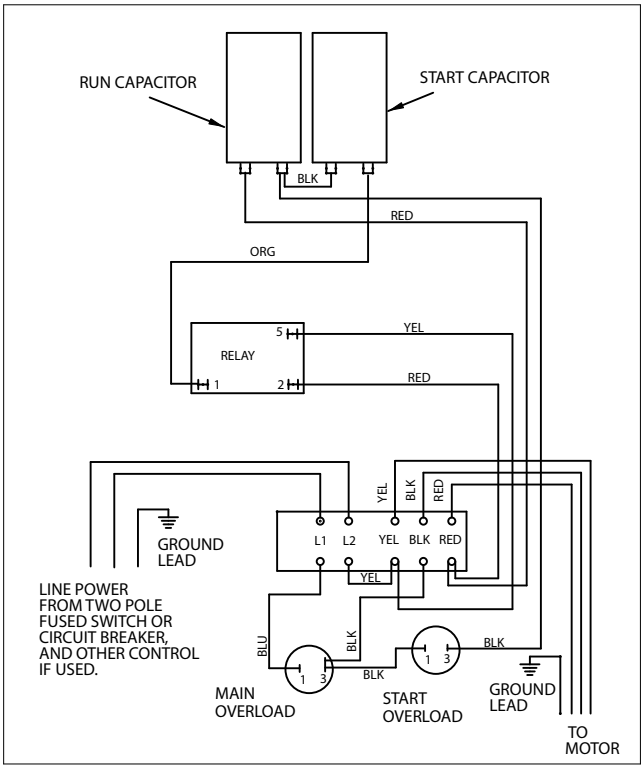
1/3 - 1 hp QD RELAY
280 10_ 4915
Sixth digit depends on hp



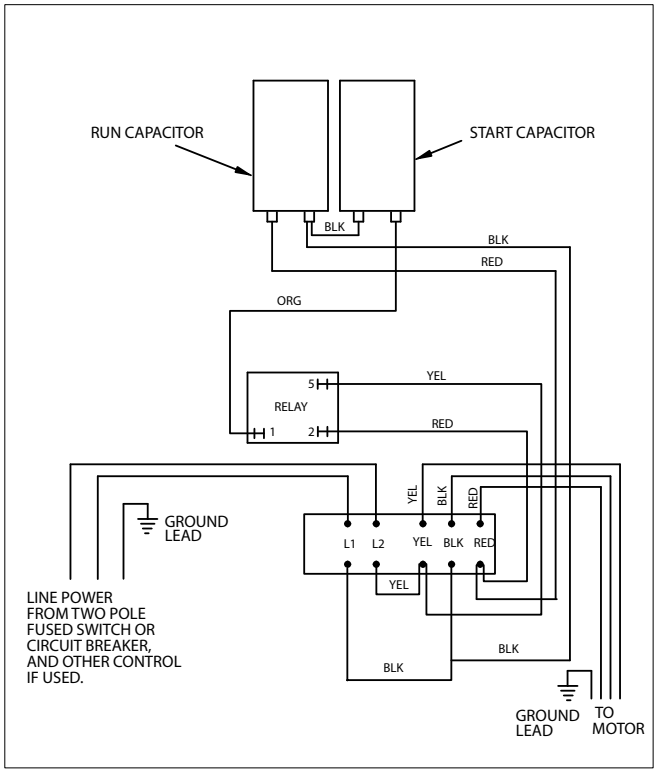
1/2 - 1 hp CRC QD RELAY
282 40_ 5015
Sixth digit depends on hp



1 - 1.5 hp
282 300 8110
(Date Codes 11C19 & Older)

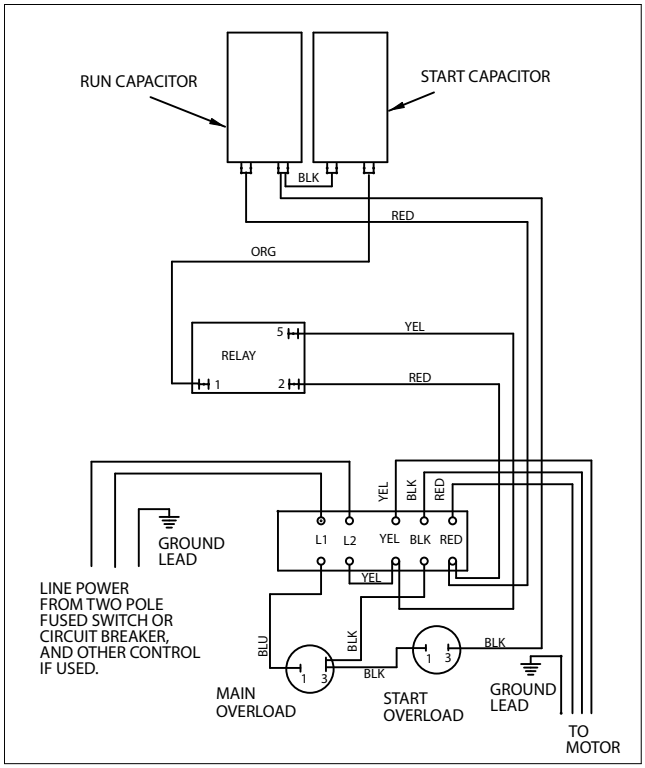


1 - 1.5 hp
282 300 8110
(Date Codes 11C19 & Newer)

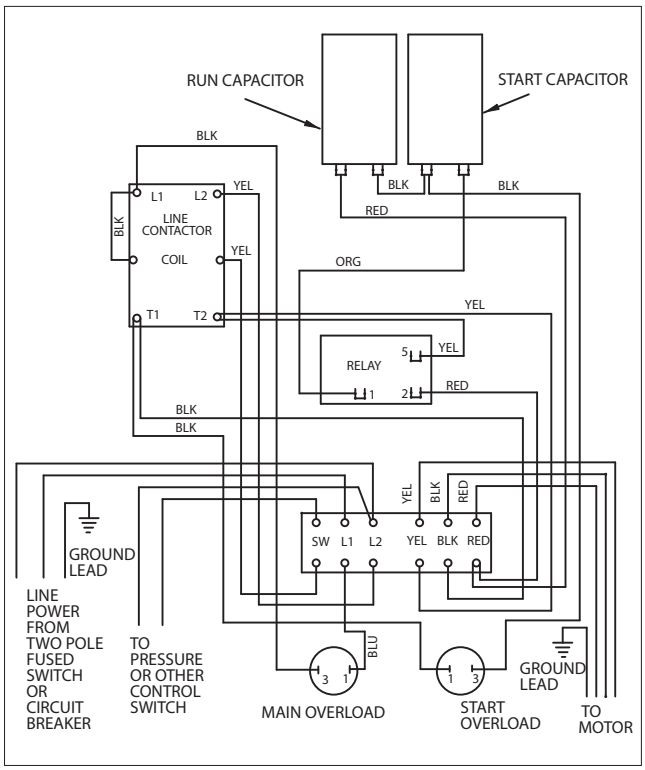


1 - 1.5 hp
282 300 8610

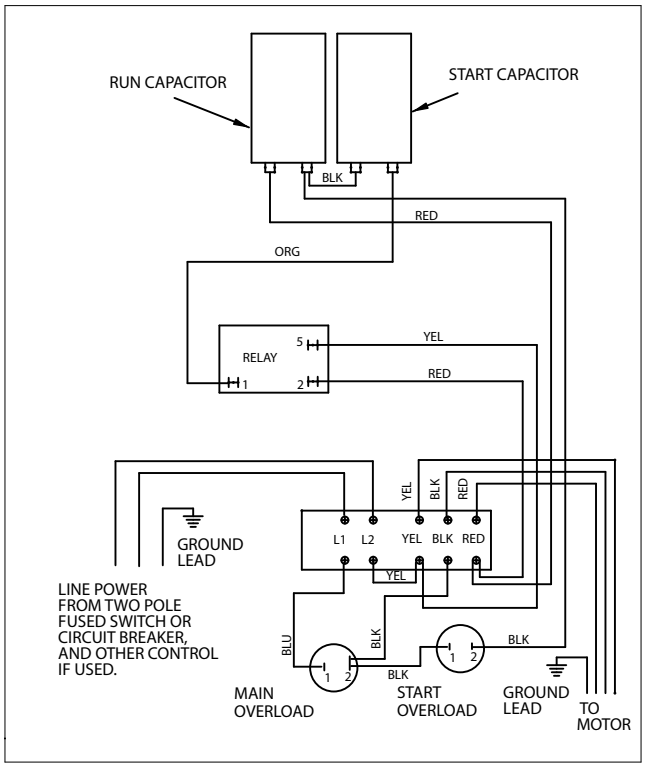
Single-Phase Motors & Controls



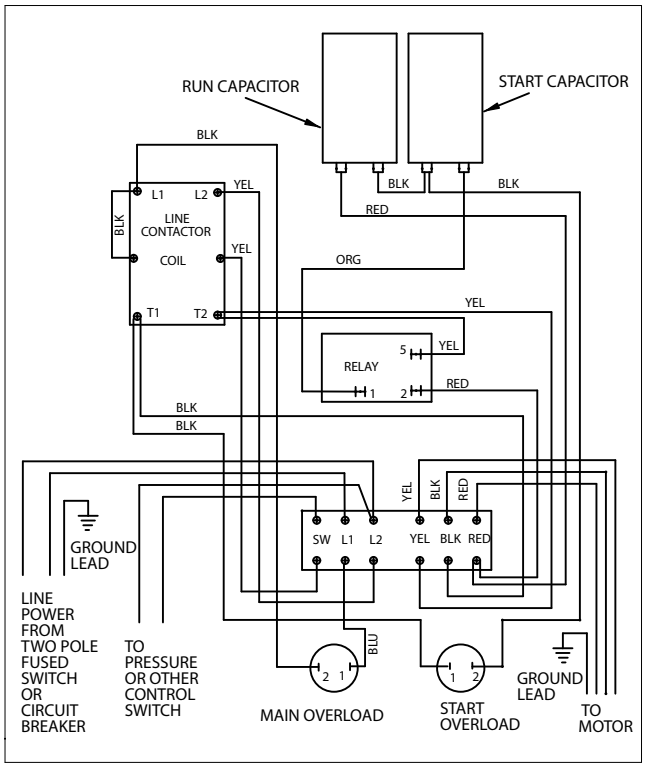
2 hp STANDARD
282 301 8110



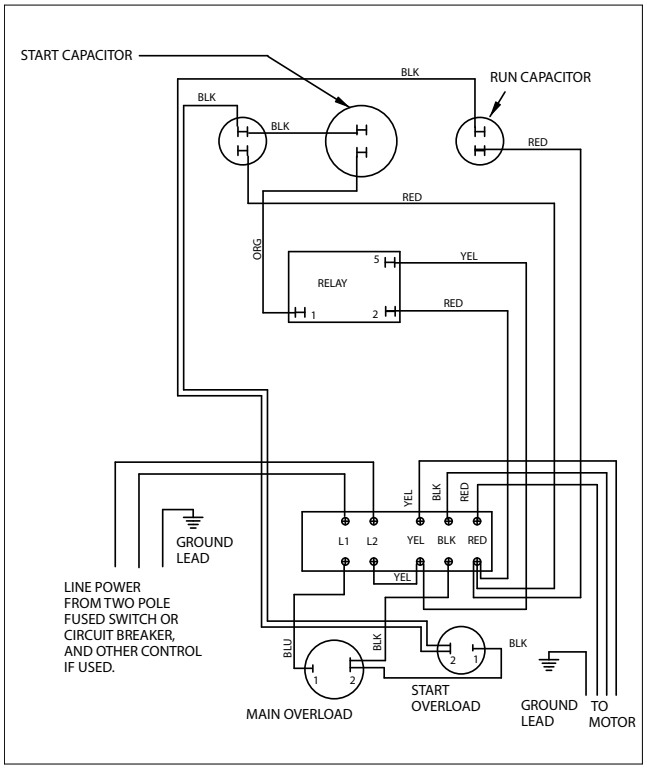
2 hp DELUXE
282 301 8310



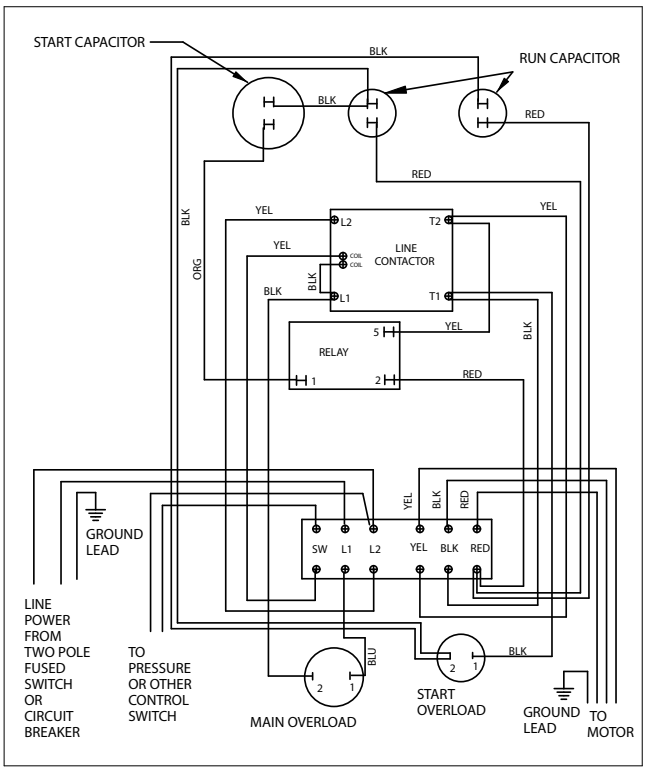
3 hp STANDARD
282 302 8110



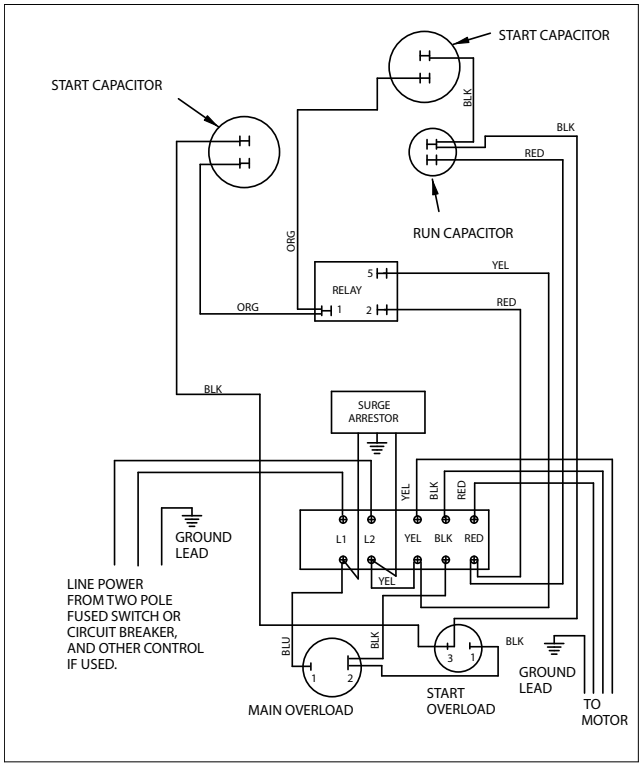
3 hp DELUXE
282 302 8310



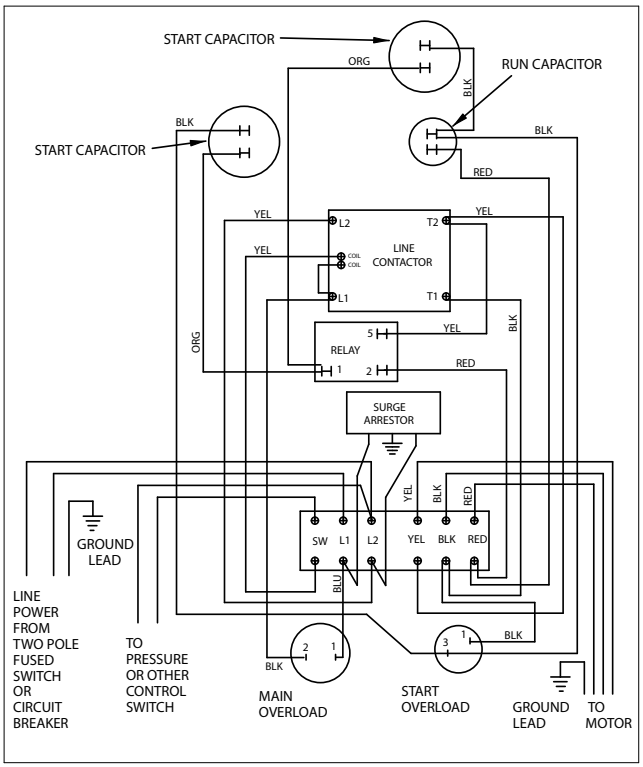
5 hp STANDARD
282 113 8110



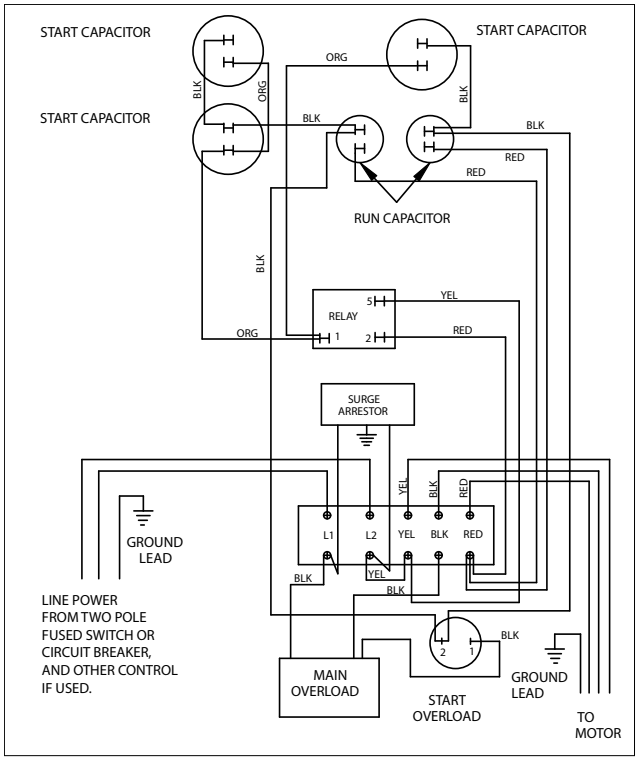
5 hp DELUXE
282 113 8310 or 282 113 9310



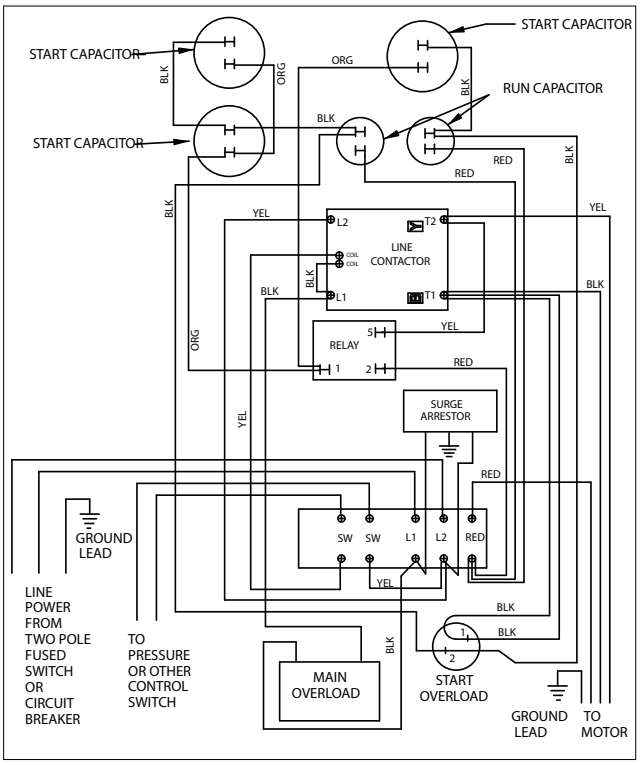
7.5 hp STANDARD
282 201 9210



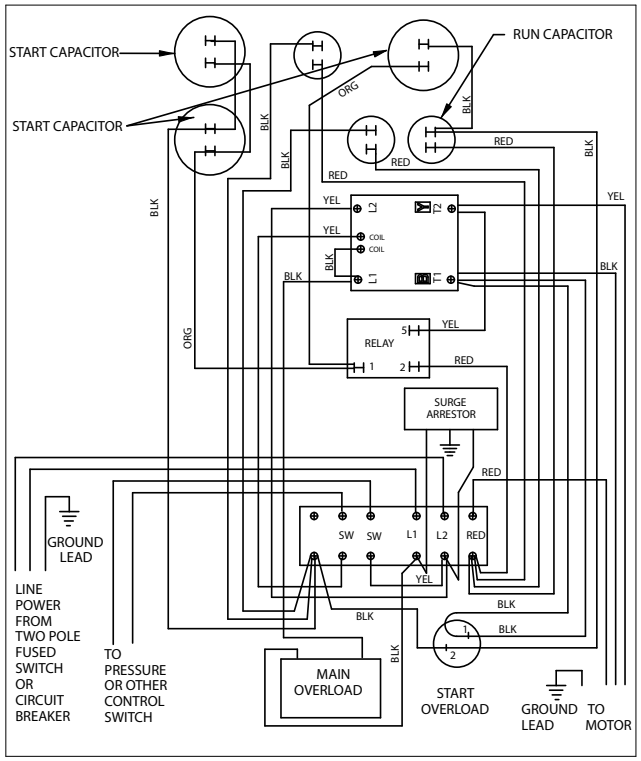
7.5 hp DELUXE
282 201 9310



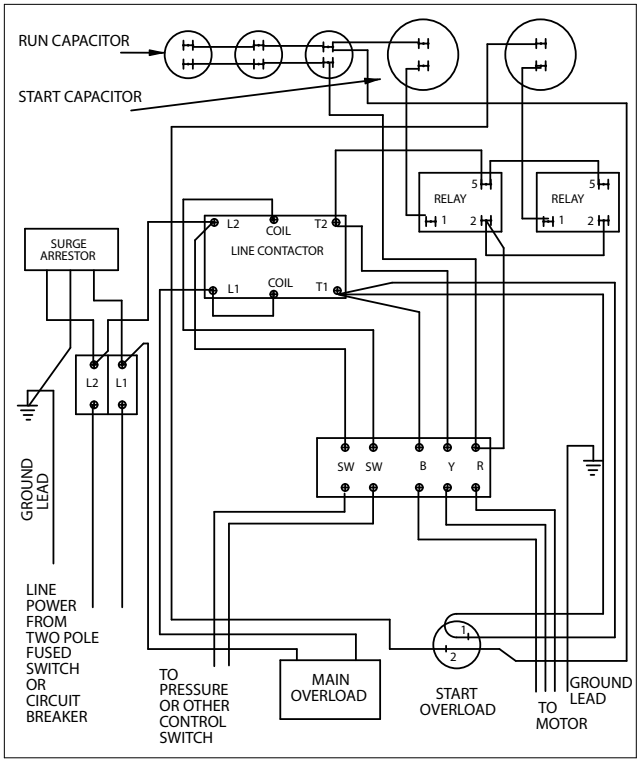
10 hp STANDARD
282 202 9210 or 282 202 9230



10 hp DELUXE
282 202 9230 or 282 202 9330



15 hp DELUXE
282 203 9310 or 282 203 9330



15 hp X-LARGE
282 203 9621

Pumptec-Plus

Pumptec-Plus is a pump/motor protection device designed to work on any 230 V single-phase induction motor (PSC, CSCR, CSIR, and split phase) ranging in size from 1/2 to 5 horsepower. Pumptec-Plus uses a micro-computer to continuously monitor motor power and line voltage to provide protection against dry well, water logged tank, high and low voltage and mud or sand clogging.

Pumptec-Plus – Troubleshooting During Installation

SYMPTOM	POSSIBLE CAUSE	SOLUTION
Unit Appears Dead (No Lights)	No Power to Unit	Check wiring. Power supply voltage should be applied to L1 and L2 terminals of the Pumptec-Plus. In some installations the pressure switch or other control devices is wired to the input of the Pumptec-Plus. Make sure this switch is closed.
Flashing Yellow Light	Unit Needs to Be Calibrated	Pumptec-Plus is calibrated at the factory so that it will overload on most pump systems when the unit is first installed. This overload condition is a reminder that the Pumptec-Plus unit requires calibration before use. See step 7 of the installation instructions.
	Miscalibrated	Pumptec-Plus should be calibrated on a full recovery well with the maximum water flow. Flow restrictors are not recommended.
Flashing Yellow Light During Calibration	2-Wire Motor	Step C of the calibration instructions indicate that a flashing green light condition will occur 2 to 3 seconds after taking the SNAPSHOT of the motor load. On some two-wire motors the yellow light will flash instead of the green light. Press and release the reset button. The green should start flashing.
Flashing Red and Yellow Lights	Power Interruption	During the installation of Pumptec-Plus power may be switched on and off several times. If power is cycled more than four times within a minute Pumptec-Plus will trip on rapid cycle. Press and release the reset button to restart the unit.
	Float Switch	A bobbing float switch may cause the unit to detect a rapid cycle condition on any motor or an overload condition on two-wire motors. Try to reduce water splashing or use a different switch.
Flashing Red Light	High Line Voltage	The line voltage is over 253 volts. Check line voltage. Report high line voltage to the power company.
	Unloaded Generator	If you are using a generator the line voltage may become too high when the generator unloads. Pumptec-Plus will not allow the motor to turn on again until the line voltage returns to normal. Overvoltage trips will also occur if line frequency drops too far below 60 Hz.
Solid Red Light	Low Line Voltage	The line voltage is below 207 volts. Check line voltage.
	Loose Connections	Check for loose connections which may cause voltage drops.
	Loaded Generator	If you are using a generator the line voltage may become too low when the generator loads. Pumptec-Plus will trip on undervoltage if the generator voltage drops below 207 volts for more than 2.5 seconds. Undervoltage trips will also occur if the line frequency rises too far above 60 Hz.

Pumptec-Plus

Pumptec-Plus - Troubleshooting After Installation

SYMPTOM	POSSIBLE CAUSE	SOLUTION
Solid Yellow Light	Dry Well	Wait for the automatic restart timer to time out. During the time out period the well should recover and fill with water. If the automatic reset timer is set to the manual position, then the reset button must be pressed to reactivate the unit.
	Blocked Intake	Clear or replace pump intake screen.
	Blocked Discharge	Remove blockage in plumbing.
	Check Valve Stuck	Replace check valve.
	Broken Shaft	Replace broken parts.
	Severe Rapid Cycling	Machine gun rapid cycling can cause an underload condition. See flashing red and yellow lights section below.
	Worn Pump	Replace worn pump parts and recalibrate.
Yellow Flashing Light	Stalled Motor	Repair or replace motor. Pump may be sand or mud locked.
	Float Switch	A bobbing float switch can cause two-wire motors to stall. Arrange plumbing to avoid splashing water. Replace float switch.
	Ground Fault	Check insulation resistance on motor and control box cable.
Solid Red Light	Low Line Voltage	The line voltage is below 207 volts. Pumptec-Plus will try to restart the motor every two minutes until line voltage is normal.
	Loose Connections	Check for excessive voltage drops in the system electrical connections (i.e. circuit breakers, fuse clips, pressure switch, and Pumptec-Plus L1 and L2 terminals). Repair connections.
Flashing Red Light	High Line Voltage	The line voltage is over 253 volts. Check line voltage. Report high line voltage to the power company.
Flashing Red and Yellow Lights	Rapid Cycle	The most common cause for the rapid cycle condition is a waterlogged tank. Check for a ruptured bladder in the water tank. Check the air volume control or snifter valve for proper operation. Check setting on the pressure switch and examine for defects.
	Leaky Well System	Replace damaged pipes or repair leaks.
	Stuck Check Valve	Failed valve will not hold pressure. Replace valve.
	Float Switch	Press and release the reset button to restart the unit. A bobbing float switch may cause the unit to detect a rapid cycle condition on any motor or an overload condition on 2-wire motors. Try to reduce water splashing or use a different switch.

QD Pumptec and Pumptec

QD Pumptec and Pumptec are load sensing devices that monitor the load on submersible pumps/motors. If the load drops below a preset level for a minimum of 4 seconds the QD Pumptec or the Pumptec will shut off the motor.

The QD Pumptec is designed and calibrated expressly for use on Franklin Electric 230 V 3-wire motors (1/3 to 1 hp.) The QD Pumptec must be installed in QD relay boxes.

The Pumptec is designed for use on Franklin Electric 2- and 3-wire motors (1/3 to 1.5 hp) 115 and 230 V. The Pumptec is not designed for jet pumps.

QD Pumptec & Pumptec – Troubleshooting

SYMPTOM	CHECKS OR SOLUTION
If the QD Pumptec or Pumptec trips in about 4 seconds with some water delivery.	A. Is the voltage less than 90% of nameplate rating? B. Are the pump and motor correctly matched? C. Is the **QD Pumptec** or **Pumptec** wired correctly? For the **Pumptec** check the wiring diagram and pay special attention to the positioning of the power lead (230 V or 115 V). D. For **QD Pumptec** is your system 230 V 60 Hz or 220 V 50 Hz?
If the QD Pumptec or Pumptec trips in about 4 seconds with no water delivery.	A. The pump may be airlocked. If there ia a check valve on top of the pump, put another section of pipe between the pump and the check valve. B. The pump may be out of water. C. Check the valve settings. The pump may be dead-heading. D. Pump or motor shaft may be broken. E. Motor overload may be tripped. Check the motor current (amperage).
If the QD Pumptec or Pumptec will not timeout and reset.	A. Check switch position on side of circuit board on **Pumptec**. **QD Pumptec** check timer position on top/front of unit. Make sure the switch is not between settings. B. If the reset time switch is set to manual reset (position 0), **QD Pumptec** and **Pumptec** will not reset (turn power off for 5 sec. then back on to reset).
If your pump/motor will not run at all.	A. Check voltage. B. Check wiring. C. Remove the **QD Pumptec** from the control box. Reconnect wires in box to original state. If motor does not run the problem is not **QD Pumptec**. Bypass **Pumptec** by connecting L2 and motor lead with jumper. Motor should run. If not, the problem is not **Pumptec**. D. On **Pumptec** only check that **Pumptec** is installed between the control switch and the motor.
If your QD Pumptec or Pumptec will not trip when the pump breaks suction.	A. Be sure you have a Franklin motor. B. Check wiring connections. On **Pumptec** is lead power (230 V or 115 V) connected to correct terminal? Is motor lead connected to correct terminal? C. Check for ground fault in the motor and excessive friction in the pump. D. The well may be “gulping” enough water to keep **QD Pumptec** or **Pumptec** from tripping. It may be necessary to adjust the **QD Pumptec** or the **Pumptec** for these extreme applications. Call the Franklin Electric Service Hotline at 800-348-2420 for information. E. On **Pumptec** applications does the control box have a run capacitor? If so, **Pumptec** will not trip. (Except for Franklin 1.5 hp motors).
If your QD Pumptec or Pumptec chatters when running.	A. Check for low voltage. B. Check for waterlogged tank. Rapid cycling for any reason can cause the **QD Pumptec** or the **Pumptec** relay to chatter. C. On **Pumptec** make sure the L2 and motor wires are installed correctly. If they are reversed, the unit can chatter.

SubDrive2W, 75, 100, 150, 300, MonoDrive, & MonoDrive XT

The Franklin Electric SubDrive/MonoDrive Constant Pressure controller is a variable-speed drive that delivers water at a constant pressure.

WARNING: Serious or fatal electrical shock may result from failure to connect the motor, SubDrive/MonoDrive Controller, 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 the risk of electrical shock, disconnect power before working on or around the water system. Capacitors inside the SubDrive/MonoDrive Controller can still hold a lethal voltage even after power has been removed. Allow 10 minutes for dangerous internal voltage to discharge. Do not use motor in swimming areas.

SubDrive2W, 75, 100, 150, 300, MonoDrive, & MonoDrive XT

SubDrive/MonoDrive Troubleshooting

Should an application or system problem occur, built-in diagnostics will protect the system. The “FAULT” light or digital display on the front of the SubDrive/MonoDrive Controller will flash a given number of times or display a number indicating the nature of the fault. In some cases, the system will shut itself off until corrective action is taken. Fault codes and their corrective actions are listed below. See SubDrive/MonoDrive Installation Manual for installation data.

NUMBER OF FLASHES OR DIGITAL DISPLAY	FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
1	MOTOR UNDERLOAD	- Overpumped well - Broken shaft or coupling - Blocked screen, worn pump - Air/gas locked pump - SubDrive not set properly for pump end	- Frequency near maximum with less than 65% of expected load, 42% if DIP #3 is “on” - System is drawing down to pump inlet (out of water) - High static, light loading pump - reset DIP switch #3 to “on” for less sensitivity if not out of water - Check pump rotation (SubDrive only) reconnect if necessary for proper rotation - Air/gas locked pump - if possible, set deeper in well to reduce - Verify DIP switches are set properly
2	UNDERVOLTAGE	- Low line voltage - Misconnected input leads	- Line voltage low, less than approximately 150 VAC (normal operating range = 190 to 260 VAC) - Check incoming power connections and correct or tighten if necessary - Correct incoming voltage - check circuit breaker or fuses, contact power company
3	LOCKED PUMP	- Motor and/or pump misalignment - Dragging motor and/or pump - Abrasives in pump	- Amperage above SFL at 10 Hz - Remove and repair or replace as required
4 (MonoDrive & MonoDriveXT only)	INCORRECTLY WIRED	- MonoDrive only - Wrong resistance values on main and start	- Wrong resistance on DC test at start - Check wiring, check motor size and DIP switch setting, adjust or repair as needed
5	OPEN CIRCUIT	- Loose connection - Defective motor or drop cable - Wrong motor	- Open reading on DC test at start. - Check drop cable and motor resistance, tighten output connections, repair or replace as necessary, use “dry” motor to check drive functions, if drive will not run and exhibits underload fault replace drive
6	SHORT CIRCUIT	- When fault is indicated immediately after power-up, short circuit due to loose connection, defective cable, splice or motor	- Amperage exceeded 50 amps on DC test at start or max amps during running - Incorrect output wiring, phase to phase short, phase to ground short in wiring or motor - If fault is present after resetting and removing motor leads, replace drive
	OVER CURRENT	- When fault is indicated while motor is running, over current due to loose debris trapped in pump	- Check pump
7	OVERHEATED DRIVE	- High ambient temperature - Direct sunlight - Obstruction of airflow	- Drive heat sink has exceeded max rated temperature, needs to drop below 85 °C to restart - Fan blocked or inoperable, ambient above 125 °F, direct sunlight, air flow blocked - Replace fan or relocate drive as necessary
8 (SubDrive300 only)	OVER PRESSURE	- Improper pre-charge - Valve closing too fast - Pressure setting too close to relief valve rating	- Reset the pre-charge pressure to 70% of sensor setting. Reduce pressure setting well below relief valve rating. Use next size larger pressure tank. - Verify valve operation is within manufacturer’s specifications. - Reduce system pressure setting to a value less than pressure relief rating.
RAPID	INTERNAL FAULT	- A fault was found internal to drive	- Unit may require replacement. Contact your supplier.
9 (SubDrive2W only)	OVER RANGE (Values outside normal operating range)	- Wrong hp/voltage - Internal fault	- Verify motor hp and voltage - Unit may require replacement. Contact your supplier.

SubMonitor

SubMonitor Troubleshooting

FAULT MESSAGE	PROBLEM/CONDITION	POSSIBLE CAUSE
SF Amps Set Too High	SF Amps setting above 359 Amps.	Motor SF Amps not entered.
Phase Reversal	Reversed incoming voltage phase sequence.	Incoming power problem.
Underload	Normal line current.	Wrong SF Max Amps setting.
	Low line current.	Over pumping well. Clogged pump intake. Closed valve. Loose pump impeller. Broken shaft or coupling. Phase loss.
Overload	Normal line current.	Wrong SF Max Amps setting.
	High line current.	High or low line voltage. Ground fault. Pump or motor dragging. Motor stalled or bound pump.
Overheat	Motor temperature sensor has detected excess motor temperature.	High or low line voltage. Motor is overloaded. Excessive current unbalance. Poor motor cooling. High water temperature. Excessive electrical noise (VFD in close proximity).
Unbalance	Current difference between any two legs exceeds programmed setting.	Phase loss. Unbalanced power supply. Open Delta transformer.
Overvoltage	Line voltage exceeds programmed setting.	Unstable power supply.
Undervoltage	Line voltage below programmed setting.	Poor connection in motor power circuit. Unstable or weak power supply.
False Starts	Power has been interrupted too many times in a 10 second period.	Chattering contacts. Loose connections in motor power circuit. Arcing contacts.

Continued on next page

Subtrol-Plus (Obsolete - See SubMonitor)

Subtrol-Plus - Troubleshooting After Installation

SYMPTOM	POSSIBLE CAUSE OR SOLUTION
Subtrol-Plus Dead	When the Subtrol-Plus reset button is depressed and released, all indicator lights should flash. If line voltage is correct at the Subtrol-Plus L1, L2, L3 terminals and the reset button does not cause lights to flash, Subtrol-Plus receiver is malfunctioning.
Green Off Time Light Flashes	The green light will flash and not allow operation unless both sensor coils are plugged into the receiver. If both are properly connected and it still flashes, the sensor coil or the receiver is faulty. An ohmmeter check between the two center terminals of each sensor coil connected should read less than 1 ohm, or coil is faulty. If both coils check good, receiver is faulty.
Green Off Time Light On	The green light is on and the Subtrol-Plus requires the specified off time before the pump can be restarted after having been turned off. If the green light is on except as described, the receiver is faulty. Note that a power interruption when the motor is running will initiate the delay function.
Overheat Light On	This is a normal protective function which turns off the pump when the motor reaches maximum safe temperatures. Check that amps are within the nameplate maximum on all three lines, and that the motor has proper water flow past it. If overheat trip occurs without apparent motor overheating, it may be the result of an arcing connection somewhere in the circuit or extreme noise interference on the power lines. Check with the power company or Franklin Electric. A true motor overheat trip will require at least five minutes for a motor started cold. If trips do not conform to this characteristic, suspect arcing connections, power line noise, ground fault, or SCR variable speed control equipment.
Overload Light On	This is a normal protective function, protecting against an overload or locked pump. Check the amps in all lines through a complete pumping cycle, and monitor whether low or unbalanced voltage may be causing high amps at particular times. If overload trip occurs without high amps, it may be caused by a faulty rating insert, receiver, or sensor coil. Recheck that the insert rating matches the motor. If it is correct, carefully remove it from the receiver by alternately lifting sides with a knife blade or thin screwdriver, and make sure it has no pins bent over. If the insert is correct and its pins are okay, replace receiver and/or sensor coils.
Underload Light On	This is a normal protective function. A. Make sure the rating insert is correct for the motor. B. Adjusting the underload setting as described to allow the desired range of operating conditions. Note that a DECREASE in underload setting is required to allow loading without trip. C. Check for drop in amps and delivery just before trip, indicating pump breaking suction, and for unbalanced line current. D. With the power turned off, recheck motor lead resistance to ground. A grounded lead can cause underload trip.

Subtrol-Plus (Obsolete - See SubMonitor)

Subtrol-Plus - Troubleshooting After Installation (Continued)

SYMPTOM	POSSIBLE CAUSE OR SOLUTION
Tripped Light On	Whenever the pump is off as a result of Subtrol-Plus protective function, the red tripped light is on. A steady light indicates the Subtrol-Plus will automatically allow the pump to restart as described, and a flashing light indicates repeated trips, requiring manual reset before the pump can be restarted. Any other red light operation indicates a faulty receiver. One-half voltage on 460 V will cause tripped light on.
Control Circuit Fuse Blows	With power turned off, check for a shorted contactor coil or a grounded control circuit lead. The coil resistance should be at least 10 ohms and the circuit resistance to panel frame over 1 megohm. A standard or delay-type 2 amp fuse should be used.
Contactor Will Not Close	If proper voltage is at the control coil terminals when controls are operated to turn the pump on, but the contactor does not close, turn off power and replace the coil. If there is no voltage at the coil, trace the control circuit to determine if the fault is in the Subtrol-Plus receiver, fuse, wiring, or panel operating switches. This tracing can be done by first connecting a voltmeter at the coil terminals, and then moving the meter connections step by step along each circuit to the power source, to determine at which component the voltage is lost. With the Subtrol-Plus receiver powered up, with all leads disconnected from the control terminals and with an ohmmeter set at RX10, measure the resistance between the control terminals. It should measure 100 to 400 ohms. Depress and hold in the reset button. The resistance between the control terminals should measure close to infinity.
Contactor Hums or Chatters	Check that coil voltage is within 10% of rated voltage. If voltage is correct and matches line voltage, turn off power and remove the contactor magnetic assembly and check for wear, corrosion, and dirt. If voltage is erratic or lower than line voltage, trace the control circuit for faults similar to the previous item, but looking for a major drop in voltage rather than its complete loss.
Contactor Opens When Start Switch is Released	Check that the small interlocks switch on the side of the contactor closes when the contactor closes. If the switch or circuit is open, the contactor will not stay closed when the selector switch is in HAND position.
Contactor Closes But Motor Doesn't Run	Turn off power. Check the contactor contacts for dirt, corrosion, and proper closing when the contactor is closed by hand.
Signal Circuit Terminals Do Not Energize	With the Subtrol-Plus receiver powered up and all leads disconnected from the signal terminals, with an 0hmmeter set at RX10, measure the resistance between the signal terminals. Resistance should measure close to infinite. Depress and hold in the reset button. The resistance between the signal terminals should measure 100 to 400 ohms.

Abbreviations

A	Amp or amperage
AWG	American Wire Gauge
BJT	Bipolar Junction Transistor
°C	Degree Celsius
CB	Control Box
CRC	Capacitor Run Control
DI	Deionized
Dv/dt	Rise Time of the Voltage
EFF	Efficiency
°F	Degree Fahrenheit
FDA	Federal Drug Administration
FL	Full Load
ft	Foot
ft-lb	Foot Pound
ft/s	Feet per Second
GFCI	Ground Fault Circuit Interrupter
gpm	Gallon per Minute
HERO	High Efficiency Reverse Osmosis
hp	Horsepower
Hz	Hertz
ID	Inside Diameter
IGBT	Insulated Gate Bipolar Transistor
in	Inch
kVA	Kilovolt Amp
kVAR	Kilovolt Amp Rating
kW	Kilowatt (1000 watts)
L1, L2, L3	Line One, Line Two, Line Three
lb-ft	Pound Feet
L/min	Liter per Minute
mA	Milliamp
max	Maximum
MCM	Thousand Circular Mils
mm	Millimeter
MOV	Metal Oxide Varister
NEC	National Electrical Code
NEMA	National Electrical Manufacturer Association
Nm	Newton Meter
NPSH	Net Positive Suction Head
OD	Outside Diameter
OL	Overload
PF	Power Factor
psi	Pounds per Square Inch
PWM	Pulse Width Modulation
QD	Quick Disconnect
R	Resistance
RMA	Return Material Authorization
RMS	Root Mean Squared
rpm	Revolutions per Minute
SF	Service Factor
SFhp	Service Factor Horsepower
S/N	Serial Number
TDH	Total Dynamic Head
UNF	Fine Thread
V	Voltage
VAC	Voltage Alternating Current
VDC	Voltage Direct Current
VFD	Variable Frequency Drive
W	Watts
XFMR	Transformer
Y-D	Wye-Delta
Ω	ohms

Notes

Notes

Notes

Notes

TOLL FREE HELP FROM A FRIEND

800-348-2420 • 260-827-5102 (fax)

Phone Franklin's toll free SERVICE HOTLINE for answers to your pump and motor installation questions. When you call, a Franklin expert will offer assistance in troubleshooting and provide immediate answers to your system application questions. Technical support is also available online. Visit our website at:

www.franklin-electric.com

Franklin Electric

The Company You Trust Deep Down

M1311 07.11

APPENDIX 'D'

WATER METERS

Cold Water Recordall® Turbo 200 Meter with Integral Strainer

Size 2" (DN 50 mm)

Technical Brief

DESCRIPTION

Badger Meter offers the 2" Turbo Series meter with Integral Strainer in Cast Bronze and a Low Lead Alloy. The Low Lead Alloy (Trade Designation: Turbo Series LL-NS (with Integral Strainer)) version complies with NSF/ANSI Standard 61, Annex G and carries the NSF-61 Mark on the product.

APPLICATIONS: For use in measurement of potable cold water in commercial and industrial services where flow is in one direction only.

OPERATION: Water flows into the meter's measuring element contacting the multi-vaned rotor. Flow readings are obtained by rotor revolutions transmitted by magnetic drive coupling through the meter's cover plate to the sealed register. Magnetic drive is achieved by a right angle worm drive, coupling the rotor to a vertical transmission spindle, driving a gear set rotating the magnet carrier. A ceramic magnet in a carrier rotates around a vertical axis. Through the magnetic coupling, rotor rotation is transmitted to a follower magnet which transmits rotation to the register gearing.

The turbo measuring element is designed to greatly reduce wear by reducing friction potential between the moving parts of the rotor and bearing system. Less wear, in this critical area of the design, provides the utility manager with a lower life cycle cost for meter application. Throughout the normal operating range of the meter, the rotor floats between the thrust bearing system.

OPERATING PERFORMANCE: The Badger® Recordall Turbo 200 meter meets and exceeds registration accuracy for the low flow rate, normal operating flow rate, and maximum continuous operation flow rate as specifically stated in AWWA Standard C701.

CONSTRUCTION: The Badger Recordall 200 Turbo meter construction which complies with ANSI and AWWA C701 standards, consists of three basic components: meter housing, interchangeable measuring element and permanently sealed register. The housing is bronze, with round or elliptical flanges. The measuring element consists of the transmission coupling, measuring element insert, rotor, inlet and outlet straightening vanes with nose cones, and calibration ring assembly. The unique inlet and outlet straightening vanes minimize swirl from piping arrangements upstream as well as downstream.

To simplify maintenance, the register and measuring element can be removed without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of certain parts between 1 1/2" - 4" like-sized meters also minimizes spare parts inventory investment.

MAGNETIC DRIVE: Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading, remote or automatic meter reading options.

SEALED REGISTER: The standard register consists of a straight-reading odometer-type totalization display, 360° test circle with center sweep hand and flow finder to detect leaks. Register gearing consists of self-lubricating thermoplastic gears to minimize friction and provide long life. Permanently sealed; dirt, moisture, tampering and lens fogging problems are eliminated. Multi-position register simplifies meter installation and reading. Automatic meter reading and close proximity systems are available for all Recordall Turbo meters. (See back of sheet for additional information.) All reading options are removable from the meter without disrupting water service.

TAMPER-PROOF FEATURES: Customer removal of the register to obtain free water can be prevented when the option tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Both can be installed at the meter site or at the factory. A tamper resistant calibration plug seal provides protection from unauthorized personnel.

STRAINER: The meter is designed with an integral stainless steel strainer screen built into its inlet end. A removeable cover plate permits easy access to the strainer for routine cleaning.

MAINTENANCE: Badger Recordall Turbo meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location. As an alternative to repair by the utility, Badger offers various maintenance and meter component exchange programs to fit the needs of the utility.

CONNECTIONS: Companion flanges for installation of meters on various pipe types and sizes are available in cast iron or bronze as an option.

TEST PLUG: An 1 1/2" NPT test plug puts an end to removing and reinstalling meters during field accuracy and pressure testing.

Turbo 200 with 1 1/2" Test Plug and Integral Strainer

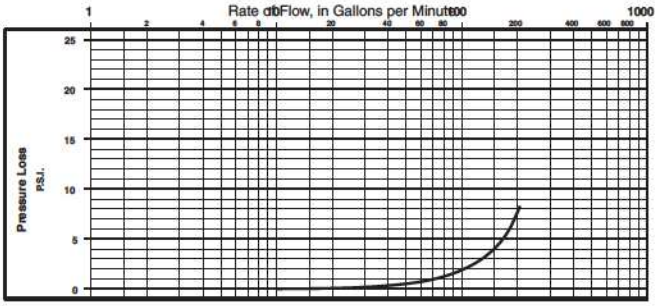
SPECIFICATIONS

Typical Operating Range (100% ± 1.5%)	4 - 310 GPM (0.9 to 56.7 m³/h)
Maximum Continuous Operation	200 GPM (45.4 m³/h)
Maximum Intermittent Flow	310 GPM (70.3 m³/h)
Typical Low Flow (Min. 95%)	2.5 GPM (0.6 m³/h)
Pressure Loss at Maximum Continuous Operation	8.3 PSI (.57 bar at 45.4 m³/h)
Maximum Operating Temperature	120°F (49°C)
Maximum Operating Pressure	150 PSI (10 bar)
Meter Flanges	2" Elliptical or Round Flanges, AWWA 125 pound class
Register	Straight reading, permanently sealed magnetic drive standard. Automatic Meter Reading and Close Proximity units optional.
Registration	100,000,000 Gallons 100 gallons/sweep hand revolution. 10,000,000 Cubic Feet 10 cubic ft./sweep hand revolution. 1,000,000 m³ 1 m³/sweep hand revolution. 100,000,000 Imperial Gallons 100 ImperialGallons/sweep hand revolution.

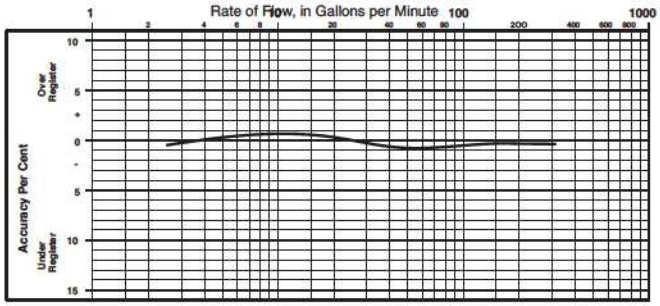
MATERIALS

Housing	Cast Bronze (B81), Low Lead Alloy
Turbo Head	Cast Bronze (B81), Low Lead Alloy
Nose Cone and Straightening Vanes	Thermoplastic
Rotor	Thermoplastic
Rotor Radial Bearings	Lubricated Thermoplastic
Rotor Thrust Bearings	Sapphire Jewels
Rotor Bearing Pivots	Passivated 316 Stainless Steel
Calibration Mechanism	Stainless Steel and Thermoplastic
Magnet	Ceramic
Register Lid and Shroud	Thermoplastic, Bronze
Trim	Stainless Steel

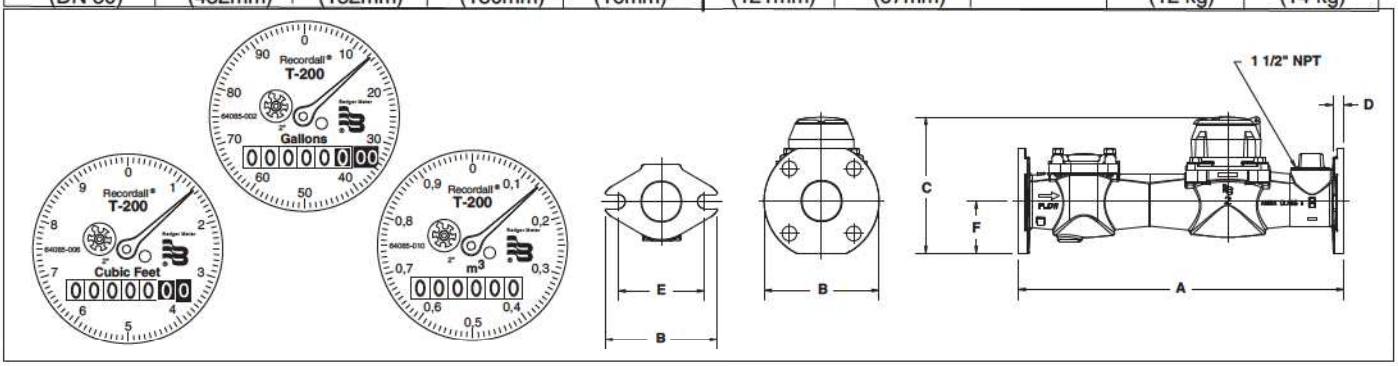
PRESSURE LOSS CHART



ACCURACY CHART

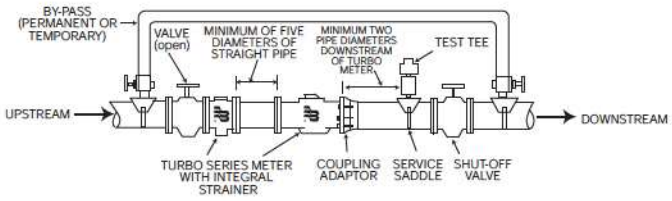


Meter & Pipe Size	DIMENSIONS								
	Length	Width	Height	Flange	Bolt Circle	Centerline	No.	Net	Shipping
2" EL	A 17"	B 5 27/32"	C 6 1/2"	D 27/32"	E 4 1/2"	F 2 1/16"	Bolts 2	Weight 24 lb.	Weight 28 lb.
(DN 50) 2" RD	(432mm) 17"	(148mm) 6"	(165mm) 7 3/32"	(47mm) 5/8"	(114mm) 4 3/4"	(52mm) 2 5/8"	4	(11kg) 26 lb.	(13 kg) 30 lb.
(DN 50)	(432mm)	(152mm)	(180mm)	(16mm)	(121mm)	(67mm)		(12 kg)	(14 kg)



PROPER INSTALLATION: The following installation guidelines will insure optimum field performance and reliability when installing a Badger Turbo meter.

1. For Turbo meters with a strainer, a minimum of five (5) pipe diameters of straight pipe upstream of the meter is recommended.
2. ONLY full-open gate valves should be used immediately upstream of the meter. Butterfly valves MUST be five (5) pipe diameters or more upstream of the meter. Full-open gate or butterfly valves can be used downstream.
3. DO NOT install pressure reducing devices or check valves upstream of the meter.
4. Unweighted check valves MUST be located at least three (3) pipe diameters downstream of the meter.
5. Pressure reducing devices and externally weighted check valves MUST be located at least five (5) pipe diameters downstream of the meter.



Please see our website at
www.badgermeter.com
for specific contacts.

Due to continuous research, product improvements and enhancements, Badger Meter reserves the right to change product or system specifications without notice, except to the extent an outstanding contractual obligation exists.

BadgerMeter, Inc.
P.O. Box 245036, Milwaukee, WI 53224-9536
(800) 876-3837 / Fax: (888) 371-5982
www.badgermeter.com

APPENDIX 'E'

IRRIGATION CONTROLLER & SENSOR

PRO-C

Hunter®


NEW
1200
MANUAL START
PRESS & HOLD
PRG
RUN
BYPASS
ACTIVE
RAIN SENSOR
Hunter Pro-C
SYSTEM OFF
MANUAL - SINGLE STATION
SEASONAL ADJUSTMENT
SET PUMP OPERATION
SET CURRENT DATE / TIME
SET PROGRAM START TIMES
SET STATION RUN TIMES
SET DAYS TO WATER

The Hunter Pro-C.
The Right Candidate for Any Job.

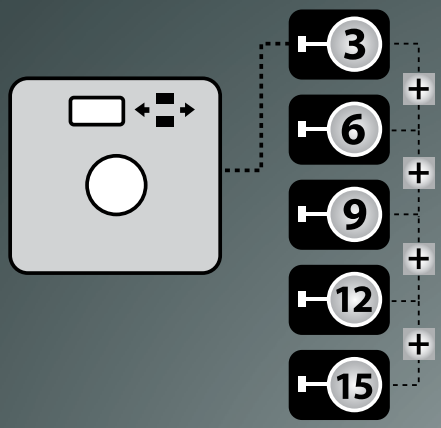
On the job, you need choice. So Hunter has two controllers working hard to get your vote. The modular Pro-C (PC Series) offers a customizable controller expandable from 3-, 6-, 9-, 12-, or 15-stations with PCM modules. For a cost-effective candidate, the new Pro-C (PCC Series) is the best selection for contractors with fixed station control needs. Both controllers also feature some great benefits, including three programs with multiple start times, independent day scheduling options with a programmable "event day off", one-touch manual start and rapid advance, one-button reset, a heavy duty locking cabinet, and two-level superior surge protection. For a higher client approval rating, elect Hunter.

Kick It Up a Notch. Way Up.

It may be a Pro, but it just keeps getting better. The new Power-Lock Slide on the modular Pro-C allows one or more modules to be easily removed or installed, and prevents any potential issues removing modules under power. Both controllers boast simplified end-user programming, allowing the ability to turn "on or off" features that are not in use or unneeded, and a total runtime calculator keeps you in the know on individual station times. We also expanded the range for seasonal adjust, now at 0 to 300%, in 5% increments, and added an Easy Retrieve™ Memory for simple access to a previously saved program. And both controllers are now sensor programmable by station, for continued, specific zone watering.

EXERCISE YOUR FREEDOM OF CHOICE

PRO-C

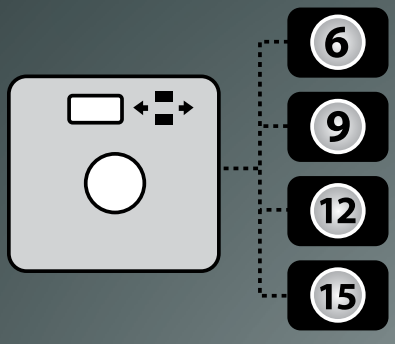


Pro-C: Convenient

At Hunter, we believe in the Freedom of Choice. And we stand behind both of our candidates. Does convenience get your vote? Forget lugging around all those different controllers, and pick the Pro-C. With its ability to customize to the particular size that you need—from 3 to 15 stations—the Pro-C reforms inventory time with only three types of units to keep in stock: indoor cabinets, outdoor cabinets, and station modules. Modularity also means the ability to retrofit for future expansion. And the Pro-C now boasts the Power-Lock Slide feature, which allows for a less taxing module removal.

Modular Edition

PCC



Pro-C Conventional: Cost Effective

Debating which controller to choose? The new Hunter Pro-C PCC Series is your cost-effective choice to save some capital. Focused on economics, the Pro-C PCC is a simple option for fixed station control, when you know what you need. And if you elect to have the new Solar Sync as a running mate, the Pro-C PCC is designed for the module to be installed directly in the controller cabinet, for a compact, coordinated system.

Conventional Edition

Pro-C Power

ADDED

Easy Retrieve Memory allows for retrieval of saved program

Features and Benefits

Independent scheduling options

Days of the week, odd/even, or 31-day intervals

Non-volatile memory

No battery required for backing up programs and current date and time; holds programs indefinitely; excellent insurance against unreliable power

Two levels of superior surge protection

Includes Hunter Quick Check™ self-diagnostic short circuit protection; microcircuits are protected from electrical spikes, with no fuses to worry about

Three programs (A, B, C) with multiple start times

Independent programming handles various watering requirements

Central control compatibility

Ready to work with Hunter's IMMS water management system

ADDED

Total run time calculator determines total of individual station run times per program

ADDED

Sensor programmable by station allows continued watering on specific zones during rain events

Remote control ready. Supplied with connection for ROAM and ICR remote controls.

Large LCD display for simplified programming

Modular Edition

3-Station base controller expandable to 15 stations with PCM modules.

Servicing is made easy. Power-Lock feature allows for easy removal and automatic recognition of modules.

Simplified inventory means lower inventory costs.

Ability to retrofit for future expansion.

Conventional Edition

Designed to allow for installation for Solar Sync module inside controller cabinet.

Economical option for fixed station control.

Common features and benefits as the modular edition.

Pro-C Sensor Compatibility

Solar Sync

The best under the sun. The Pro-C works even harder with our new Solar Sync. The solar sensor measures the sun's rays and temperature to keep your lawn at peak performance with optimal watering. That means no worrying when temperatures are too hot or too cold. So take a break! We won't tell.

ROAM Remote

The Pro-C works with Hunter's ROAM Remote, the mid-range solution for residential and commercial applications, operating up to a 1000-foot range. Conveniently able to be attached to the Pro-C, it's always on hand.

Charts and Specs

SPECIFICATIONBUILDER

MODEL	FEATURES	OPTIONS
PC = Pro-C Controller	300i = 3-Station Base Unit Controller, Indoor Model, Plug-in Transformer, Expands to 15 Stations 230/240V **300** = 3-Station Base Unit Controller, Outdoor Model, Internal Transformer, Expands to 15 Stations	
International	301i = International Model 3-Station Base Unit Controller, Indoor Model, Plug-in Transformer, Expands to 15 Stations 301 = International Model 3-Station Base Unit Controller, Outdoor Model, Internal Transformer, Expands to 15 Stations	A = Australian Markets 240VAC (Outdoor Model Supplied with Cord) E = Europe 230VAC
PCM	300 = 3-Station Plug-in Module for use with any PC Controller Model 900 = 9-Station Plug-in Module for use with any PC Controller Model	
▶ **PC**	▶ **300**	▶ Leave blank if no option chosen)

EXAMPLE ▶ **PC - 300**

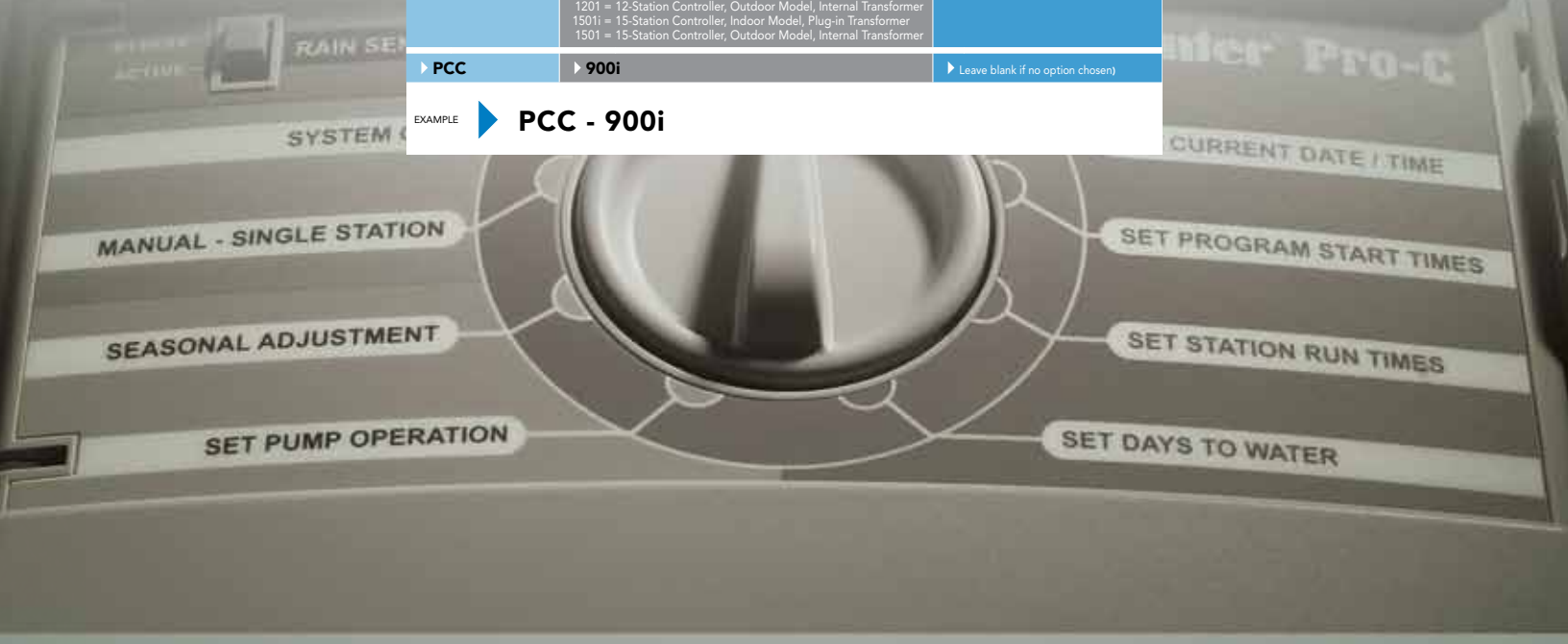
Pro-C QUICK REFERENCE CHART

Desired Station Configuration	Order Base Unit	Plus Number of modules	Specify as:
3 Zone	PC-300 or PC-300i	no module needed	PC-300 or PC 300i
6 Zone	PC-300 or PC-300i	one PCM-300	PC-600 or PC 600i
9 Zone	PC-300 or PC-300i	two PCM-300	PC-900 or PC 900i
12 Zone	PC-300 or PC-300i	three PCM-300	PC-1200 or PC 1200i
15 Zone	PC-300 or PC-300i	one PCM-300 & one PCM-900	PC-1500 or PC 1500i

SPECIFICATIONBUILDER

MODEL	FEATURES	OPTIONS
PCC = Pro-C Controller (Conventional)	600i = 6-Station Controller, Indoor Model, Plug-in Transformer 600 = 6-Station Controller, Outdoor Model, Internal Transformer **900i** = 9-Station Controller, Indoor Model, Plug-in Transformer 900 = 9-Station Controller, Outdoor Model, Internal Transformer 1200i = 12-Station Controller, Indoor Model, Plug-in Transformer 1200 = 12-Station Controller, Outdoor Model, Internal Transformer 1500i = 15-Station Controller, Indoor Model, Plug-in Transformer 1500 = 15-Station Controller, Outdoor Model, Internal Transformer	
International	601i = 6-Station Controller, Indoor Model, Plug-in Transformer 601 = 6-Station Controller, Outdoor Model, Internal Transformer 901i = 9-Station Controller, Indoor Model, Plug-in Transformer 901 = 9-Station Controller, Outdoor Model, Internal Transformer 1201i = 12-Station Controller, Indoor Model, Plug-in Transformer 1201 = 12-Station Controller, Outdoor Model, Internal Transformer 1501i = 15-Station Controller, Indoor Model, Plug-in Transformer 1501 = 15-Station Controller, Outdoor Model, Internal Transformer	E = 230 VAC with European Connections A = 240 VAC with Australian Connections (Outdoor Model has Internal Transformer with Cord)
▶ **PCC**	▶ **900i**	▶ Leave blank if no option chosen)

EXAMPLE ▶ **PCC - 900i**



Hunter® THE IRRIGATION INNOVATORS

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Hunter®

PRODUCT INFORMATION

Pro-C Controller

A Complete Family of Full-Featured Residential and Light Commercial Controllers

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PRODUCT OVERVIEW

A Complete Family of Full-featured Indoor and Outdoor Residential and Light Commercial Controllers

For the end user, for the contractor...there has never been a residential and light commercial controller so remarkably easy to handle as this. Presenting the new Hunter Pro-C Controller.

Borrowing the innovative concept of modular design from its big brother, the ICC, this latest addition to the Hunter product line-up is destined to become the leading controller in its market segment in the years to come. Starting with a base model of 3 stations, it is possible to expand the controller up to 15 stations simply by adding plug-in modules. So, there's no need to bring along a variety of different-sized controllers to see which one is best for the job. With its ability to customize to the particular size you need, the Pro-C will always be the right choice. Being a modular system, the new Pro-C also makes inventory a breeze for contractors—there are only three different units to stock (indoor cabinets, outdoor cabinets and station modules).

But, modularity isn't all this controller has to offer, with great features such as three programs with multiple start times, independent day scheduling options, "one touch" manual start and rapid advance, a programmable event day off, robust heavy-duty locking plastic cabinet, and superior surge protection.

The Pro-C controller: delivering maximum flexibility for landscapes that require a minimal number of stations.

FEATURES AND BENEFITS

Outdoors

Indoors

Outdoor or Indoor Models Available

A versatile controller, covering the needs of any installation

The Pro-C controller is offered as an outdoor model when the need for weather resistance is required and as an indoor model for installations where protection from the elements is available. Both models are listed with UL and CE.

Modular Design

One controller does it all; no need to stock or carry multiple units

Hunter is a leader in fulfilling customer wishes and the Pro-C controller simply the latest in a long history of quality irrigation products. Here is an impressive controller, with its modular design for inventory management, three stations factory installed, and the ability to easily add more stations, this is one well-conceived controller that will satisfy both contractor and end user alike.

"Custom-tailored" to the Project. Start with the PC-300 outdoor or PC-300i indoor 3-station controller base model and then customize it to your project with the addition of the PCM-300 3-station plug-in modules. The PCM-900 9-station module can also be added to expand the Pro-C station capacity to 15 stations. One to three additional modules can be added covering the zone requirements of the majority of all residential and light commercial jobs. No longer does the installer have to spend extra money on a controller with extra zones that aren't necessary.

Easy Inventory Management. Now, only one controller need be stocked for all projects. With its modularity, the Pro-C can be called out as a 3-, 6-, 9-, 12- or 15-station controller on most irrigation designs, making it the only controller necessary to keep on hand. Simply stock the base unit for all jobs and keep a box of modules to easily add stations to the controller as required.

Modular Design Eliminates Service Hassles. When heavy electrical surges (lightning) hit a controller, the damage it inflicts can occur in the primary or secondary circuitry. The Pro-C is the easiest controller to service with its readily removable primary power and station modules. Because of the modular design, when clock repair is necessary, the simple repair process is to extract the damaged module from the unit and replace. The contractor will find that there is no requirement to remove the controller from the wall.

Future Expansion. Easy addition of stations is a component of the modular concept. When your customers add on to their landscapes in future projects, the Pro-C is up to the task. The PCM station modules can be added, to make future expansion a breeze.

Large LCD Display

Easy to read for schedule review and entry

The large LCD display simplifies programming, making it easy to read and verify. In low light conditions, a large display is a welcome sight to any user.

Non-volatile Memory

Holds programs indefinitely; excellent insurance against unreliable power

The Pro-C has what every user of electronic controllers has wished for: the ability to keep all programs in memory without a backup battery. In the event of a power failure or if AC power is suspended from the controller by the user, the Pro-C's non-volatile memory will maintain programs forever, without need for a battery. Normal watering will resume when AC power is restored.

No Battery Required

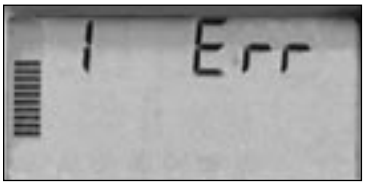
Maintain time of day up to four weeks

The circuitry of the Pro-C has such low power consumption that the controller will accurately track the time of day for up to four weeks after AC power has been removed from the controller by the user or in the event of a power outage. This timekeeping occurs without need for a battery. When power is restored the controller will continue to water, right on schedule. The controller will also reset its circuits to allow another 4 weeks of time keeping.

Self-Diagnostic Electronic Short Circuit Protection

No fuses to worry about; only faulty stations stop watering

The Pro-C automatically skips shorted stations allowing the rest of the system to operate as normal. The self-diagnostic electronic short circuit protection system is very beneficial to the user because of its ability to aid in identifying field wiring problems. It is almost as if the controller can trouble-shoot the system itself.



The self-diagnostic system detects a high current path—a "short"—through an operating station (the most common causes of shorts are faulty solenoids or when a bare valve common wire touches a bare station control wire). When a short circuit is detected on a station, instead of blowing a fuse which would shut down the entire irrigation system, the controller will skip over that station and continue to water the rest of the zones in the program. The controller will indicate what zone is shorting by showing the station number followed by ERR in the LCD display. The controller will continue to "jump over" that zone during every watering until the zone is repaired. To remove the ERR message from the display, just turn the dial or push any button.

FEATURES AND BENEFITS *(continued)*

Intuitive Dial Programming
For easy program entry

For contractors and homeowners alike, the Pro-C provides step by step programming. No complicated entry functions or repetitive keystrokes. Just turn the dial to the section of the program that needs to be changed and use the plus, minus and next buttons to make the adjustments. No other programming method is easier.

Removable Front Panel for Remote Programming
Set the controller up without having to stand in front of it

A removable hinge design allows easy removal of the front panel without disturbing field wiring. With the use of a 9-volt battery, you can set the program away from the cabinet location. This timesaving feature allows the contractor to program before going out to the job (also serves as a great sales demo when talking to a potential client). The contractor can also give the homeowner the front panel while the job is being installed to allow the homeowner to try the programming functions early on. When it comes time to actually set up the controller, the homeowner is completely clued in, making the whole programming process a very simple one.

3 Programs (A, B, C) with Multiple Start Times
Different watering requirements are met with independent programming

The Pro-C allows for many different irrigation applications using three completely independent programs. This is ideal for various types of plants that have separate watering day requirements. Each program has the ability to water up to four start times per day. The user has complete flexibility with watering schedules for new seed or sod lawns, multiple cycles for low infiltration-rate soils, slopes, morning or evening irrigation and other watering window restrictions.

Up to Six-hour Station Run Times
Allows accurate watering for all types of plant material

Each station will operate up to six hours of run time in any or all three programs. Run times from 0-120 minutes program in one-minute increments and then in ten-minute increments up to six hours. The factory default for all stations is set at 0 minutes to eliminate any unneeded stations before programming.

Note: Using the water budget feature, station run times may only be increased to a maximum of 6 hours.

Choice of Independent Day Scheduling Options
Days of the week or 31-day interval for maximum flexibility

The watering day schedules in programs A, B or C may be set up independently from each other. In each program, the choice of Custom (day of the week), Interval (up to 31-days), Odd or Even days may be selected. This allows the user to water on certain days of the week such as Monday, Wednesday and Friday or water on a repeating day cycle (Interval) such as every third day, or odd/even days in any or all three of the programs.

365-day Calendar with Leap Year Intelligence

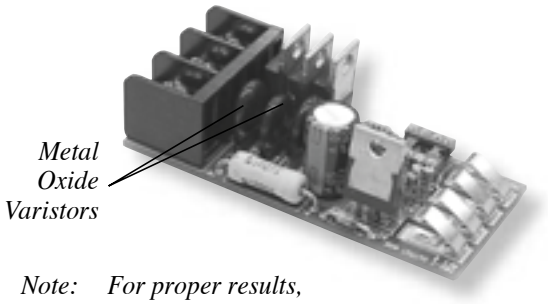
True odd or even day programming

In many areas of the United States, summer water rationing is a way of life. With its 365-day, leap year intelligent calendar the Pro-C makes programming true Odd/Even day watering possible, automatically correcting for 31-day months. Interval or Day of the Week scheduling is possible as well, to cover any watering day restrictions that may be enacted.

Superior Surge Protection

All microcircuits are protected from electrical spikes/lightning

The Pro-C is equipped with electronic components called MOVs (Metal-Oxide Varistor). These MOVs are designed to shunt electrical surges away from microcircuits through the controller's grounding circuit. The Pro-C uses these MOVs to protect the controller from minor power surges coming in through the primary (110/230VAC) input side and also the secondary output side (24VAC).



Note: For proper results, the ground circuit must measure 10 ohms or less.

Global Water Budget/Seasonal Adjustment

Changing run times could not be easier, from 10% to 150%

The water budget/seasonal adjustment setting allows the user to make global changes to the run times of each zone from 10-150 percent of the original programmed run time in 10 percent increments. This feature is perfect for making small changes that are necessary as the weather changes, without reprogramming the entire controller. A unique bar graph (thermometer display) in the large LCD display lets the programmer know at a glance what percent from the original settings the controller is operating the station run times. The ability to immediately view the recalculated run times for each of the zones is another unique feature built into the seasonal adjustment.

Note: The controller should always be initially programmed in the seasonal adjustment in the 100% position.

FEATURES AND BENEFITS *(continued)*

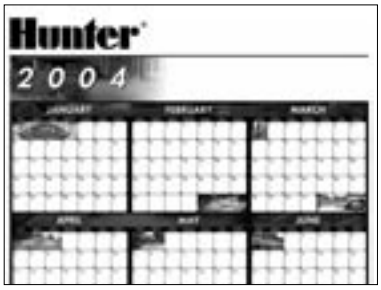
Weather Sensor Compatible
Built-in bypass switch eliminates extra watering

The Pro-C allows easy connection of any rain or weather sensor device including the Hunter Rain-Clik™, along with other Hunter sensors. With the sensor circuit on the controller, wiring is fast and easy. There's a built-in bypass switch to turn off the sensor for maintenance. Best of all, the controller will display Sen Off in the LCD display indicating when the sensor is interrupting irrigation. In all cases, use of the sensor does not alter any programmed watering schedule. The hookup is as simple as removing the jumper that is attached across the SEN terminals of the controller and connecting the sensor wires to the terminals.

Rain-Clik™

Programmable Event Day(s) Off
Maximum versatility when keeping the water off is important

Need to make certain that the controller does not water on a specific day or days of the week? The Pro-C handles this task with ease. When Interval programming has been selected as the Day Schedule this event day off programming overrides the interval function to keep the controller always off on the day(s) selected. For example, an interval program is scheduled to water every third day but Saturdays have been designated as a "mow day," so no watering can occur. Under the Event Day Off selection, Saturdays can be turned off. Sports fields, community centers, schools and parks will find this feature satisfies their requirements in this regard.



One Touch Manual Start and Rapid Advance
Simple operation for a quick check of zones

The One Touch Start and Rapid Manual Advance feature increases user-friendliness of the controller by using fewer steps to activate stations. This feature is great for a quick cycle when extra watering is needed or if you would like to scroll through the stations to inspect the system.

Remote Ready
Provide your controller with simple and reliable operation away from its mounting location

The Pro-C is remote ready! A SmartPort® harness is supplied with the Pro-C controller to permit the attachment of a Hunter SRR or ICR remote receiver. The SRR remote control is great for residential/light commercial sites, and offers features that other remotes can't at a price that can't be beat. The ICR remote control provides the installer maximum range capability (up to 2 miles) for large commercial sites. These easy to install remotes can save time and money by allowing remote valve operation away from the controller.

Heavy-Duty Cabinet

Built to overcome the elements—for a long time

The Pro-C is built using a robust heavy-duty plastic UL listed and NEMA 3R rated cabinet, which is not subject to UV degradation or color changes. For faster installation, the cabinet door hinge pin is removable when the door is unlocked and open. In addition, the cabinet uses the same professional key lock on the outdoor model as the Hunter ICC commercial controller. The Pro-C cabinet is also designed with a ¾"-1" knockout option on the back of the cabinet, and a 1" opening for low voltage and a ½" opening for high voltage in the bottom of the cabinet to accommodate the wiring needs of any job.

Programmable 0-7 Day Rain Delay

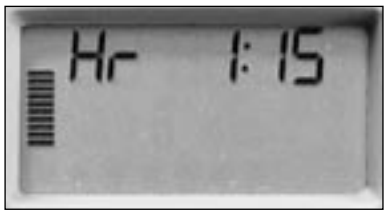
No need to return to the controller to turn it back on

The Pro-C allows you to turn off the controller for a predetermined period of time (1-7 days) during rainy weather. All programs are affected, as this delay is global. After the specified period has elapsed, the controller will return to automatic mode and water as scheduled. This delay feature is very convenient because when the controller is turned off for an event such as rain or a social activity, the operator will not have to make a trip to the site to reactivate the controller. In residential systems, when the operator uses the watering delay feature there's no need to worry about remembering that the controller has been turned off.

Programmable Delay Between Stations

Slow closing valves and well recovery will never be an issue

A programmable delay between stations solves the problem of slow closing valves because of a hydraulic overload condition. The delay also solves the problem of a system operating off of a slow filling well, allowing the well to recover between zones. The Pro-C's programming will allow it to fit into any situation where a delay is necessary, as the delay is programmable up to four hours. Delays from 0 to 60 seconds are allocated in 5-second increments and then up to 4 hours in 1-minute increments. Note: If the MV circuit is programmed to operate on the zone, it will stay hot for the first minute of any programmed delay.



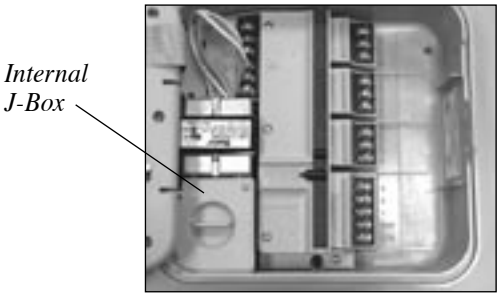
FEATURES AND BENEFITS *(continued)*

Pump Start/MV Circuit, Programmable By Station
Activate a pump or master valve only when needed

A programmable pump start circuit can activate a pump relay or master valve by individual zone. For systems that require only certain zones to receive a boost in pressure from a pump (such as rotor zones) this programmable MV circuit feature is the perfect solution, since it allows the pump to only operate when needed.

Internal Junction Box (on Outdoor Model Only)
Primary power connection made inside the controller

No extra trips to the distributor for a forgotten electrical box. The Pro-C comes with a primary power junction box built inside the cabinet. Installation time is reduced because a J-Box does not have to be fitted and screwed down tight. All that is required for proper installation is electrical conduit.



24VAC Valve Test
Easy arrangement of zones during wire hookup

When wiring up the controller so numbered irrigation zones will run in sequential order, installers find that an “always on” 24VAC valve test terminal post simplifies this process. Touching the valve wire to a hot 24 volt terminal to determine numbered zones without having to program a ‘manual start’ in the controller makes wire installation quick and efficient.

Primary Voltage Source Choices
Indoors or outdoors, operates off a variety of power sources

Pro-C models can be supplied with a 115VAC/60 Hz transformer for domestic use or a 230VAC/50 Hz transformer for international use. This versatile transformer selection enables users to install the Pro-C anywhere in the world.

AM/PM or 24 Hour Clock Settings
Choose your favorite method of timekeeping

Operating the controller in either AM/PM mode or in 24-Hour mode is selectable by the user. The Pro-C allows the user to pick the time format that is most desirable. Wherever you are in the world, the Pro-C can operate under local time keeping preferences.

Single Station Manual Start
If all that is needed is a little extra on a single zone!

Many times throughout the year and for many reasons (e.g., watering fertilizer or pesticides into the soil, spot seeding), the user will want to add extra water to a particular zone. With single station manual start, the Pro-C is able to accomplish that task. Just turn the dial to Manual-One Station, use the arrow button to move to the desired station, then turn the dial to the Run position. The user may also increase or decrease the run time setting if preferred. After the zone is finished, the controller will return to automatic mode with its original schedule, even if modified for the manual operation.

Start Time Stacking
Prevent hydraulic overload

Preventing hydraulic overload is very important when designing irrigation systems, especially residential ones. All electronic controllers such as the Pro-C allow the user to input start times into the programs that could cause the controller to overlap station run times. This occurs when the station run times add up to more minutes than the amount of time programmed between the start times. In the Pro-C, the start times will stack and not begin to actually water until the previous start time has completed its run through of all zones programmed. This great feature will eliminate the possibility of more than one zone operating at a time, causing the system to perform poorly when water pressure and flow are minimal.

Multi-language Capability
User friendly in all parts of the world

The Pro-C line is available as a multi-language controller family. Separate customization kits are available in Spanish (INT-451), French (INT-452), Italian (INT-453), and German (INT-454). These kits include an owner's operation manual, door instruction card and a faceplate overlay that replaces the English version included with the controller.

Operate Three 7.2 VA Solenoids Simultaneously
Able to accommodate larger water volume systems

The Pro-C has the power capacity to operate up to three 7.2 VA solenoids simultaneously. There are times when the need to operate two valve solenoids off of one station terminal (and one solenoid on the pump start/MV terminal) is required. This type of operation may be the result of reduced watering windows, a retrofit with a city water system switching over to a water well system, or low volume (drip) zones added to regular zones. Whatever the reason may be, the Pro-C can handle it.

Assign Zones to Any or All Programs
Complete versatility for any watering requirement

Any station can be assigned to any or all programs in the Pro-C, making the Pro-C a truly versatile controller. This feature allows zones to have more than one watering schedule if required by the landscape.

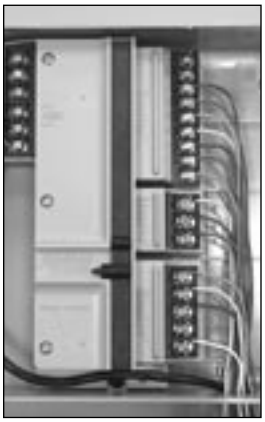
Automated Chronological Ordering of Start Times
No more "phantom" starts!

When more than one start time is entered into a program, in any order of sequence, the Pro-C automatically shifts the start times in ascending order from the earliest start time to the latest start time. The Pro-C will also shift or "rubber band" the start times if times were inadvertently added after empty start time slots. The controller will fill the start #1 slot first, and then the #2 slot second, and so on making it easier for the user to check all times. No "phantom" starts will occur from an unknown start time buried deep in the program.

FEATURES AND BENEFITS *(continued)*

Easy Access Wire Compartment
Simplified wire hookups

The Pro-C permits fast and easy connection of wiring in the spacious wiring compartment. With the sturdy terminal block, the wire can be inserted without bending for simplified installation. The primary terminal block has dedicated terminal screws for both a sensor hookup and a 24VAC connection for accessories. Each terminal will accommodate two 20-12 gauge wires.



Upgrade to Centralized Control
Network through IMMS™ to make programming changes and monitor system conditions from your computer

The Pro-C can be networked to your computer through the Hunter Irrigation Management and Monitoring System™ (IMMS). The IMMS allows the user to program controller functions that would typically be handled directly at each controller. Scheduling days to water, run times, start times and more can be done from a single computer at a desk miles away from the installation. A key function of the IMMS is its ability to monitor changing conditions with the aid of such options as flow sensors, rain sensors, and other weather-sensing devices. No system available today is more cost effective than the Hunter IMMS. Best of all it is able to team with any or all of the Hunter controllers, including the Pro-C.

Test Program
Simple test program feature allows for quick system checks

The Pro-C has a built-in test program feature that allows the user to run all stations for a predetermined number of minutes. This feature is great for conducting a quick system check on all zones or to activate valves during winterization.

The one button activation and single run time entry makes the test program simple and easy to use.

PRODUCT COMPARISONS

	Hunter® Pro-C	Rain Bird® E-CLASS	Rain Bird® ESP	Rain Bird® ESP-M	Irritrol® TOTAL CONTROL	Irritrol® RAIN DIAL™ PLUS	Irritrol® RAIN DIAL	Nelson® SMARTZONE EZ	Weathermatic® WEATHERMATE	Toro® CUSTOM COMMAND
True Modular Design with Station Expansion Modules	✔			✔						
Models for up to 15 stations in one family	✔	✔			✔	✔	✔	✔	✔	✔
Non-Volatile Memory Saves Programs Indefinitely	✔			✔	✔	✔		✔	✔	✔
Battery Not Required To Keep Current Time and Day (Up to 4 Weeks)	✔			✔						
Electronic Short Circuit Protection - No Fuses to Replace or Breakers to Reset	✔	✔		✔	✔	✔	✔	✔	✔	✔
Intuitive Dial Programming	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Removable Face Panel for Remote Programming	✔			✔	✔	✔	✔			✔
3 Independent Programs (A,B,C)	✔	✔		✔	✔	✔	✔	✔	✔	✔
Minimum of 4 Daily Starts per Program	✔	✔		✔	✔					✔
Up to 12 Starts Per Day	✔	✔		✔	✔					✔
Station Run Times Can Be Programmed For Up to 6 Hrs.	✔			4	✔	5.9	5.9	✔	✔	✔
True Odd / Even Programming (365 day calendar clock)	✔	✔		✔	✔	✔		will water on 31st	✔	✔
1-31 Day Interval Programming	✔			✔	30			30	30	30
Choice of Independent Day Scheduling Options By Programs	✔	✔		✔	✔	✔	✔	✔	✔	✔
Primary and Secondary Surge Protection	✔	✔	✔	✔	primary only	✔	✔	primary only	primary only	✔
Seasonal Adjustment / Water Budget	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Seasonal Adjustment With Visible In-Display Thermometer	✔									
Weather Sensor: Displays When Sensor is Active	✔					✔		✔		✔
Rain Sensor Override Bypass on Front Panel	✔			✔					✔	✔
Programmable Event Day Off for All Day Schedules	✔			✔	odd/even only	odd/even only			odd/even only	odd/even only
One Touch Manual Start / Rapid Advance	✔		✔	✔						
Remote Control Ready From Factory	✔			✔					✔	
Programmable 0-7 Day Rain Delay	✔				✔					✔
Programmable Delay Between Stations	✔									
Pump Start/MV Circuit, Programmable By Station	✔									
NEMA 3R Rated Outdoor Enclosure	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Key Lock on Outdoor Cabinet	✔			✔	✔					✔
Electrical Knockouts on Back of Cabinet	✔			✔						
Primary Power Connections Made Inside Cabinet - No Junction Box Required	✔	✔		✔				✔		
24VAC Valve Test Terminal	✔			✔	✔				✔	✔
Choose AM/PM or 24-Hour Clock Mode	✔	✔								
Multi-Language Capability	✔					✔	✔			
Upgradeable to Central Control	✔									
User Programmable Test Cycle	✔	✔							✔	

TECHNICAL INFORMATION

Operating Specifications

- Outdoor models, 115VAC transformer with internal junction box
- Indoor model, 115VAC two prong plug-in transformer
- Station output 24VAC .56 Amps
- Transformer output 24VAC 1.0 Amps
- Capable of operating equivalent of 3 solenoids simultaneously
- Operating Temperature: 0 - 150 degrees F
- NEMA rated outdoor cabinet
- UL Listed

Dimensions

- Indoor Model: 8.3" H x 9.6" W x 3.7" D
- Outdoor Model: 8.9" H x 9.9" W x 4.3" D

Models

PC-300i – base model indoor plastic cabinet with plug-in 115VAC transformer, expands to 15 stations

PC-300 – base model outdoor locking plastic cabinet with 115VAC transformer, expands to 15 stations

PCM-300 – 3 station plug in module for use with any PC controller model

PCM-900 – 9 station plug in module for use with any PC controller model (expands Pro-C station capability to 15 stations with 1 PCM-300 installed)

Additional Features

- 4 start times per program for repeat watering needs
- Removable front panel for field or desktop programming; Panel interchangeable between indoor and outdoor units
- Up to six hours run time on all stations
- Automated chronological ordering of start times/start time stacking
- 365-day calendar with leap year intelligence
- Programmable event day off allows specific day(s) to be designated as always “off”
- Rain Sensor bypass switch compatible with micro-switch based sensors, displays when sensor is active
- Programmable delay between stations 0-4 hours for well recovery or slow-closing valves
- Programmable rain delay for 1-7 days
- Compatible with Hunter’s SRR and ICR remote control systems
- Upgradeable to central control with Hunter IMMS™

SPECIFICATION GUIDE

EXAMPLE: **PC - 300i**

MODEL	FEATURES
PC = Pro-C Controller	**300i** = 3-Station Base Unit Controller, Indoor Model, Plug-in Transformer, Expands to 15 Stations **300** = 3-Station Base Unit Controller, Outdoor Model, Internal Transformer, Expands to 15 Stations
PCM	**300** = 3-Station Plug-in Module for use with any PC Controller Model **900** = 9-Station Plug-in Module for use with any PC Controller Model

INSTALLATION

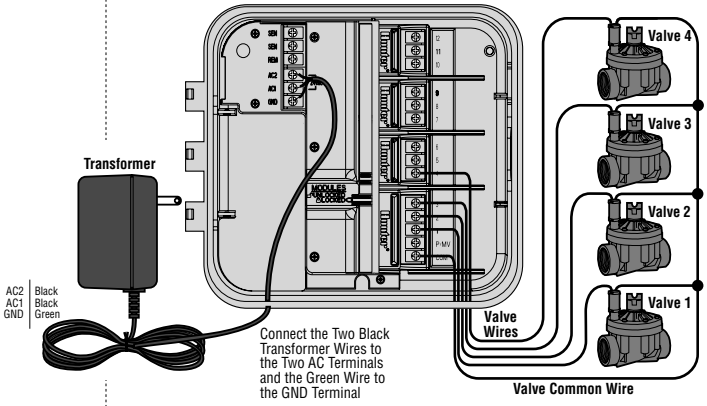
Connecting Valves and AC Power

1. Route valve wires between control valve location and controller.
2. At valves, attach a common wire to either solenoid wire of all valves. This is most commonly a white colored wire. Attach a separate control wire to the remaining wire of each valve. All wire splice connections should be done using water-proof connectors.
3. Open hinged faceplate on the controller to access the terminal strip area.
4. Route valve wires through the conduit and attach conduit to the controller at the large conduit opening on the right side of the bottom of the cabinet.
5. Strip ½" (13 mm) of insulation from ends of all wires. Secure valve common wire to C (Common) terminal on the first module. Then attach all individual valve control wires to appropriate station terminals.

> Note: It is recommended that a licensed electrician perform the following power installation.

Indoor Cabinet

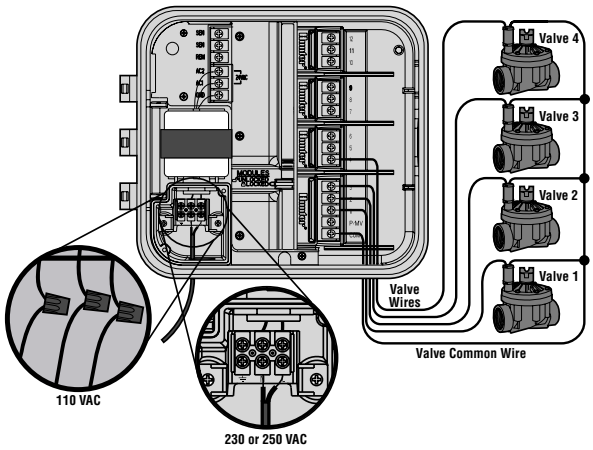
Route transformer cable through the left side of the controller and connect the wires to the screws marked **AC**. Before closing the compartment door make sure wires hang in the slotted areas so that the door can snap shut without damaging wires.



Outdoor Cabinet

Route **AC** power cable and conduit through the ½" (13 mm) conduit opening on the left side of the bottom of the cabinet. Connect the wires to the transformer wires located inside the junction box. International units are supplied with a built in terminal strip. Always use a UL listed conduit ½" (13 mm) male adapter when installing the **AC** wiring. Insert the adapter (male threads first) into the ½" hole at the bottom of the controller until it enters the wiring enclosure. Attach the nut to the adapter inside the enclosure.

> NOTE: It is usually best to connect all field wires prior to powering up the computer.



INSTALLATION *(continued)*

Connecting Station Modules

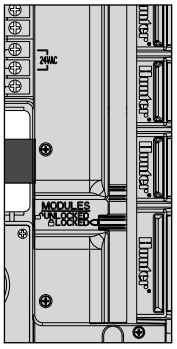
The Pro-C controller is supplied with a factory-installed base module for up to 3 stations. Additional modules may be added in increments of 3 stations (PCM-300) or a single 9-station (PCM-900) to expand the controller's station capability to 15 stations. Additional modules are sold separately.

Note: The use of a PCM-900 to expand your controller to 15 stations requires that one PCM-300 be installed in the first slot (stations 4-6) and the PCM-900 in the upper two slots.

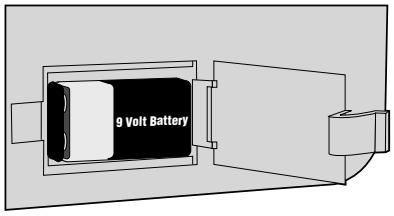
The Pro-C utilizes automatic module recognition firmware (Pro-C controllers manufactured Nov. 2003 and after) to identify when PCM modules are installed or removed from the controller. This feature will recognize the correct number of stations without having to reset or cycle power to the controller.

The Pro-C controller is designed with a simple to use Easy-Lock™ feature that assures that the modules are firmly secured into the controller. The Easy-Lock can lock or unlock all modules at one time by simply pushing the Easy-Lock slide.

Note: The Easy-Lock feature was added to Pro-C controllers dated coded 12/01/02 or newer.



1. Slide the Easy-Lock into the unlock position. Insert the module(s) into the appropriate sequential position in the back of the controller.
2. Once all of the modules are in place, slide the Easy-Lock into the locked position to secure all the modules into the controller.
3. The Pro-C will automatically recognize the correct number of stations. It is not necessary to press the reset button or cycle the power to the controller.



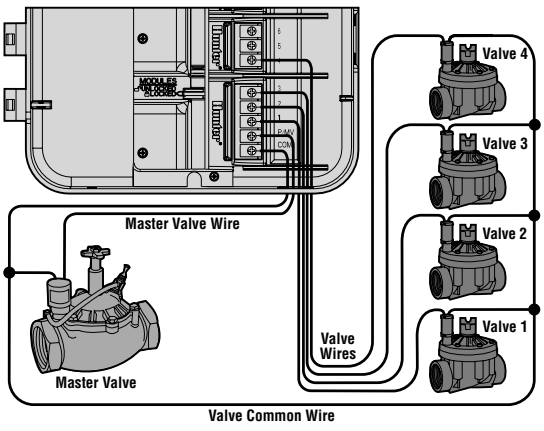
Connecting the Battery (Optional)

Connect a 9-volt **alkaline** battery (not included) to the battery terminals and place in the battery compartment in the controller cabinet. The battery allows the user to program the controller without **AC** power. Watering will not occur without **AC** power. Since this controller has non-volatile memory, the program clock and calendar will be retained during a power outage even if no battery is installed.

> NOTE: Complete this section only if you have a master valve installed. A master valve is a normally closed valve installed at the supply point of the main line that opens only when the automatic system is activated.

Connecting a Master Valve

1. At the Master Valve, attach the common wire to either solenoid wire of the valve. Attach a separate control wire to the remaining solenoid wire.
2. Route the wires into the controller via the field wire conduit.
3. Connect either wire from Master Valve to the **P/MV** terminal. Connect remaining wire to the **C** (Common) terminal.



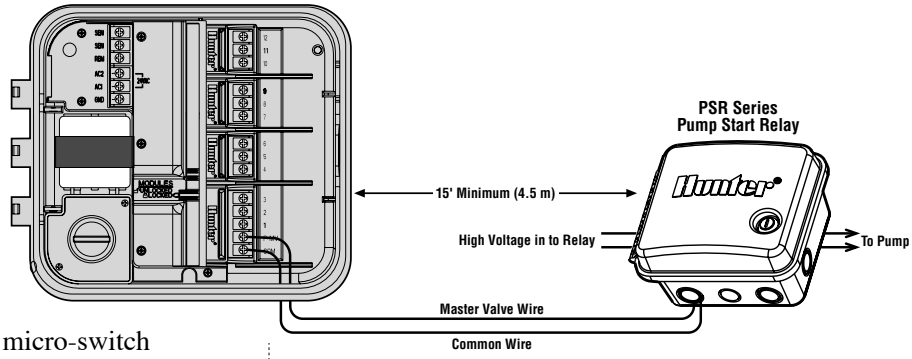
NOTE: Complete this section only if you have a pump and pump start relay installed. A pump start relay is an electronic device that uses a signal current from the irrigation controller to activate a pump to provide water to your system.

Connecting a Pump Start Relay

The controller should be mounted at least 15 feet (4.5 m) away from both the pump start relay and the pump. When a pump is to be operated by the controller, a pump start relay must be used. Hunter offers a full range a pump start relays for most applications.

1. Route a wire pair from the pump relay into the controller housing.
2. Connect a common wire to the terminal slot **C** (Common) and the remaining wire from the pump relay to the **P/MV** screw slot.

Relay holding current draw must not exceed .28 amps. Do not connect the controller directly to the pump—damage to controller will result.

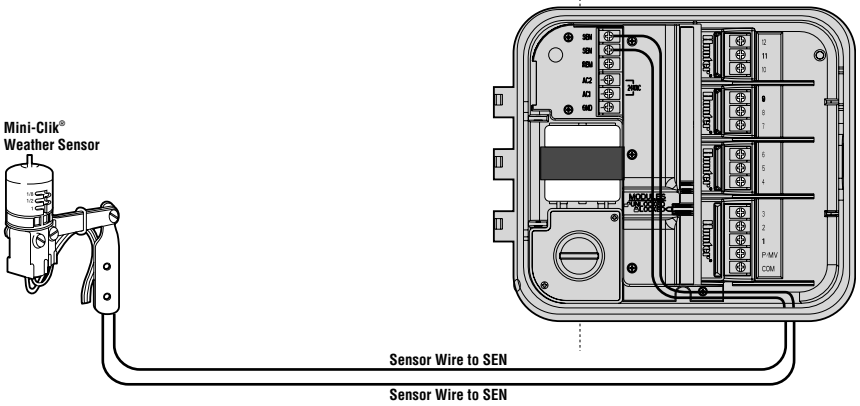


Connecting a Weather Sensor (Not Included)

A Hunter Mini-Clik® rain sensor or other type of micro-switch weather sensor may be connected to the Pro-C. The purpose of this sensor is to stop watering when precipitation is sufficient. The sensor connects directly to the controller and allows you to easily override the sensor by using the Rain Sensor bypass switch on the controller.

NOTE: If the rain sensor switch is left in the ACTIVE position and no sensor is connected and the jumper has been removed, the display will read SEN OFF and no irrigation will occur. To eliminate this problem when no sensor is connected, leave the switch in the BYPASS position or install a short jumper wire between the sensor terminals.

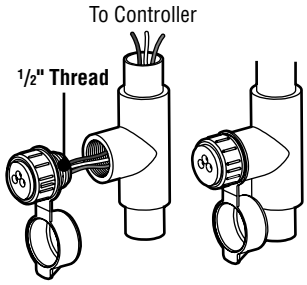
1. Route the wires from the rain sensor up through the same conduit used for valve wiring.
2. Remove the jumper from the two SEN terminals.
3. Connect one wire to the SEN terminal and one to the other SEN terminal on the power module.



INSTALLATION *(continued)*

Connecting an SRR or ICR Remote Control (Not Included)

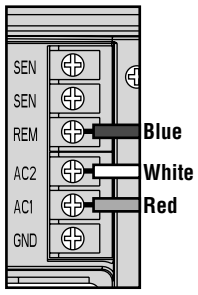
The Pro-C controller is shipped with a SmartPort® wiring harness, allowing for fast and easy use of Hunter remote controls. The remote makes it possible for contractors and end users alike to operate a system without having to walk back and forth to the controller.



Pre-assembled *Assembled*

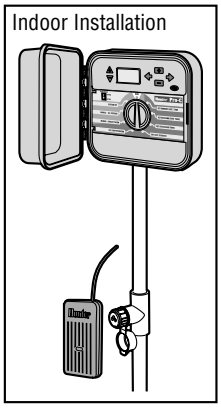
To utilize the SRR or ICR Remote Control System you must install the SmartPort® outlet.

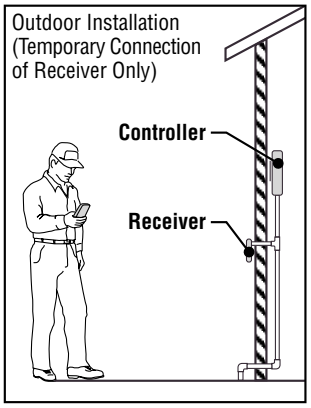
1. Install a ½" female threaded "Tee" in the field wiring conduit approximately 12" below the Pro-C.
2. Feed the red, white, and blue wires of the harness through the base of the "Tee" and into the wiring compartment as shown in Fig. 1.
3. Screw the SmartPort harness housing into the "Tee" as shown in Fig. 1.
4. Access the terminal strip area and attach the red wire to the bottom most **AC** screw slot, attach the white wire to the upper **AC** screw slot and attach the blue wire to the screw slot marked **REM**.



The SmartPort is now ready for SRR or ICR remote control use. Please refer to the Owner's Manual for further information or contact your local Hunter distributor for ordering information.

NOTE: Any extension of the wiring on the SmartPort® may result in an error message in the controller display and possible malfunction of the remote unit due to radio interference. In some situations, lengthening of the harness may work fine, in others it may not work at all (it is site specific). In either case, extending the wiring harness should be done using shielded cable to minimize the possible effects of electrical noise. For easiest installation, order a new Hunter SmartPort shielded cable wiring harness (part #SRR-SCWH) with a full 25 feet of shielded cable.





Power Failures

Due to the possibility of power failures, the controller has non-volatile memory to preserve the clock, calendar, and program indefinitely. There is no default program so there will be no surprise watering.

PROGRAMMING

Programming the Controller

Two key features of the Pro-C that make programming a snap are its clear, easy-to-read LCD display and its easy-to-use dial design.

The Pro-C display shows time and day when the controller is idle. The display changes when the dial is rotated to indicate the specific programming information to enter. When programming, the flashing portion of the display can be changed by pressing the + or − buttons. To change something that is not flashing, press ◄ or ► until desired field is flashing.

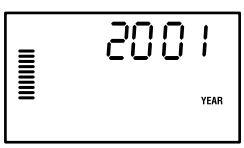
The Pro-C controller offers maximum scheduling flexibility including three programs, each with up to 4 daily start times, permitting plants with different watering requirements to be separated on different day schedules. Multiple start times permit morning, afternoon and evening watering, perfect for the establishment of new lawns and thirsty annual flowers. A built in 365-day calendar clock accommodates odd/even watering restrictions without requiring monthly reprogramming. Or, just simply designate the days of the week you want to water or use the convenient day interval watering.

> NOTE: A basic programming rule is that whatever symbol or character is flashing will be the item programmed. For instance, if the hour is flashing when setting the time, the hour can be changed or programmed. For illustration purposes, flashing characters are in Gray type.

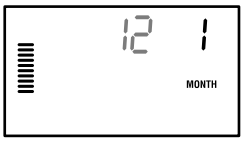
Setting the Current Date and Time

1. Turn the dial to the **SET CURRENT DATE/TIME** position.

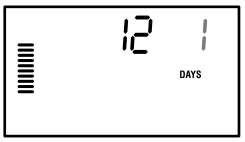
2. The current year will be flashing in the display. Use the + and − buttons to change the year. After setting the correct year, push the ► button to proceed to setting the month.



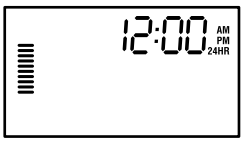
3. The month and day will be in the display. The month will be flashing. Use the + and − buttons to change the month. Press the ► button to proceed to setting the day.



4. The day will be flashing: Use the + and − buttons to change the day of the month (The day of the week is automatically selected.) Press the ► button to proceed to setting the time.

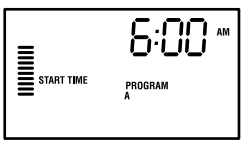


5. The time will be displayed: Use the + and − buttons to select AM, PM, or 24 hr. Press the ► button to move to hours. Hours will be flashing. Use the + and − buttons to change the hour shown in the display. Press the ► button to move onto minutes. Minutes will be flashing. Use the + and − buttons to change the minutes shown in the display. The date, day, and time have now been set.



Setting Watering Start Times

1. Turn the dial to the **SET WATERING START TIMES** position.
2. The factory preset is set on program A. If necessary you can select program B or C by pressing the PRG button.
3. Use the + and − buttons to change the start time. (Advances in 15-minute increments.) *One start time will activate all stations sequentially in that program*. This eliminates the need to enter a start time for each station. Multiple start times in a program can be used for separate morning, afternoon, or evening watering cycles.

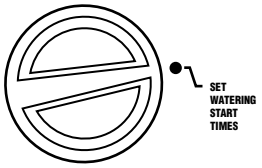


PROGRAMMING *(continued)*

4. Turn the dial to **SET STATION RUN TIMES** to continue programming the selected program.
5. Press the ➔ button to add an additional start time, or PRG for the next program.

> NOTE: Regardless of the order in which the start times are entered, the Pro-C will always arrange the start times in chronological order when the dial is moved off the SET WATERING START TIMES position.

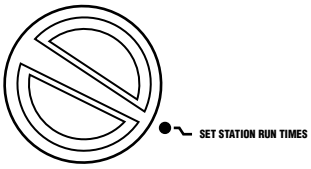
Eliminating a Program Start Time



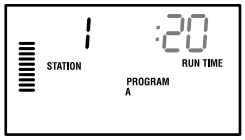
With the dial set to the **SET WATERING START TIMES** position, push the + and − buttons until you reach 12:00 a.m. (Midnight). From this position push the − button once to reach the **OFF** position.

> NOTE: If a program has all four start times turned off, then that program is off (all other program details are retained). Because there are no start times, there will be no watering with that program. This is a convenient way to stop watering on one program only without turning the dial to the off position.

Setting Station Run Times (Length of Watering for Each Area)

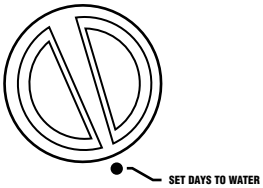


1. Turn the dial to the **SET STATION RUN TIMES** position.
2. The display will show the last program selected (**A**, **B**, or **C**) the station number selected, and the run time for that station will be flashing. You can switch to another program by pressing the PRG button.
3. Use the + and − buttons to change the station run time on the display.
4. Press the ➔ button to advance to the next station.
5. Repeat steps 4 and 5 for each station.



6. You may set station run times from 1 minute to 6 hours.
7. You can move between programs while staying on the same station. However, it is recommended that one program is completed before going on to the next program. Jumping between programs can be confusing and may result in program errors.

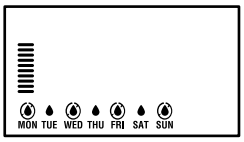
Setting Days to Water



1. Turn the dial to the **SET DAYS TO WATER** position.
2. The display will show the last program selected (**A**, **B**, or **C**) the station number selected, and the run time for that station will be flashing. You can switch to another program by pressing the PRG button.
3. The controller displays currently programmed active day schedule information. This dial position provides four different water day options: choose to water on specific days of the week, you can choose interval watering, or choose to water on odd days or even days. Each program can only operate using one type of water day option.

Selecting Specific Days of the Week to Water

1. Press the Press the + button to activate a particular day of the week to water (the display always starts with Monday). Press the − button to cancel watering for that day. After pressing a button the display automatically advances to the next day. A ♦ indicates a water day. A ◉ indicates a no water day.



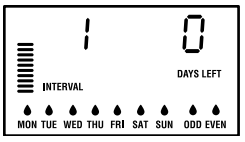
2. Repeat step 1 until desired days have been selected.

After programming, set dial to **RUN** to enable automatic execution of all selected programs and start times.

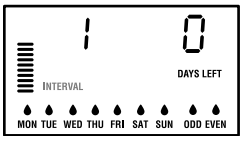
Selecting Interval Watering

This feature is convenient if you want to have a more consistent watering schedule without having to worry about the day of the week or the date. The interval you select is the amount of days between watering. The days remaining indicates how many days until the next watering. For example if you select an interval of 2 with 1 days remaining, watering will begin tomorrow at the scheduled time.

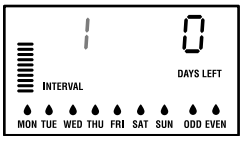
1. With the cursor on Sunday, press the ➔ button. Interval days left, Odd and Even will appear in the display.



2. Interval is flashing press the + button. The display will increment the interval.



3. Press ➔ , the number of days will be flashing. Use the + and − buttons to select the number of days left until the next watering.

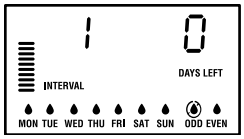


After programming, set dial to **RUN** to enable automatic execution of all selected programs and start times.

Selecting Odd or Even Days to Water

This feature uses a numbered day of the month for watering instead of specific days of the week (odd days 1st, 3rd, 5th, etc.; even days 2nd, 4th, 6th, etc.).

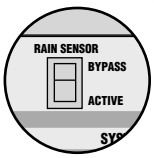
1. Using the instructions for **Interval Watering**, set the interval to one.
2. Press the ➔ button until the cursor is on either **EVEN** or **ODD** in the display. Select whichever you choose as **No Water Days**. If you select **ODD** as **No Water Days**,then the controller will only water on even days of the month. Conversely, if you select **EVEN** as **No Water Days** then the controller will only water on odd days of the month.



> ⚠ NOTE: The 31st of any month and February 29th are always “off” days if Odd watering is selected.

After programming, set dial to **RUN** to enable automatic execution of all selected programs and start times.

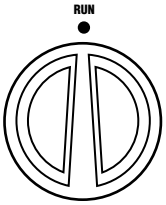
Weather Sensor Bypass



With this built-in feature, there is no need for an additional manual bypass switch when using rain sensors (the Pro-C works with the Hunter Mini-Clik®, plus some other rain, wind, and freeze sensors on the market today). If the system is preventing system operation (or no sensor is installed and the switch is in the **ACTIVE** position), **SENSOR OFF** will be displayed. Simply move the switch to **BYPASS** and the weather sensor will be bypassed. This allows you to use the system.

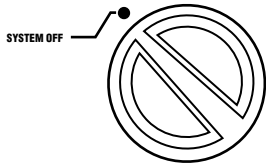
PROGRAMMING *(continued)*

Run



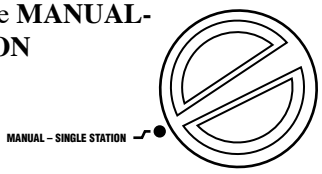
After programming is complete, turn the dial to **RUN** to enable automatic execution of all selected programs and start times. **Watering will not occur unless dial is in the RUN position.**

System Off

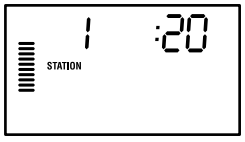


Valves currently watering will be shut off after the dial is turned to the **SYSTEM OFF** position for two seconds. All active programs are discontinued and watering is stopped. To return controller to normal automatic operation, simply return dial to **RUN** position.

Manually Run a Single Station

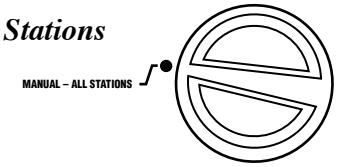


1. Turn the dial to the **MANUAL-SINGLE STATION** position.
2. Station run time will flash in the display. Use the ➡ button to move to the desired station. You may then use the ➕ and ➖ buttons to select the amount of time for a station to water.

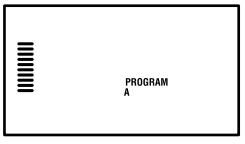


3. Turn the dial to the **RUN** position to run the station (only the designated station will water, then controller will return to automatic mode with no change in the previously set program).

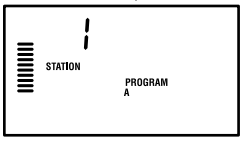
Manually Run All Stations



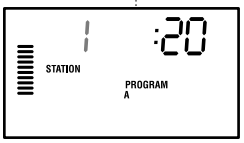
1. Turn the dial to **MANUAL-ALL STATIONS**.
2. You can select program **A**, **B**, or **C** by pressing the PRG button.



3. Press the ➡ button until desired starting station is displayed.
4. Station run time will flash in the display. Use the ➕ and ➖ buttons to select the amount of run time for the station to water if different from the run time displayed.



5. Use the ➡ button to move to the next station.



6. Repeat steps 3 and 4 to customize each station if desired.
7. Press the ➡ button until desired starting station is displayed.
8. Return the dial to **RUN** (custom program will water the entire program beginning with the station number last left in the display, then controller will return to automatic mode with no change in the previously set program).

> ⚠ NOTE: The station that is on the display when you turn the dial to RUN, will be the first station to run. The controller will then proceed to water in sequential order only. It will not water previous stations.

One Touch Manual Start and Advance

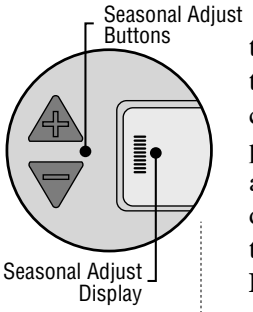
You can also activate all stations to water without using the dial.

1. Hold down the ➡ button for 2 seconds.
2. This feature automatically defaults to program **A**. You can select program **B**, or **C** by pressing the PRG button.
3. The station number will be flashing. Press the ⬅ or ➡ button to scroll through the stations and use the ➕ and ➖ buttons to adjust the station run times. (If no buttons are pressed during step 2 or 3, the controller will automatically begin program **A**.)
4. Press the ➡ button to scroll to the station you wish to begin with. After a 2 second pause, the program will begin.

This feature is great for a quick cycle when extra watering is needed or if you would like to scroll through the stations to inspect your system.

Seasonal Adjustment

Seasonal Adjust is used to make global run time changes without re-programming the entire controller. This feature is perfect for making small changes that are necessary as the weather changes without reprogramming the entire controller. For instance, hotter times of the year may require a bit more water. Seasonal adjust can be increased so that the stations will run longer than the programmed time. Conversely, as Fall approaches, the seasonal adjust can be reduced to allow for short watering durations.



To use the seasonal adjust, simply press the up or down seasonal adjust buttons to set the percentage desired. Each bar on the graph can be adjusted from 10% to 150% of original program. The season adjust can be changed at any time regardless of the programming dial position. To view the new adjusted run time, simply turn the rotary dial to the **Set Run Times** position, the displayed run time will be updated accordingly as the seasonal adjustment is made.

> NOTE: The controller should always be initially programmed in the 100% position.

Test Program

You can activate all stations for a set number of minutes.

1. Hold the PRO button for 2 seconds.
2. Station run time will flash in the display. Use the + or − buttons to select the amount of run time from 1 to 15 minutes.
3. After a 2 second pause the test program will run each station for the set run time.

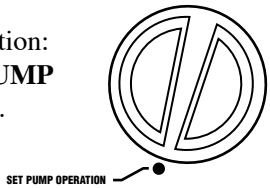
This feature is great for a quick system check or to activate valves during winterization.

Advanced Features

There are three advanced features available to customize the Pro-C to more complex watering requirements. One of these features is “hidden” to make accidentally programming them nearly impossible.

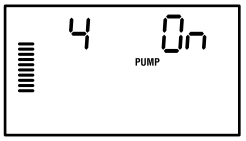
1) Set Pump/Master Valve Operation

The default is for all stations to have the master valve/pump start circuit **ON**. The master valve/pump start can be set **ON** or **OFF** by station, regardless of which program the station is assigned. This feature may be utilized on systems where it is desirable for a booster pump not to operate with certain zones.



To program pump operation:

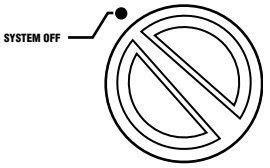
1. Turn the dial to **SET PUMP OPERATION** position.
2. Press the + or − buttons to toggle the master valve/pump start **ON** or **OFF** for the specific station.



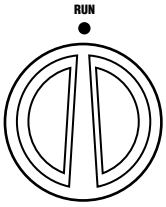
3. Press the ➔ button to advance to the next station.
4. Repeat steps 2 and 3 for all necessary stations.

2) Programmable Rain Off

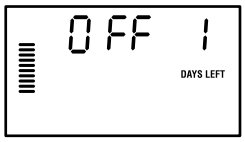
This feature permits the user to stop all programmed waterings for a designated period from 1 to 7 days. At the end of the programmable rain off period, the controller will resume normal automatic operation.



1. Turn the dial to the **SYSTEM OFF** position.
2. Press the + button and a 1 will be displayed and the **DAYS LEFT** icon will illuminate. The 1 will be blinking at this point.
3. Press + as many times as needed to set the number of days off desired (up to 7).
4. To validate this setting (and to make sure the controller comes back on after the period is over), turn the dial back to the **RUN** position at which time, **OFF**, a number and the **DAYS** icon all remain on.



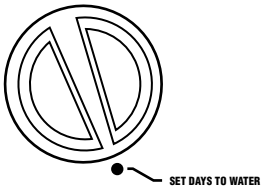
PROGRAMMING *(continued)*



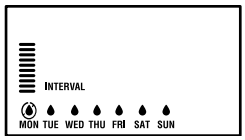
5. Leave the dial in the **RUN** position. The days off remaining will decrease at midnight of each day. When it goes to zero, the display will show the normal time of day and normal irrigation will resume at the next scheduled start time.

3) Setting Event Day(s) Off

Programming in a No Water Day(s) is useful to inhibit watering on mowing days, etc. For instance, if you always mow the lawn on Saturdays you would designate Saturday as a **No Water Day** so you are not mowing wet grass.



1. Turn the dial to the **DAYS TO WATER** position.
2. Press ➔ until the cursor has moved to Monday, following the interval setup.

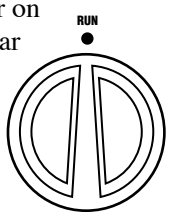


3. Press ➔ to select the day(s) you would like off.
4. Press ▬ to turn the day off. Days off will be indicated by 💧.
5. Repeat steps 3 and 4 until all desired event day(s) are off.

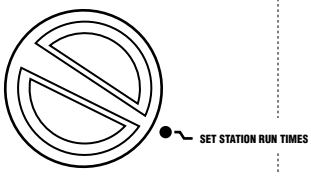
Hidden Features

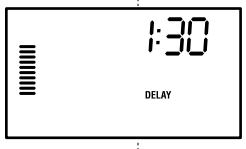
1) Programmable Delay Between Stations

This feature allows the user to insert a delay between when one station turns off and the next station turns on. This is very helpful on systems with slow closing valves or on pump systems that are operating near maximum flow or have slow well recovery.

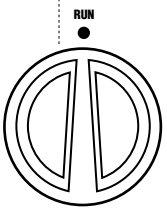


1. Start with the dial in the **RUN** position.
2. Press and hold the ▬ button down while turning the dial to the **SET STATION RUN TIMES** position.





3. Release the ▬ button. At this point the display will show a delay time for all stations in seconds, which will be blinking. The **DELAY** icon shall also be lit at this time.
4. Press the ✚ and ▬ buttons to increase or decrease the delay time between 0 and 59 seconds in 1 second increments and then in one minute increments up to four hours. **HR** will be displayed when the delay changes from seconds to minutes and hours.
5. Return the dial to the **RUN** position.



> ⚠ NOTE: The Master Valve/Pump Start circuit will operate during the first minute of any programmed delay to aid in the closing of the valve and to avoid unnecessary cycling of the pump. It is recommended that a pressure relief valve be installed on the system should this one minute be too long for a particular system. Consult your pump contractor or supplier for details.

2) Clearing Controller's Memory/ Resetting Controller

If you feel that you have misprogrammed the controller, there is a process that will reset the memory to factory defaults and erase all programs and data that have been entered into the controller. Press the ➔, ▬ and PRG and hold them down simultaneously. Press and release the reset button then release the ➔, ▬ and PRG buttons. Time display should show 12:00 a.m. All memory has been cleared and the controller may now be reprogrammed.

3) Hunter Quick Check™

Irrigation professionals are continuously looking for ways to more efficiently and effectively diagnose programs in the field. Instead of having to physically check each field wiring circuit for potential problems, the user can run the Hunter Quick Check circuit test procedure. This circuit diagnostic procedure is very beneficial because of its ability to aid in quickly identifying "shorts" commonly caused by faulty solenoids or when a bare common wire touches a bare station control wire.

To initiate the Hunter Quick Check test procedure; Press the +, −, ← and → buttons simultaneously. In the standby mode, the LCD will display all segments (helpful when troubleshooting display problems). Press the + button to begin the Quick Check test procedure. Within seconds, the system searches all stations in an effort to detect a high current path through the station terminals.

When a field wiring short is detected, an ERR symbol preceded by the station number will momentarily flash on the controller LCD display. After the Hunter Quick Check completes running this circuit diagnostic procedure, the controller returns to the automatic watering mode.

TROUBLESHOOTING GUIDE

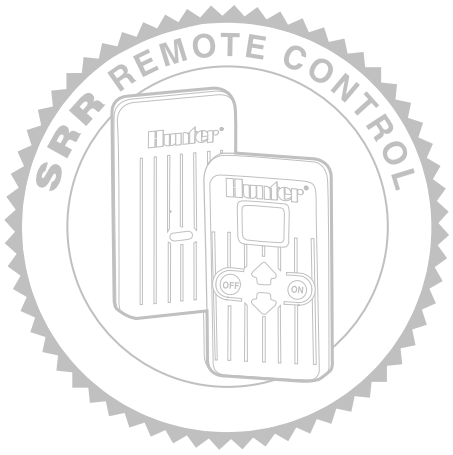
PROBLEM	CAUSES	SOLUTIONS
There is no display.	Check AC power wiring.	Correct any errors.
The display reads "ERR".	Electrical noise is entering the system.	Check the SmartPort® wiring harness. If the wires were extended then they will need to be replaced with shielded cable. Contact your local distributor for information on shielded cable.
The display reads "P ERR".	There is a ground fault in the wire to the pump start or master valve.	Check the master valve or pump start wire for continuity. Replace or repair the broken wire. Check that all wire connections are good and water tight.
The display reads a station number and ERR, such as "2 ERR".	There has been a ground fault with the wire leading to that station.	Check the station wire for continuity. Replace or repair broken wire. Check that all wire connections are good and water tight.
The display reads "NO AC".	There is no AC power present.	Check to see if the transformer is properly installed.
The display reads "SENSOR OFF".	The rain sensor is interrupting irrigation or not installed.	Slide the Rain Sensor switch on front panel to the **BYPASS** position to bypass rain sensor circuit.
Rain sensor will not shut off system.		Make sure sensor is micro-switch type such as Mini-Clik®. Rain Bird®, Rain Check™ is not this type and will not work. Check that the the jumper has been removed from the **SEN** terminals.
The controller recognizes 15 stations all the time.		Make sure AC power is connected. Reset controller using method described on page 24.
The controller does not respond to all stations. Example, the controller has 12 stations but the display will only go to 6 stations.	Controller does not recognize modules.	Turn off the power to the controller and remove the battery. Check all module connections to the controller. Power the controller back up. The microprocessor will recognize all modules.

PRODUCT OVERVIEW

Hunter is pleased to introduce the SRR – a Simple and Reliable Remote Control for use with our Pro-C, ICC and SRC controllers. The SRR can offer the installer features that other remotes can't, at a price that can't be beat.

How often does a contractor have to walk back to the controller to start or stop a manual watering cycle when doing new installation or maintenance on a landscape project? How difficult and costly is it to winterized an irrigation system with two workers instead of one? How time consuming is it to keep returning to the controller to start or stop a manual cycle?

Now it's no trouble at all, with the Hunter SRR! Plus, the contractor can leave the SRR remote with the property owner, allowing the homeowner or building manager to remotely activate a manual watering without the need to visit the controller. The SRR is the simplest, most reliable remote control available.



PRODUCT FEATURES AND BENEFITS

One Transmitter, One Receiver Does the Job

Portable and reusable at every location

With the SRR, a contractor can visit one site, attach the receiver to the SmartPort® wire harness at the controller, complete the irrigation operations, remove the receiver and travel on to the next job. Or the receiver can be left permanently mounted, if desired, to permit operation by the homeowner or building manager.

Internal Antenna on Transmitter

Out of sight, out of mind

The SRR's transmitter has no external antenna that can be broken or lost.

Large LCD Display and Four-Button Operation

Easy to view and a snap to operate

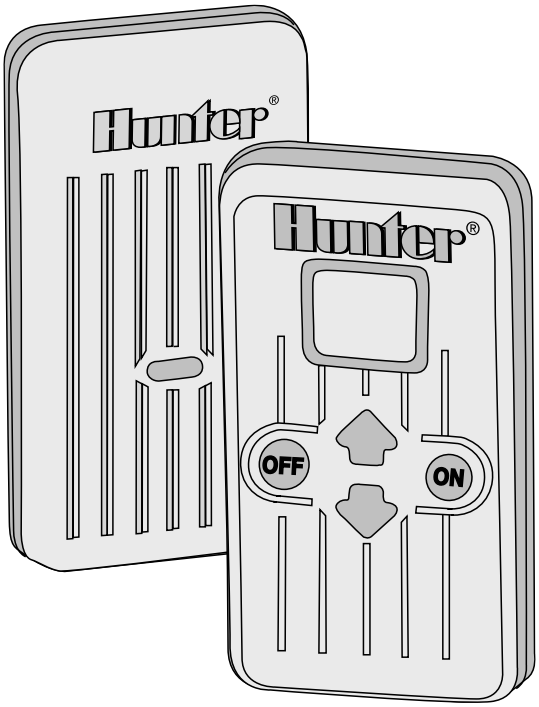
Simply press the ▲ and ▼ buttons to display the station or program that is desired, then press the "ON" or "OFF" buttons. After several minutes of inactivity, the SRR turns itself off to extend battery life. It can be reactivated by touching any button.

Sturdy ABS Construction

Tough and rugged for any user

The SRR transmitter and receiver are made of heavy-duty ABS plastic that will withstand the toughest conditions and repeat uses.

SRR Remote Control



Small and Compact Size
Slips into shirt or pants pocket

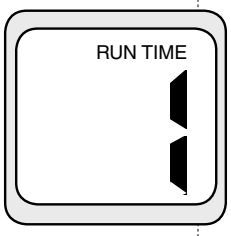
Both the transmitter and receiver are small enough to fit into the palm of your hand. And because they are so compact, they can be easily transported in a shirt or pants pocket during daily uses.

Standard 9V Alkaline Battery
Easy to purchase and lasts a long time

Any convenience, hardware or building supply store carries standard 9V alkaline batteries.

8 Different Remote-Activated Run Time Settings
Quick or lengthy, for total versatility

The SRR can be programmed for 8 different run time remote-activated settings (1, 2, 5, 10, 15, 20, 25 and 30 minute increments are available) for the many irrigation functions that may be required. The default setting is 10 minutes.



User Programmable Address
Added user security

Both the SRR transmitter and receiver have an “address” that they use when communicating with each other. If the addresses do not match, the receiver will ignore the transmission. The SRR comes from the factory with both addresses set at 0. The transmitter address may be changed to any setting from 0-127 for added security. The receiver will then “learn the address.” The programmable address is useful for areas where multiple homes or buildings are utilizing SRR remotes.

Programmable Number of Stations Controlled
Customize the remote to the number of stations on the controller

The SRR is fully reprogrammable and can access up to 48 stations, allowing for increased flexibility as well as use with future controller products.

INSTALLATION AND PROGRAMMING

SmartPort® Wiring Harness

Preparing the Communication Port

To utilize the SRR Remote Control System, your Hunter controller must be equipped with the SRR SmartPort wiring harness. This wiring harness provides the communication port where the SRR receiver is attached. The SmartPort installation instructions are included in the Pro-C installation and programming instructions. Additional wiring harnesses can be purchased separately to allow you to utilize the transmitter and receiver with additional controllers.

Installing the SRR Remote Wiring Harness

1) Install a ½" female threaded "Tee" in the field wiring conduit approximately 12" below the Pro-C controller.

Note: The harness may be installed outdoors by first bringing the conduit through an exterior wall, then installing the appropriate fitting.

2) Feed the red, white and blue wires of the harness through the base of the "Tee" and into the controller wiring compartment as shown in Figure 1.

3) Screw the harness housing into the "Tee" (or other fitting) as shown in Figure 1.

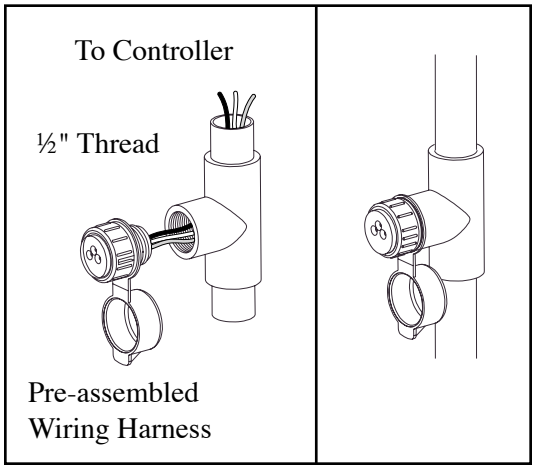


Fig. 1

4) Attach the red, white and blue wires from the harness to the terminal block of the controller as shown in Figure 2.

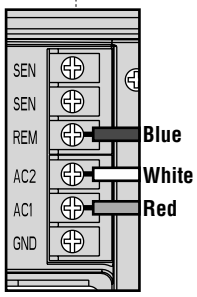
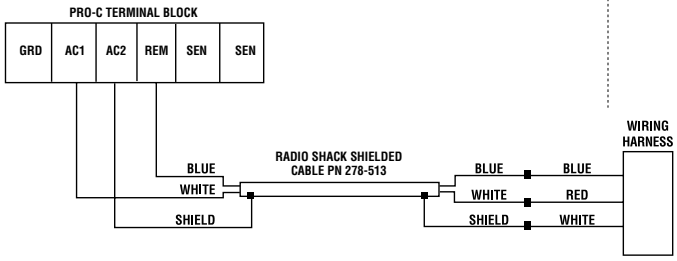


Fig. 2

Extending the Wiring Harness

Any extension of the wiring on the harness may result in an error message in the controller display and possible malfunction of the remote unit due to radio interference. In some situations, lengthening of the harness may work fine, in others it may not work at all (it is site specific). In either case, extending the wiring harness should be done using shielded cable (Radio Shack P/N 278-513) to minimize the possible effects of electrical noise. See diagram below.

Proper Extension of Wiring Harness Using Shielded Cable



Transmitter

Preparing the Transmitter for Use

Your SRR System is designed to work right out of the box. This means that other than installing the battery, you may chose to skip this entire section. However, we recommend you read it because with a few simple steps you can customize your SRR to add functionality and security to your system. Be aware that if you change your transmitter address or maximum station number as described below, you should make a note of the new settings, since when the battery is removed and a new one installed, the transmitter will revert back to the original settings.

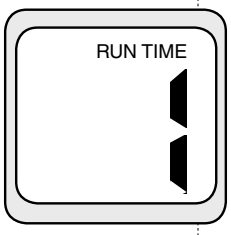
Installing the Transmitter Battery

Your SRR Transmitter requires a 9V alkaline battery. To install the battery, slide open the battery door (on the back of the transmitter), attach the battery to the clip, insert the battery, and slide the door shut again. (When changing the battery, push the battery down in the case to reveal the battery clip before attempting to remove the battery from the case.)

Changing the Transmitter Address

Both the SRR Transmitter and Receiver have an "address" that they use when communicating. If the addresses do not match, the Receiver will ignore the transmission. Your SRR comes from the factory with both Transmitter and Receiver address set to 0. You may change the address to any value from 0-127 for added security. Note that if you change the Transmitter address, the Receiver must "learn" the new address as described in "Preparing the Receiver for Use" section.

To change the Transmitter address follow the steps below:



1. If the unit is **OFF** (no display), power the Transmitter by pressing any of the buttons for at least 1 second then releasing the button. The Transmitter will first illuminate the entire display for 1 second then display the active station.
2. Simultaneously press the ▲ and ▼ buttons, until the word "RUN TIME" along with the current Run Time is displayed. The display will be blinking at this point.
3. While the display is blinking and showing the current Run Time, Press the "ON" button. The word "ADDRESS" will now illuminate and the current address will be blinking. Note that if more than 5 seconds go by without a button being pressed, the Transmitter will revert back to displaying the active station.
4. Use the ▲ and ▼ buttons to change the address to any value between 0 and 127. Then do not touch any of the buttons for 5 seconds and the display will stop blinking, and return back to the active station.

Receiver

Preparing the Receiver for Use

As stated earlier, your SRR System is designed to work right out of the box. If you have decided to change your Transmitter address as described in the previous section, you must allow the Receiver to "learn" this new address. Once learned, the only way to remove the address from Receiver memory is to learn a different address. This can be done by following the simple steps outlined below.

Changing the Receiver Address

1. Hold down the single button on the face of your Receiver while you are plugging it into an active wiring harness (one connected to a powered controller). When this is done, the Receiver will beep 4 times.
2. After the Receiver starts to beep, release the button.
3. Press either the "ON" or "OFF" button of your Transmitter.
4. The Receiver will beep 4 additional times indicating that it has learned the new Transmitter address and will respond only to it from this point on.

INSTALLATION AND PROGRAMMING *(continued)*

Run Time

You have the ability to adjust the amount of time that a station will run once it has been turned on by your SRR System. This does not affect the run time programmed into your controller. This adjustment is made at the transmitter as described below.

To change the Run Time follow the steps below:

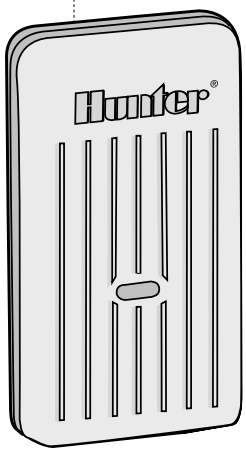
1. If the unit is **OFF** (no display), power the transmitter up by pressing any of the buttons for at least 1 second then releasing the button. The transmitter will first illuminate the entire display for 1 second then display the active station.
2. Simultaneously press the ▲ and ▼ buttons, until the word "RUN TIME" along with the current Run Time is displayed (default is 10 minutes). The display will be blinking at this point. If more than 5 seconds go by without a button being pressed, the Transmitter will revert back to displaying the active station.
3. Use the ▲ or ▼ buttons to change the Run Time to any of 8 settings ranging from 1 to 30 minutes. Then do not touch any of the buttons for 5 seconds and the display will stop blinking, and return back to the active station.

Activating a Station with the SRR Remote Control System

The SRR System will allow you to remotely turn on and off any station on your Pro-C controller with the press of a button. Once on, the station will run for the run time you have designated in the remote.

To remotely activate a station or program follow the steps below:

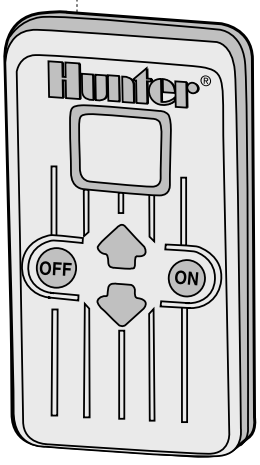
1. Plug the Receiver into an active wiring harness (one attached to a powered controller) and wait for 2 beeps indicating that the Receiver is ready.
2. If your Transmitter is not on (no display), press any button for at least 1 second and release. The Transmitter will first illuminate the entire display, then display the active station.
3. Use the ▲ or ▼ buttons to display the station or program you would like to start.
4. Momentarily press the "ON" button to start the station or program. The Transmitter will display the word "TRANSMIT" and will flash for about 4 seconds indicating that it is sending the command to the Receiver. If you are near the Receiver, you will hear it beep 2 times, indicating that it has received the command.
5. Press the "OFF" button to turn off any station that is on. The display will again read "TRANSMIT" and flash, and the Receiver will again beep twice. The SRR System is designed to turn one station on at a time. Therefore, turning a station on while another station is already on will cause the first station to turn off.



Receiver Unit

Note: The SRR remote can activate any station on the controller whether the controller dial is in the "System Off", "Run" or any other position.

If a sensor device has been wired to the controller and the rain sensor switch is in the active position, the SRR remote will not override the sensor for manual operation.



Transmitter Unit

Changing the Maximum Station Number

Your SRR Transmitter comes from the factory with the maximum station number set to 9. This means that when you use the ▲ and ▼ buttons to change the station, you may change it to any number between 1 and 9. However, if you have a 3 or 6-station Pro-C controller, you will not need to access the station numbers above your station count. Likewise, perhaps you own a 12-station Pro-C controller, so in this case you will want to access the stations above 9. The SRR Transmitter allows you to set the maximum

station number as follows:

1. If the unit is OFF (no display), power the Transmitter up by pressing any of the buttons for at least 1 second then releasing the button. The Transmitter will first illuminate the entire display for 1 second then display the active station.
2. Simultaneously press the ▲ and ▼ buttons, until the word "RUN TIME" along with the current Run Time is displayed. The display will be blinking at this point.
3. While the display is blinking and showing the current address, press the "ON" button. The display will continue to blink, but the word "ADDRESS" will be illuminated.
4. Press the "ON" button again. The display will continue to blink, but the word "ADDRESS" will no longer be illuminated.
5. Use the ▲ or ▼ buttons to change the maximum station number to the value you desire. Then, do not press any buttons for 5 seconds and the display will stop blinking and return to the active station number.
6. You may now change the active setting to the new maximum station value.

Maximizing Operating Range

There are many factors which influence operating range. Listed below are a few things you can do to assure you are getting the maximum range possible.

1. Do not install the outlet of the wiring harness (that the Receiver connects to) near large sources of metal such as power meters, water pipes, and aluminum siding.
2. Do not install the outlet of the wiring harness in a basement or underground location. The higher, the better.
3. For maximum range in all directions from the Receiver, the Receiver antenna should be pointed straight up (vertically). If the Receiver is mounted with its antenna oriented horizontally, reception will be very good if the Transmitter is on either side of the antenna, but very poor if it is facing the end of the Receiver antenna.
4. When operating the Transmitter, hold the Transmitter as vertical as possible and turn and face the direction of the Receiver, even if it is several hundred feet away.

A Word About Range

There are many claims being made about the range of various remote control systems, whether they be for auto alarms, garage doors, or irrigation systems for that matter. The published range for the SRR System is up to 450 feet. Most users will achieve this range or more, but a few may not. It is the attempt of this section to educate the user about those factors that influence operating range. We believe that we have achieved the maximum performance available on this frequency.

Here's why

The range of any remote control system is dependent on many factors. These include theterrain at a particular site, obstructions such as buildings and walls, the strength of the various interfering signals, the sensitivity of the Receiver, the ability of the Receiver to reject "unwanted" signals, and the strength of the Transmitter. Since it is impossible to control the obstructions, terrain at a site, and the strength of interfering signals, it is impossible to guarantee an operating range under all conditions. However, we have done everything under our control to maximize the operating range of this system.

The SRR Transmitter has been designed to transmit the maximum power allowed by the FCC. Furthermore, it has special circuitry to assure that this maximum output power is maintained until just before the battery goes dead. Other transmitters emit less and less power as the battery wears down. The Receiver employs a reception method far superior to that used in a typical garage door opener or auto alarm.

The SRR has been designed to give you simple, reliable operation for many years.

TECHNICAL INFORMATION

Models

SRR-KIT - Transmitter, receiver, wiring harness and owners manual

SRR-SCWH - Connection Kit with 25' shielded cable

SRR-TR - Transmitter

SRR-R - Receiver

Dimensions

Transmitter

- Height: 4¾" (12 cm)
- Width: 2½" (6 cm)
- Depth: 1¼" (3 cm)

Receiver

- Height: 4¾" (12 cm)
- Width: 2½" (6 cm)
- Depth: 1" (2.5 cm)

Operating Specifications

- Number of user-set address codes: 128
- Maximum stations supported: 48
- Run times: Eight settings from 1 to 30 min
- Range: Up to 450' (137 m)

Electrical Specifications

- Transmitter: 9V alkaline battery
- Receiver: 24VAC, 0.010 Amps from controller
- Receiver Type: Superheterodyne
- System Operating Frequency: 315 MHz
- Install SmartPort® up to 50 feet from controller (use shielded cable wiring harness)

Hunter Industries Incorporated • The Irrigation Innovators
1940 Diamond Street • San Marcos, California 92078
www.HunterIndustries.com

P/N 700757 LIT-325 10/04

RESIDENTIAL & COMMERCIAL IRRIGATION
Built on Innovation

01 **Easy:** Fast, simple installation for both wired and wireless models

02 **Versatile:** Compatible with most Hunter controllers

03 **Smart:** Shuts down irrigation the moment rain is detected

RAIN-CLIK® SENSORS

Rain-Clik's Quick Response™ Stops Irrigation The Instant Rain Starts To Fall

Most rain-sensing devices work by accumulating a set amount of rainfall before a switch is activated that interrupts the circuit from the controller and shuts off the system. In that "accumulation time", the system will unnecessarily continue to water. This can look especially bad for conservation-conscious municipalities, businesses, and residences. With built-in Quick Response technology, the Hunter Rain-Clik and Wireless Rain-Clik can command a controller to shut off right when it starts to rain. The Rain-Clik can be mounted on an eave or any flat vertical surface like a wall or fence. A gutter mount is also available that allows for easy installation of the Rain-Clik on the edge of a gutter.

Learn more. Visit hunterindustries.com/rainclik for more detailed information.

RAIN-CLIK™ FEATURES & SPECIFICATIONS

Features

- Quick Response™ feature shuts the system off as soon as it starts raining
- Maintenance-free design with 10-year battery life for Wireless Rain-Clik™
- Adjustable vent ring allows for setting of reset delay
- Rugged polycarbonate housing and metal extension arm
- Rain-Clik includes 25 ft of 20 AWG sheathed, two-conductor, UL-approved wire
- Wireless unit available with 800 ft range from wireless sensor to receiver
- Compatible with most controllers
- Warranty period: 5 years (10 year battery warranty for wireless model)

Specifications

- Wiring: normally closed or normally open
- Time to turn off irrigation system: 2 to 5 minutes approx. for Quick Response
- Time to reset Quick Response: 4 hours approx. under dry, sunny conditions
- Time to reset when fully wet: 3 days approx. under dry, sunny conditions
- UL listed, CUL (CSA), CE
- Switch rating: 24 VAC, 3 A
- Freeze sensor shuts system off when temperatures fall below 37˚ F (Rain/Freeze-Clik model)
- System operating frequency: 433 MHz
- UL listed, FCC approved, suitable for use in Australia, CUL (CSA), CE
- Communication range up to 800 ft. line of sight (Wireless model)
- Rain/Freeze-Clik shuts system off when temperatures fall below 37˚ F
- Receiver input power: 24 VAC (from controller)

Models

RAIN-CLIK
Height: 2½"
Length: 7"

WIRELESS RAIN CLIK TRANSMITTER
(with metal arm)
Height: 3"
Length: 8"

WIRELESS RAIN CLIK RECEIVER
Width: 3¼"
Height: 4"

RAIN-CLIK™	
Model	**Description**
RAIN-CLIK	Rain-Clik sensor
RFC	Rain/Freeze-Clik sensor
WR-CLIK	Wireless Rain-Clik system
WRF-CLIK	Wireless Rain/Freeze-Clik system

USER INSTALLED OPTION (Specify Separately)	
Model	**Description**
SGM	Optional gutter mount (included in the WRF-CLIK)

Website hunterindustries.com | **Customer Support** 760-744-5240 | **Technical Service** 760-591-7383

Helping our customers succeed is what drives us. While our passion for innovation and engineering is built into everything we do, it is our commitment to exceptional support that we hope will keep you in the Hunter family of customers for years to come.

Richard E. Hunter, CEO of Hunter Industries

LIT-348 J 8/12

APPENDIX 'F'

NELSON BIG GUN IRRIGATION SPRINKLERS

the original
BIG GUN® SPRINKLER

NELSON

WWW.NELSONIRRIGATION.COM

NELSON BIG GUN® SPRINKLERS

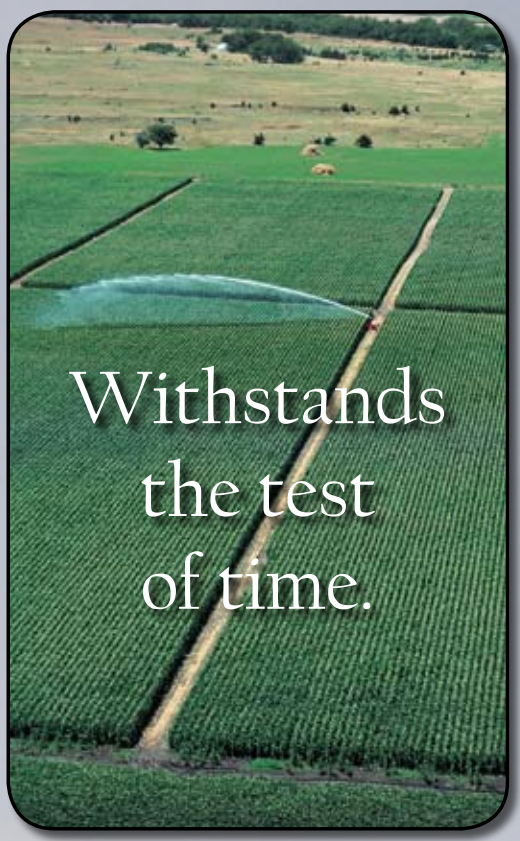
The Leader in Quality, Performance & Support

In the field of large-volume sprinklers, Nelson Big Guns® are recognized the world over as the leader in quality, performance and technical support. They are engineered and precision manufactured for heavy-duty reliability and long wear life. Every Nelson Big Gun® is subjected to the toughest inspection testing and quality control standards in the industry — including individual water testing of every gun at the factory.

Durable and reliable with engineered simplicity.

The preferred choice for tough applications.

NELSON www.nelsonirrigation.com



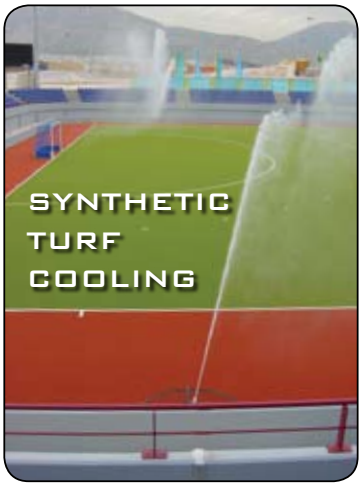
The only gun for hour after hour, year after year operation.

SET IT AND FORGET IT. A simple, positive, reliable adjustment allows for setting the arc to within 1 degree, without overriding the stops. The setting will not change over time, a concept proven with years in the field.

WORKS RIGHT OUT OF THE BOX. Nelson pioneered the concept of a slow, steady and uniform forward and reverse drive action. The drive vane automatically compensates through the full range of nozzle sizes and pressures.

APPLICATIONS

- Pivot End Gun Irrigation
- Traveler Irrigation
- Solid Set Irrigation
  - Corn, Sugar Cane, Pineapple, Pastures, etc.
- Environmental Applications
  - Feedlot Dust Suppression & Cooling
  - Wastewater Applications
  - Mining Dust Suppression
- Sports Field Applications
  - Turf Irrigation
  - Synthetic Turf Cooling & Conditioning



43° BIG GUN FOR DUST SUPPRESSION

OPTIONS

- Adjustable Trajectory
- 800 Series Valve/Big Gun® Combination
- Nozzle Valve
- Quick Coupling Valve
- Special Coatings
- Add-on Kits: Secondary Nozzle, Wedge and Counterbalance

(See *Big Gun® Add-on Kits* literature for details.)

NOZZLE VALVE

800P END GUN CONTROL VALVE*

*No electric solenoid required for Big Gun® control when used with a booster pump

HEAVY DUTY — PRECIS

THE BIG GUN® NAME has a world-wide reputation for quality, performance and support in a number of heavy-duty agricultural and industrial applications.

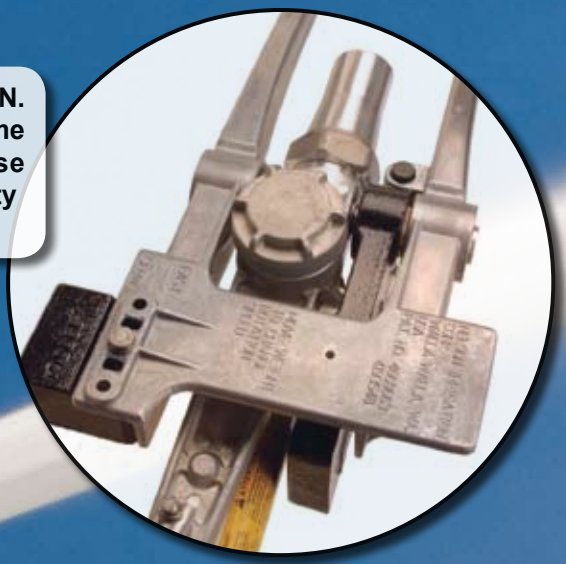
GREATEST RANGE OF OPTIONS. Full & part-circle sprinklers available in a variety of trajectory, nozzle & coating options.

TWIN BALL BEARING IN LOWER BEARING UNIT. Gun has a total of 9 ball bearings — all sealed and lifetime lubricated for long wear life and reliability.

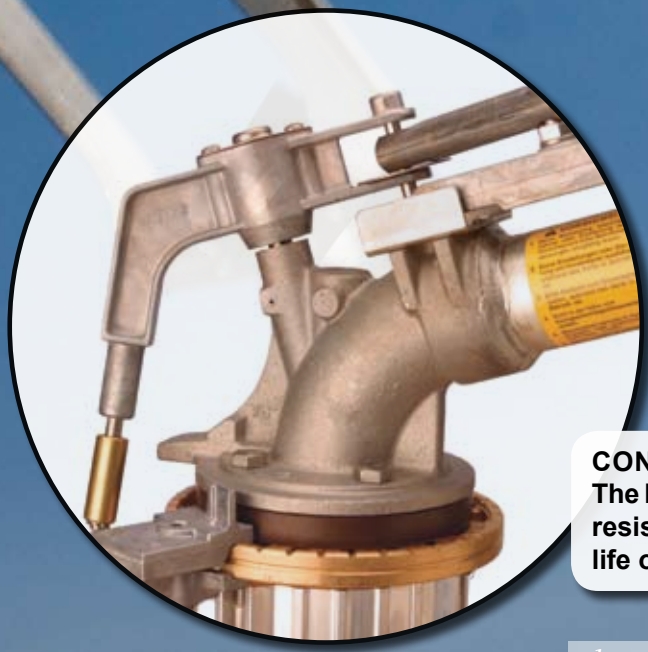
HAND ADJUSTABLE STOPS for Precise Arc Control.

SION MANUFACTURED

EXCELLENT DRIVE ACTION. The SR Series has the same slow forward and reverse speeds, increasing stability and improving uniformity.

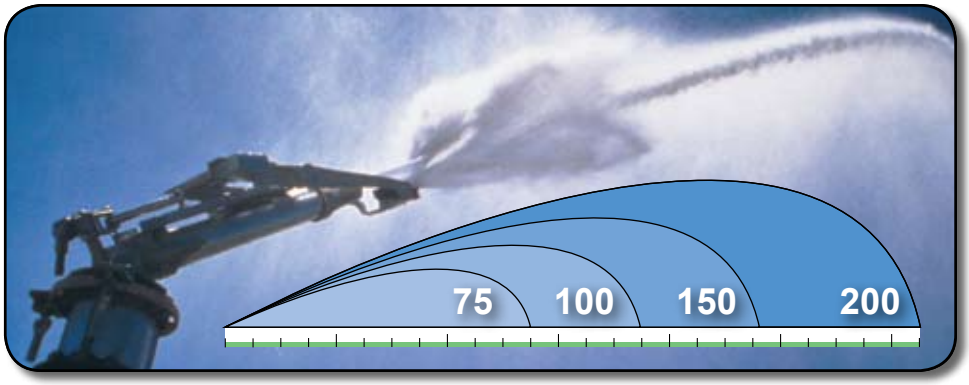


PATENTED PRESSURE AND FLOW COMPENSATING DRIVE SPOON eliminates need for adjustments throughout the full range of nozzle sizes and pressures.



CONSISTENT BRAKE LOAD. The brake provides a consistent resistance to rotation over the life of the gun.

BIG GUN® OPTIONS AVAILABLE



TO ORDER BIG GUNS® SPECIFY THE FOLLOWING:

Model No., Trajectory, Connection Size & Type, Nozzle Size & Type, Optional Coatings (Anodized or Anodized and Powder Coated) NOTE: Extended lead time may be necessary for large quantities of anodized or anodized and powder coated products.

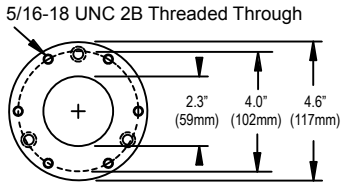
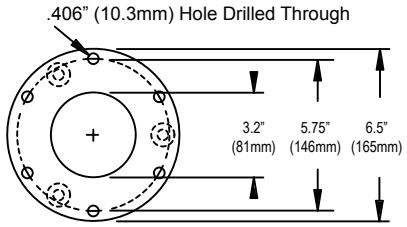
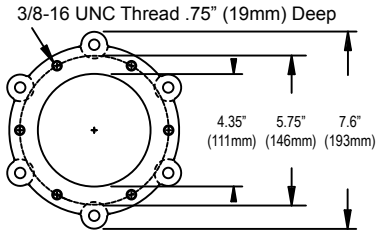
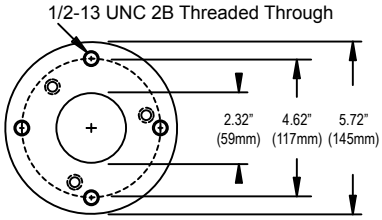
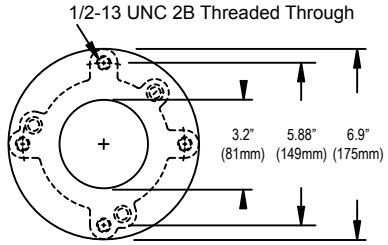
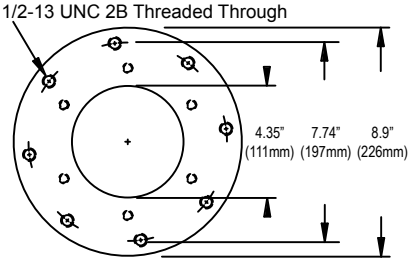
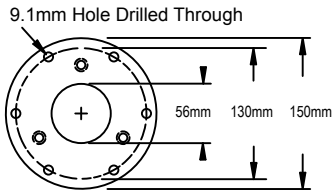
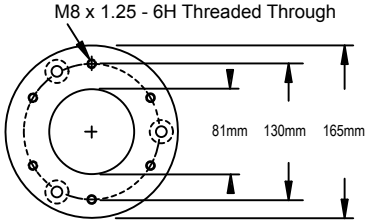
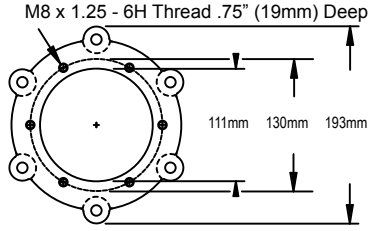
Specification Example: SR100 (24°), 2" FNPT, 100T-0.8"

	75 SERIES	100 SERIES	150 SERIES	200 SERIES
PERFORMANCE	30-160 GPM (6.8-36.3 M³/H) 25-80 PSI (1.75-6 Kg/cm²)	50-300 GPM (10-70 M³/H) 40-110 PSI (3.5-8 Kg/cm²)	100-630 GPM (23-150 M³/H) 50-120 PSI (3.5-9 Kg/cm²)	250-1200 GPM (55-275 M³/H) 60-130 PSI (4-9 Kg/cm²)
MODEL & TRAJECTORY	Full Circle F75 / Part Circle SR75	Full Circle F100 / Part Circle SR100 / Part Circle SRA100	Full Circle F150 / Part Circle SR150 / Part Circle SRA150	Full Circle F200 / Part Circle SR200
	21°, 24° / 18°, 21°, 24°, 43°	18°, 21°, 24°, 43° / 15-45° Adjustable	21°, 24° / 21°, 24°, 27°, 43° / 15-45° Adjustable	21°, 24°, 27°
NOZZLE OPTIONS — TAPER	0.4-0.8" (10.2-20.3 mm): Not Available	0.5-1.0" (12.7-25.4 mm): 100T (Specify Size)	0.7-1.4" (17.8-35.6 mm): 150T (Specify Size)	1.05-1.9" (26.7-48.3 mm): 200T (Specify Size)
NOZZLE OPTIONS — TAPER RING	0.4-0.8" (10.2-20.3 mm): TR75 (Specify Size)	0.5-1.0" (12.7-25.4 mm): 100TR (Specify Size); NA for SRNV	0.7-1.4" (17.8-35.6 mm): 150TR (Specify Size)	1.05-1.9" (26.7-48.3 mm): Not Available
NOZZLE OPTIONS — RING	0.4-0.8" (10.2-20.3 mm): Not Available	0.5-1.0" (12.7-25.4 mm): 100R (Includes Set of Rings); NA for SRNV	0.7-1.4" (17.8-35.6 mm): 150R (Includes Set of Rings)	1.05-1.9" (26.7-48.3 mm): 200R (Includes Set of Rings)
SPECIAL OPTIONS	Not Available	Anodized & Powder Coated, Vaneless Range Tube*	Anodized & Powder Coated, Stainless Steel (SRA150 N/A), Vaneless Range Tube	Anodized & Powder Coated
ADD-ON KITS	HD Lower Bearing, 12° Wedge Kit, Counterbalance Kit, Stream Straightener Vane	Low-Pressure Drive Vane Kit, Counterbalance Kit, Secondary Nozzle Kit, 12° Wedge Kit, Stream Straightener Vane	Counterbalance Kit, Secondary Nozzle Kit, Stream Straightener Vane	Secondary Nozzle Kit (standard), 12° Wedge Kit (SR200 only)
MOUNTING DETAILS	Fits QC** & 2" 800 Series Valve	Fits QC** & 2" 800 Series Valve (QC NA for SRNV100)	Substantial thrust on riser, use 3" valve minimum	Substantial thrust on riser, use 4" valve minimum
CONNECTION OPTIONS	1 1/2" or 2" FNPT or FBSP ANSI/DIN Nelson or Euro Flange	2" FNPT or FBSP, 2 1/2" FNPT ANSI/DIN, Nelson or Euro Flange / 2" FNPT or FBSP for SRNV	Nelson, Euro or ANSI/DIN Flange Also, Nelson Flange to Female Adapters	Nelson, Euro or ANSI/DIN Flange Also, Nelson Flange to Female Adapters

*Vaneless Range Tube option is for wastewater applications containing hair, straw, etc.

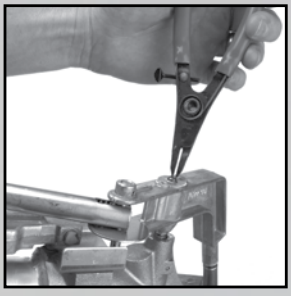
** The "Quick Coupling Valve" inlet is available in both 2" and 3" FNPT and FBSP for connection to the piping system. The "Quick Coupling Key" outlet is available in 2" FNPT, 2" FBSP, and Nelson Flange Connection for connection to the Big Gun.

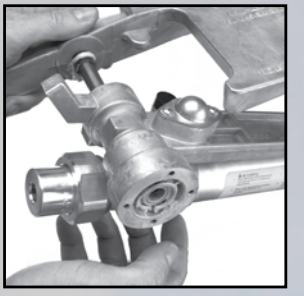
BIG GUN® FLANGE DETAILS

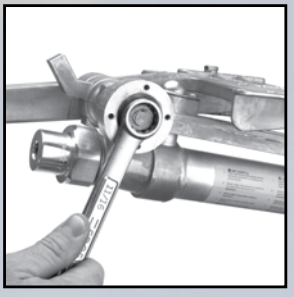
	75 & 100 SERIES	150 SERIES	200 SERIES
NELSON FLANGE	 Use 5/16-18 Bolts *Connects to 2" Nelson Flange Bolt Pattern*	 Use 3/8-16 Bolts & Nuts or M10 Bolts & Nuts *Connects to 3" Nelson Flange Bolt Pattern*	 Use 3/8-16 Bolts & Nuts *Connects to 4" Nelson Flange Bolt Pattern (F200 has same bolt pattern as SR150.)*
ANSI/DIN COMPATIBLE FLANGE	 Use 1/2-13 Bolts *Connects to 2" ANSI or 50mm DIN Flanges*	 Use 1/2-13 Bolts *Connects to 3" ANSI or 80mm DIN Flanges*	 Use 1/2-13 Bolts *Connects to 4" ANSI or 100mm DIN Flanges*
EURO FLANGE	 Use M8 Bolts & Nuts *Connects to European Traveler Flange*	 Use M8 x 1.25 Bolts *Connects to European Traveler Flange*	 Use M8 x 1.25 Bolts *Connects to European Traveler Flange*

Contact the factory or go to **www.nelsonirrigation.com** for Parts Lists, Operation & Maintenance Guides, Repair Kits, Dimensional Drawings, Add-on Kit literature & Thrust Force information.

Nelson Big Guns are easy to repair with readily available parts.







BIG GUN® PERFORMANCE (U.S. UNITS)

Flow and diameter (feet) information at various pressures with different nozzle sizes. (See information at bottom of page 11.)

75 TAPER RING NOZZLE — 24° TRAJECTORY

PSI	0.4"		0.45"		0.5"		0.55"		0.6"		0.65"		0.7"		0.75"		0.8"	
	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
25*	—	—	—	—	—	—	42	146	50	155	59	161	69	167	80	174	91	182
30*	—	—	—	—	37	158	45	158	55	165	64	172	75	182	87	187	99	192
35	—	—	32	154	40	164	49	172	59	178	69	191	81	196	93	202	106	208
40	27	149	35	160	43	171	52	180	63	190	74	198	87	204	98	213	112	221
45	29	155	37	167	46	180	56	189	67	198	79	206	91	214	104	223	118	230
50	30	161	39	174	48	186	59	195	70	203	83	212	95	220	109	230	123	237
55	32	165	41	179	50	193	62	203	74	213	87	221	100	230	115	239	130	247
60	33	169	42	184	53	198	64	208	77	220	91	228	104	237	120	245	136	254
65	35	172	44	189	55	205	67	216	80	227	95	237	109	247	125	254	142	263
70	36	175	45	194	57	210	69	221	83	232	98	243	113	254	129	260	147	270
75	37	179	47	201	59	217	72	228	86	239	101	250	117	261	134	268	153	277
80	39	182	49	207	61	222	74	234	89	244	105	256	121	266	138	274	158	283

*Operating at pressures above 30 PSI provides better performance.

100 TAPER BORE NOZZLE — 24° TRAJECTORY

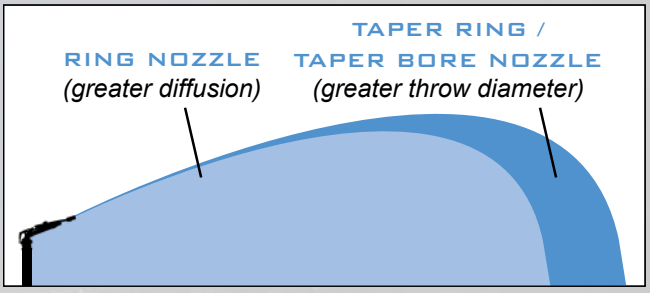
PSI	0.5"		0.55"		0.6"		0.65"		0.7"		0.75"		0.8"		0.85"		0.9"		1.0"	
	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
40	47	191	57	202	66	213	78	222	91	230	103	240	118	250	134	256	152	262	—	—
50	50	205	64	215	74	225	87	235	100	245	115	256	130	265	150	273	165	280	204	300
60	55	215	69	227	81	240	96	250	110	260	126	270	143	280	164	288	182	295	224	316
70	60	225	75	238	88	250	103	263	120	275	136	283	155	295	177	302	197	310	243	338
80	64	235	79	248	94	260	110	273	128	285	146	295	165	305	189	314	210	325	258	354
90	68	245	83	258	100	270	117	283	135	295	155	306	175	315	201	326	223	335	274	362
100	72	255	87	268	106	280	123	293	143	305	163	316	185	325	212	336	235	345	289	372
110	76	265	92	278	111	290	129	303	150	315	171	324	195	335	222	344	247	355	304	380

150 TAPER BORE NOZZLE — 24° TRAJECTORY

PSI	0.7"		0.8"		0.9"		1.0"		1.1"		1.2"		1.3"		1.4"	
	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
50	100	250	130	270	165	290	205	310	255	330	300	345	350	360	408	373
60	110	265	143	285	182	305	225	325	275	345	330	365	385	380	446	396
70	120	280	155	300	197	320	245	340	295	360	355	380	415	395	483	412
80	128	290	165	310	210	335	260	355	315	375	380	395	445	410	516	427
90	135	300	175	320	223	345	275	365	335	390	405	410	475	425	547	442
100	143	310	185	330	235	355	290	375	355	400	425	420	500	440	577	458
110	150	320	195	340	247	365	305	385	370	410	445	430	525	450	605	471
120	157	330	204	350	258	375	320	395	385	420	465	440	545	460	632	481

200 TAPER BORE NOZZLE — 27° TRAJECTORY

PSI	1.05"		1.1"		1.2"		1.3"		1.4"		1.5"		1.6"		1.75"		1.9"	
	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
60	250	345	285	355	330	375	385	390	445	410	515	430	585	445	695	470	825	495
70	270	360	310	380	355	395	415	410	480	430	555	450	630	465	755	495	890	515
80	290	375	330	395	380	410	445	430	515	450	590	470	675	485	805	515	950	535
90	310	390	350	410	405	425	475	445	545	465	625	485	715	505	855	535	1005	555
100	325	400	370	420	425	440	500	460	575	480	660	500	755	520	900	550	1060	575
110	340	410	390	430	445	450	525	470	605	495	695	515	790	535	945	565	1110	590
120	355	420	405	440	465	460	545	480	630	505	725	530	825	550	985	580	1160	605
130	370	425	425	445	485	465	565	485	655	515	755	540	860	560	1025	590	1210	620



See opposite page for nozzle descriptions.

BIG GUN® PERFORMANCE (METRIC)

Flow and diameter (meters) information at various pressures with different nozzle sizes. (See information at bottom of page.)

75 TAPER RING NOZZLE TR75 — 24° TRAJECTORY

Kg/cm²	10.2 mm			11.4 mm			12.7 mm			14.0 mm			15.2 mm			16.5 mm			17.8 mm			19.1 mm			20.3 mm		
	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
1.75*	—	—	—	—	—	—	—	—	—	2.64	9.5	44	3.17	11.4	48	3.72	13.4	49	4.30	15.5	51	4.91	17.7	54	5.59	20.1	56
2.00*	—	—	—	—	—	—	2.33	8.4	48	2.82	10.2	48	3.39	12.2	51	3.98	14.3	52	4.59	16.5	56	5.25	18.9	58	5.97	21.5	59
2.50	—	—	—	2.11	7.6	47	2.61	9.4	50	3.16	11.4	53	3.79	13.6	55	4.45	16.0	58	5.14	18.5	60	5.87	21.1	62	6.68	24.0	64
3.00	1.83	6.6	47	2.32	8.3	50	2.86	10.3	53	3.46	12.4	57	4.15	14.9	59	4.88	17.6	61	5.63	20.3	63	6.43	23.1	66	7.32	26.3	69
3.50	1.98	7.1	49	2.50	9.0	52	3.09	11.1	57	3.74	13.4	60	4.48	16.1	62	5.27	19.0	64	6.08	21.9	67	6.95	25.0	70	7.90	28.4	73
4.00	2.11	7.6	50	2.67	9.6	54	3.30	11.9	59	3.99	14.4	62	4.79	17.2	65	5.63	20.3	67	6.50	23.4	71	7.43	26.7	73	8.45	30.4	76
4.50	2.24	8.1	52	2.84	10.2	57	3.50	12.6	62	4.24	15.2	66	5.08	18.3	68	5.97	21.5	71	6.89	24.8	75	7.88	28.4	78	8.96	32.3	80
5.00	2.36	8.5	53	2.99	10.8	60	3.69	13.3	64	4.46	16.1	68	5.35	19.3	70	6.30	22.7	74	7.26	26.1	78	8.30	29.9	80	9.45	34.0	84
5.50	2.48	8.9	55	3.13	11.3	62	3.87	13.9	66	4.68	16.9	70	5.61	20.2	73	6.60	23.8	77	7.62	27.4	81	8.71	31.3	83	9.90	35.7	86
6.00	2.59	9.3	56	3.27	11.8	63	4.04	14.6	68	4.89	17.6	72	5.86	21.1	74	6.90	24.8	79	7.96	28.6	84	9.09	32.7	85	10.3	37.2	87

*Operating at pressures above 2 Kg/cm² provides better performance.

100 TAPER BORE NOZZLE — 24° TRAJECTORY

Kg/cm²	12.7 mm			14.0 mm			15.2 mm			16.5 mm			17.8 mm			19.1mm			20.3 mm			21.6 mm			22.9 mm			25.4 mm		
	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
3.0	3.00	10.8	59.5	3.73	13.4	62.6	4.33	15.6	66.1	5.09	18.3	66.8	5.84	21.0	71.4	6.71	24.1	74.5	7.64	27.5	77.5	8.74	31.5	79.5	9.67	34.8	81.4	11.9	42.8	88.1
4.0	3.40	12.2	64.3	4.25	15.3	67.8	5.00	18.0	71.8	5.86	21.1	74.8	6.82	24.6	77.8	7.73	27.8	81.0	8.66	31.2	82.8	10.1	36.2	86.4	11.2	40.4	88.6	13.8	49.5	94.8
5.0	3.79	13.6	69.0	4.72	17.0	72.7	5.59	20.1	76.4	6.56	23.6	80.2	7.62	27.5	84.4	8.66	31.2	86.7	9.91	34.9	90.4	11.3	40.5	92.5	12.5	45.2	94.7	15.5	55.6	103
6.0	4.17	15.0	73.4	5.14	18.5	77.3	6.12	22.1	80.7	7.19	25.9	85.0	8.35	30.1	88.7	9.51	34.3	91.8	10.9	38.2	94.7	12.4	44.5	97.7	13.7	49.5	101	16.8	60.5	109
7.0	4.53	16.3	77.6	5.52	19.9	81.6	6.61	23.8	85.0	7.75	27.9	89.3	9.02	32.5	93.0	10.3	37.0	96.1	11.7	41.3	99.0	13.3	48.0	102.2	14.8	53.5	105	18.2	65.5	113
8.0	4.89	17.6	81.7	5.84	21.0	85.7	7.07	25.5	89.3	8.25	29.7	93.1	9.64	34.8	97.3	11.0	39.4	99.7	12.5	44.1	103	14.2	51.2	105.8	15.9	57.2	109	19.5	70.2	116

150 TAPER BORE NOZZLE — 24° TRAJECTORY

Kg/cm²	17.8 mm			20.3 mm			22.9 mm			25.4 mm			27.9 mm			30.5 mm			33.0 mm			35.6 mm		
	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
3.5	6.39	23.0	76.0	8.29	29.8	82.0	10.5	37.8	88.0	13.0	46.9	95.0	15.9	57.1	101	19.0	68.3	105	22.3	80.1	110	25.8	92.9	114
4.0	6.83	24.6	79.6	8.86	31.9	85.6	11.2	40.4	91.6	13.9	50.1	97.8	16.9	61.0	104	20.3	73.0	109	23.8	85.7	114	27.4	98.6	118
5.0	7.63	27.5	85.4	9.91	35.7	91.6	12.6	45.2	98.6	15.6	56.0	105	18.9	68.2	111	22.7	81.7	117	26.6	95.8	121	30.8	111	126
6.0	8.36	30.1	89.7	10.9	39.1	96.7	13.8	49.5	104	17.0	61.3	110	20.8	74.7	117	24.9	89.5	123	29.1	105	128	33.6	121	133
7.0	9.03	32.5	95.0	11.7	42.2	101	14.9	53.5	108	18.4	66.3	114	22.4	80.7	122	26.8	96.6	128	31.5	113	134	36.4	131	139
8.0	9.66	34.8	99.3	12.5	45.1	105	15.9	57.2	112	19.7	70.8	118	24.0	86.3	126	28.7	103	132	33.7	121	138	38.9	140	145
9.0	10.2	36.9	104	13.3	47.9	110	16.8	60.6	117	20.9	75.1	123	25.4	91.5	131	30.4	110	137	35.7	129	143	41.1	148	149

200 TAPER BORE NOZZLE — 27° TRAJECTORY

Kg/cm²	26.7 mm			27.9 mm			30.5 mm			33.0 mm			35.6 mm			38.1 mm			40.6 mm			44.5 mm			48.3 mm		
	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
4.0	15.5	55.7	104	17.8	63.9	106	20.3	73.1	112	23.8	85.8	117	27.5	98.9	123	32.2	116	129	36.1	130	134	42.9	154	141	50.7	183	149
5.0	17.3	62.3	111	19.9	71.5	117	22.7	81.7	121	26.7	96.0	126	30.7	111	132	36.0	130	138	40.3	145	143	48.0	173	152	56.7	204	158
6.0	19.0	68.2	115	21.8	78.3	121	24.9	89.5	126	29.2	105	132	33.7	121	138	39.4	142	144	44.2	159	149	52.6	189	158	62.1	224	164
7.0	20.5	73.7	122	23.5	84.6	128	26.9	96.7	134	31.5	114	140	36.3	131	146	42.6	153	152	47.7	172	159	56.8	204	168	67.1	241	175
8.0	21.9	78.8	126	25.1	90.4	132	28.7	103	138	33.7	121	144	38.9	140	152	45.5	164	159	51.0	184	165	60.7	218	174	71.7	258	182
9.0	23.2	83.6	130	26.6	95.9	136	30.4	110	142	35.8	129	148	41.2	148	157	48.3	174	164	54.1	195	170	64.4	232	180	76.0	274	188

Diameters are based on a 24° trajectory for the 75, 100 and 150 Series and a 27° trajectory for the 200 Series. The lower trajectory angles result in better wind fighting ability, but reduced throw distances. Throw reduction depends upon nozzle flow rate. In general, the throw distance is reduced approximately 3% with each 3° drop in trajectory angle. Use of the wedge insert to modify trajectory will affect distance. Big Gun® performance data has been obtained under ideal test conditions and may be adversely affected by wind, poor hydraulic entrance conditions or other factors. Test riser height of 3 feet (0.91 meters) above measurement surface. No representation regarding droplet condition, uniformity, application rate, or suitability for a particular application is made herein.

Additional nozzle options and sizes available. Go to www.nelsonirrigation.com or contact the factory for nozzle performance.

TAPER BORE NOZZLE. Most common nozzle type. Used where the available water flow and pressure are consistent. A nozzle size must be specified when ordering a Big Gun with a Taper Bore Nozzle. *The Nozzle Valve End Gun requires a Taper Bore Nozzle.*

RING NOZZLE SET. The Ring Nozzle Set is an easy and economic way of changing nozzles to match the available water flow and pressure. These are commonly used where the available water flow and pressure are variable and or when the Big Gun is shifted between various water sources with different capacities. The abrupt orifice of the nozzle is less efficient so the radius of throw is less than that achieved with an equivalent diameter Taper Bore nozzle. The abrupt orifice of the Ring Nozzle does break the stream of water up more, which can be an advantage in low pressure applications. The Ring Nozzle comes with a set of rings. *The Ring Nozzle should not be used with the Nozzle Valve End Gun.*

TAPER RING NOZZLE. This nozzle combines the changeability of a Ring Nozzle with some of the efficiency of a Taper Bore Nozzle. When ordering the Taper Ring Nozzle, specify the size as only one Taper Ring comes with the nozzle body and cap. Additional taper ring sizes can be purchased. *The Taper Ring Nozzle should not be used with the Nozzle Valve End Gun.*

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This product may be covered by one or more of the following U.S. Patent Nos. D297,453, 3,559,887, 3,744,720, 4,193,548, 4,669,663 and other U.S. Patents pending or corresponding issued or pending foreign patents.

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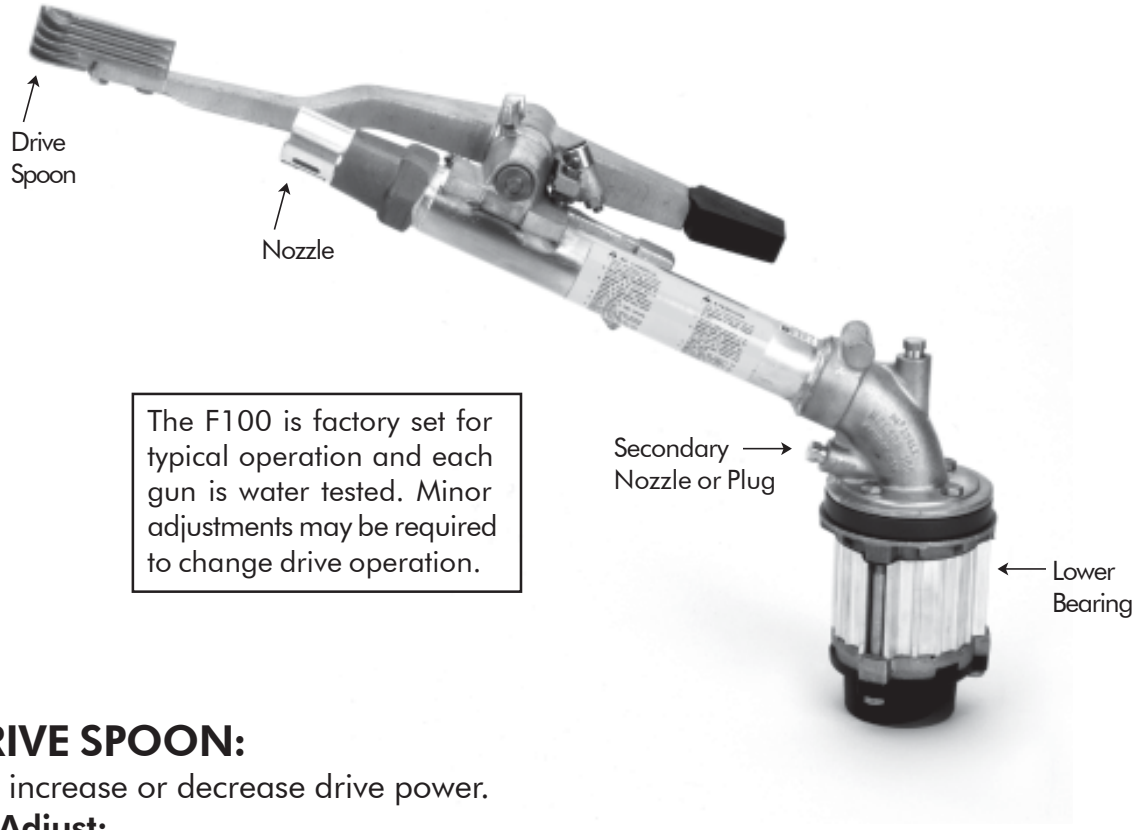
F100 BIG GUN®

F100 BIG GUN® OPERATING & ADJUSTMENT INSTRUCTIONS



The F100 is factory set for typical operation and each gun is water tested. Minor adjustments may be required to change drive operation.

THE DRIVE SPOON:

Adjust to increase or decrease drive power.

When to Adjust:

1. For low pressure operation.
2. For sloping terrain operation.

NOTE: The factory setting of the drive spoon will produce 80 to 90 arm strokes per minutes and an approximate rotation through 180° arc in one and a half minutes. Short, choppy arm strokes usually indicate marginal pressure conditions and necessitate spoon adjustment. The lower bearing assembly includes a spring loaded disc brake that does not need adjustment.

On sloping terrain, adjust the drive spoon 1/16" into the stream. For traveler operation, sloping terrain will cause the nozzle pressure to fluctuate 4.3 PSI for every 10 feet of elevation change. A counter balance kit is available for operation on a tilted riser.

For operation below 40 PSI, adjust the spoon 1/16" into the stream. **NOTE:** Operation below the recommended pressure may result in improper mechanical operation, particularly where sloping terrain conditions exist. For good irrigation droplet conditions, 55 PSI or greater is recommended.

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F100 BIG GUN® OPERATING AND ADJUSTMENT

PROBLEM: **Drive arm does not swing properly.**

SOLUTION:
- **A.** Nozzle or barrel partially plugged with debris — unplug.
- **B.** Arm Shaft loose — tighten nut.
- **C.** Bearings dirty or corroded — replace.
- **D.** Insufficient Pressure — 40 PSI minimum for irrigation.
- **E.** Broken or worn drive arm spoon — replace.

PROBLEM: **Insufficient water distribution close to the sprinkler.**

SOLUTION: Remove secondary plug, install secondary nozzle.

PROBLEM: **"Ragged" or turbulent stream discharge.**

SOLUTION:
- **A.** Debris trapped in nozzle barrel — remove.
- **B.** Inlet riser connection does not allow smooth flow of water into gun — insert 625V (2 1/2") or 600V (2") stream straightener vane into 2 1/2" or 2" x 6" pipe at base of gun.
- **C.** Nozzle worn excessively or damaged — replace.

PROBLEM: **Lower bearing hard to rotate.**

SOLUTION: Service lower bearing. (Request SR100 Operation & Maintenance Instructions for procedure.)

BE CAREFUL!!

1. **Read operating instructions before operating sprinkler or making any adjustments.**
2. **Never make adjustments or perform service while the sprinkler is in operation.**
3. **Stand clear of an operating sprinkler.**
4. **Stand clear of the high velocity water stream.**
5. **Never direct the water stream onto a roadway or electrical transmission lines.**

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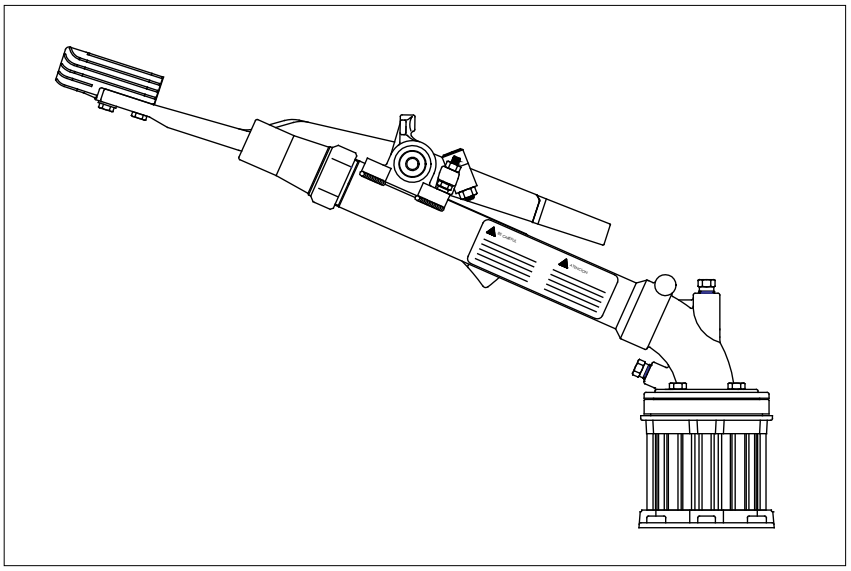
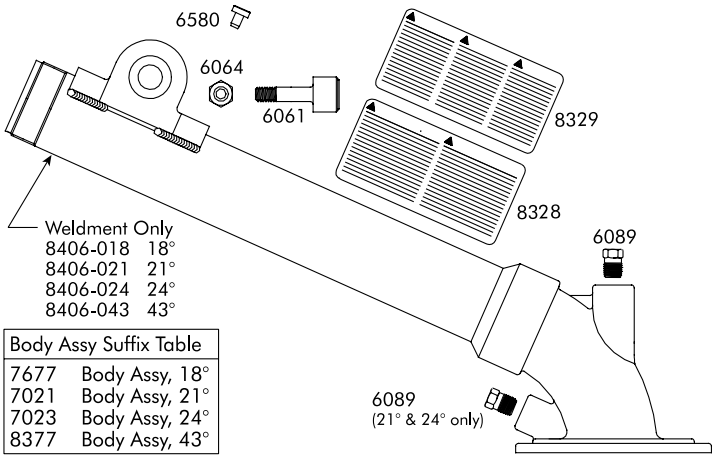
F100 BIG GUN®

F100 BIG GUN® PARTS LIST



XXXX BODY ASSEMBLY
(See Suffix Table)

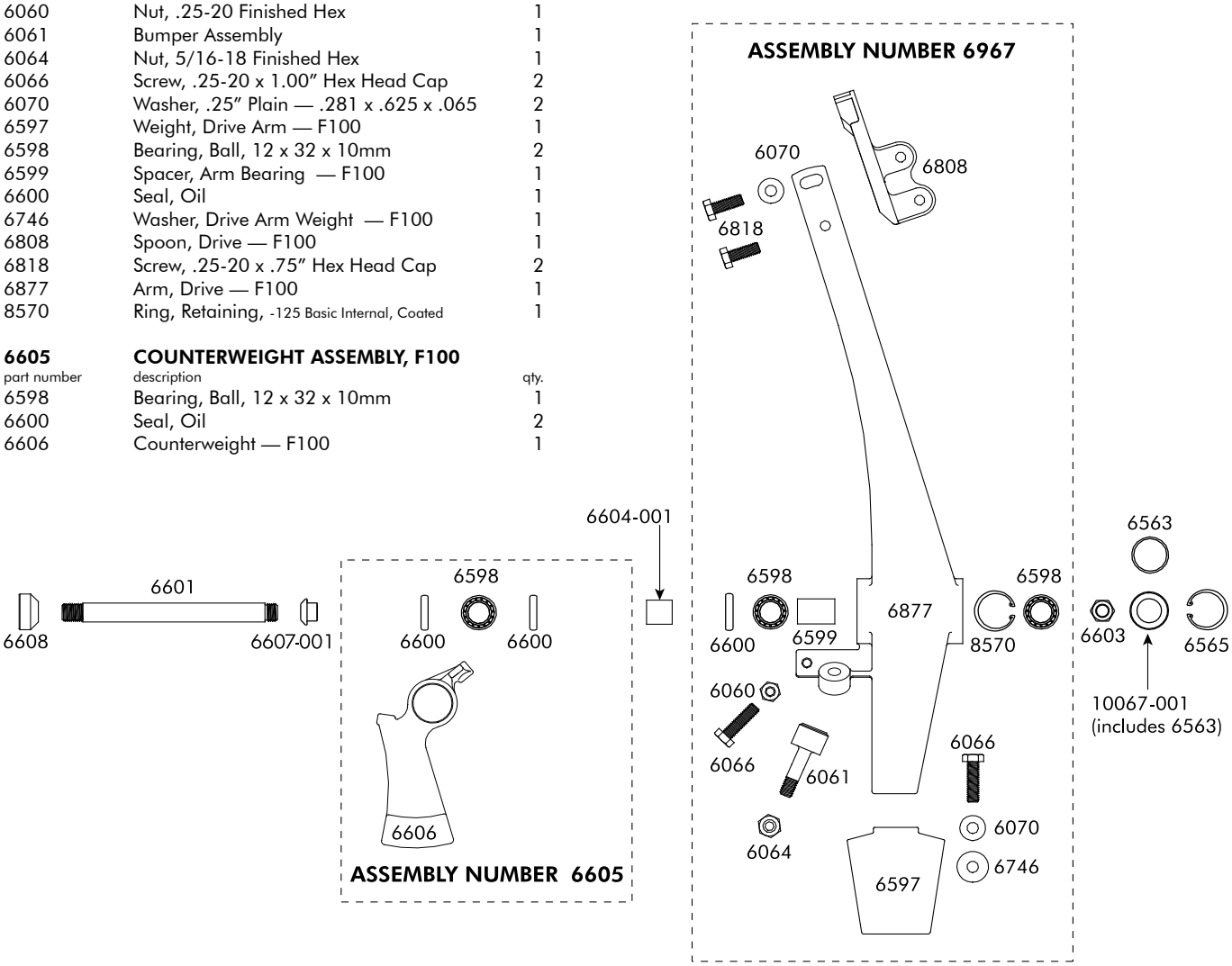


Body Assy Suffix Table	
7677	Body Assy, 18°
7021	Body Assy, 21°
7023	Body Assy, 24°
8377	Body Assy, 43°

XXXX part number	BODY ASSEMBLY, F100 description	qty.
6061	Bumper Assembly	1
6064	Nut, 5/16-18 Finished Hex	1
6089	3RN Plug	2
6580	Insert, Rest Pad	1
8328	Label, Warning — English, Spanish	1
8329	Label, Warning — German, French, Swedish	1
8406-018	Tube & Elbow Assembly, 18° — F100	1
8406-021	Tube & Elbow Assembly, 21° — F100	1
8406-024	Tube & Elbow Assembly, 24° — F100	1
8406-043	Tube & Elbow Assembly, 43° — F100	1

6967	**DRIVE ARM ASSEMBLY, F100**	
6060	Nut, .25-20 Finished Hex	1
6061	Bumper Assembly	1
6064	Nut, 5/16-18 Finished Hex	1
6066	Screw, .25-20 x 1.00" Hex Head Cap	2
6070	Washer, .25" Plain — .281 x .625 x .065	2
6597	Weight, Drive Arm — F100	1
6598	Bearing, Ball, 12 x 32 x 10mm	2
6599	Spacer, Arm Bearing — F100	1
6600	Seal, Oil	1
6746	Washer, Drive Arm Weight — F100	1
6808	Spoon, Drive — F100	1
6818	Screw, .25-20 x .75" Hex Head Cap	2
6877	Arm, Drive — F100	1
8570	Ring, Retaining, -125 Basic Internal, Coated	1

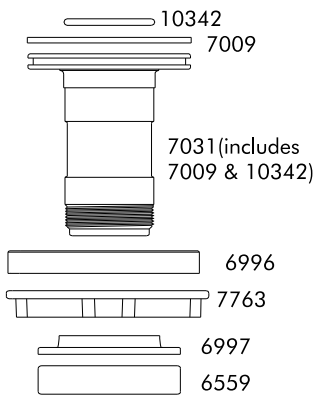
6605	**COUNTERWEIGHT ASSEMBLY, F100**	
part number	description	qty.
6598	Bearing, Ball, 12 x 32 x 10mm	1
6600	Seal, Oil	2
6606	Counterweight — F100	1

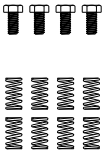


FINAL ASSEMBLY COMPONENTS

part number	description	qty.
6563	O-Ring, -024	1
6565	Ring, Retaining, -125 Basic Int	1
6601	Shaft, Drive Arm — F100	1
6603	Nut, 7/16-20 Special	1
6604-001	Spacer, Arm to Cwt — F100	1
6607-001	Spacer, Cone, Teflon Coated	1
6608	Nut, .438-20 Centering — F100	1
10067-001	Cap Assy, Arm Bearing — SR100	1

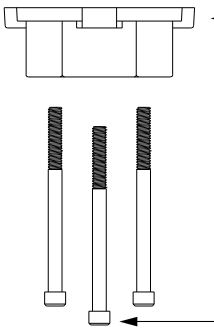
F100 BIG GUN® PARTS LIST





BEARING ASSEMBLY NOS.

7863	2" FNPT
7864	2.5" FNPT
7865	2" FBSP
7862	NELSON FLANGE
7008-018	EURO FLANGE
10265-201	ANSI/DIN FLANGE
10380-007	1.5" FNPT
10380-010	1.5" FBSP



Flg. Assy.	Connection	(3) Screws
*10088-006	1.5" FNPT	7990
*10088-007	1.5" FBSP	7990
*10088-001	2" FNPT	7990
*10088-003	2" FBSP	7990
*10088-002	2.5" FNPT	7991
10086	Nelson Flg.	7006
10094	Euro Flg.	7006
10137-001	ANSI/DIN Flg.	7006

*Includes 8967

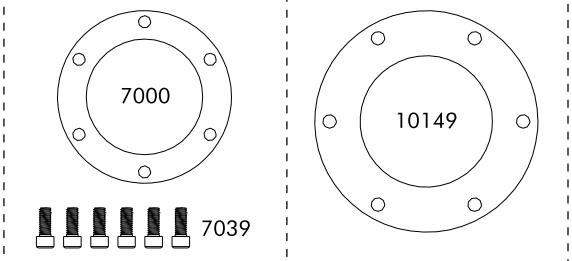
BEARING ASSEMBLY, F100

part number	description	qty.
6559	Bearing, Ball, 50 x 80 x 16mm	2
6566	Gasket, Housing - HD100	2
6635	Screw, .3125 -18 x .688" Hex Hd Cap	4
6996	Ring, Brake - HD100	1
6997	Seal, Upper - HD100	1
6998	Seal, Center - HD100	1
6999	O-Ring, -224	1
7004	Spring, Brake - HD100	8
7006	Screw, .312-18 x 3.50" Hex Skt Hd Cap	3
7007	O-Ring, -331, Special	1
7009	Seal, Dust - HD100	1
7031	Shaft Assembly - HD100	1
7763	Cover, Full Circle - HD100	1
7990	Screw, .312-18 x 4.25" Hex Hd Cap	3
7991	Screw, .312-18 x 4" Hex Skt Hd Cap	3
8472	Housing - HD100	1
8967	O-Ring -231, Special	1
10083	Retainer Assembly - HD100	1
10086	Flange Assembly, Nelson	1
10087	Spacer Assembly - HD100	1
10088-001	Flange Assembly, 2" FNPT	1
10088-002	Flange Assembly, 2.5" FNPT	1
10088-003	Flange Assembly, 2" FBSP	1
10088-006	Flange Assembly, 1.5" FNPT	1
10088-007	Flange Assembly, 1.5" FBSP	1
10094	Flange Assembly, Euro	1
10137-001	Flange Assembly, ANSI/DIN	1
10342	O-Ring, -225	1

MOUNTING HARDWARE

part number	description	qty.
7000	Gasket, Flange	1
7039	Screw, .312-18 x .75" Hex Skt Hd Cap	6
10149	Gasket, Euro Flange	1

FLANGE GASKET AND FASTENERS FOR MOUNTING GUN



F100 BIG GUN® PARTS LIST

WARRANTY AND DISCLAIMER

Nelson Big Gun sprinklers are warranted for one year from date of original sale to be free of defective materials and workmanship when used within the working specifications for which the product was designed and under normal use and service. The manufacturer assumes no responsibility for installation, is limited solely to replacement or repair of defective parts, and the manufacturer will not be liable for any crop or other consequential damages resulting from any defects or breach of warranty. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSES AND OF ALL OTHER OBLIGATIONS OR LIABILITIES OF MANUFACTURER. No agent, employee or representative of the manufacturer has authority to waive, alter or add to the provision of the warranty, nor to make any representations or warranty not contained herein.

APPENDIX 'G'

ADEQ NO-DISCHARGE PERMIT

APPENDIX 'H'

EPA OPERATIONS MANUAL FOR STABILIZATION PONDS

Operations Manual

Stabilization Ponds

by
CHUCK ZICKEFOOSE
R. B. JOE HAYES

PROJECT OFFICER
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U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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AUGUST 1977

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Introduction

BACKGROUND

Stabilization ponds were first used for wastewater treatment in the midwest for remote communities, but have since found extensive use in various parts of the country. In addition to domestic uses, ponds are now treating various types of industrial wastes including vegetable, oil refinery, slaughterhouses, dairies and rendering plants.

PURPOSE OF THIS MANUAL

Even though precise process control is not required, there are a number of factors to be conscious of from an operation and maintenance standpoint for the operator, plant owner and consulting engineer. This manual is intended to serve several functions including:

- Supplement to the specific operation and maintenance manual prepared for municipal ponds.
- Provide basic information on pond theory and features the beginning operator should know.
- Provide tips on operation and maintenance for experienced operators based on information from various parts of the nation.
- Outline troubleshooting tips for handling various problems common to ponds.

MANUAL ORGANIZATION

The manual is divided into six main parts:

- The Basics
- Control Information for Ponds
- Operation and Maintenance for Ponds
- Troubleshooting for Ponds
- Safety
- Appendices

USE OF THE MANUAL

- **The Basics** — For those wanting to brush up on fundamentals or get aquainted with types of ponds, terminology and factors to consider in operation, this section will be helpful.

- **Control Information for Ponds** — This portion of the manual considers sampling, flow control and use of information gained from either visual, nasal or laboratory investigation.

- **Operation and Maintenance for Ponds** — After gathering information, some action may be necessary and this subject is covered here. Housekeeping and day-to-day activities are presented along with a suggested checklist which can be adapted for the individual plant.

- **Troubleshooting for Ponds** — This part of the manual presents a number of potential problems and gives solutions that other operators have found to be helpful.

- **Safety** — Many times only one person is on site making it doubly important to work safely. Major points are given here.

- **Appendices** — A glossary, sample calculations, flow measurement and references are some of the inclusions. A sample checklist which can be modified for the individual plant is also included.

PLANT MANAGEMENT

Operation of a wastewater treatment system is a joint effort by a number of people, directly or indirectly. The two entities that are most involved after the contractor moves off site are the plant "owner" and operator. Each have certain areas of responsibility.

Owner

The owner may be the private agency that had the pond constructed, the governing board of a sewerage agency, the city manager or city council. It is the individual or group of individuals that the operator is ultimately responsible to and who have the authority to make policy decisions in regard to pond operation.

The owner of a pond has the responsibility of providing an operator who is conscientious, in good physical condition, and is capable of operating and maintaining the facility after being provided proper instruction and orientation. The orientation period might initially require the full-time duties of the operator.

If the current operator leaves the employ of the owner, it is the owner's responsibility to obtain immediate replacement. The replacement should be provided with proper training to make up any possible deficiency.

The owner should encourage opportunities for plant personnel to expand their knowledge by attendance at meetings, short schools, special training courses, and utilizing other opportunities for increasing their technical competence.

The owner has the responsibility to establish a salary level scale that encourages tenure of trained and experienced personnel.

It is the responsibility of the owner to obtain from the appropriate regulatory agency any permit required for operation of the plant.

The owner is ultimately responsible for the performance of the treatment facility. To maintain such performance, the owner is responsible for general supervision of the operator, in addition to supplying him or her with all necessary tools, materials, and parts for proper plant operation and maintenance. It is also the responsibility of the owner to provide adequate funds for plant expansion as needed.

Operator

The plant operator is responsible for the conscientious and proper operation and maintenance of the installation. This includes maintenance of buildings, grounds, and equipment.

The operator is responsible for maintaining a safe working environment and being safety conscious in his or her actions.

The operator is required to make those tests and observations required for the proper operation of the pond and to satisfy the appropriate reporting agency regulations. All results should be made known to the owner in terms that can be easily understood.

The operator must have the ability to inter pret laboratory tests and apply their results to the operational control of the treatment plant.

The operator is responsible in notifying the owner as to the need for tools, parts, and supplies. Sufficient notice should be given so that such items will be available when needed.

The operator has the responsibility to become fully acquainted with the plant and the treatment process used. He should take advantage of training offered by the regulatory agency, manufacturer-supplier or local community college.

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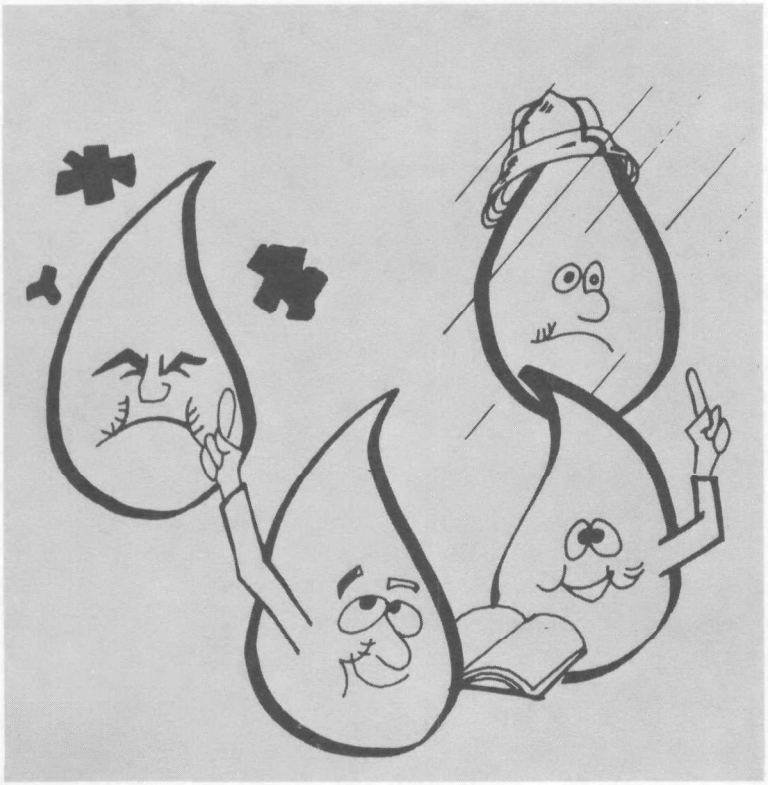
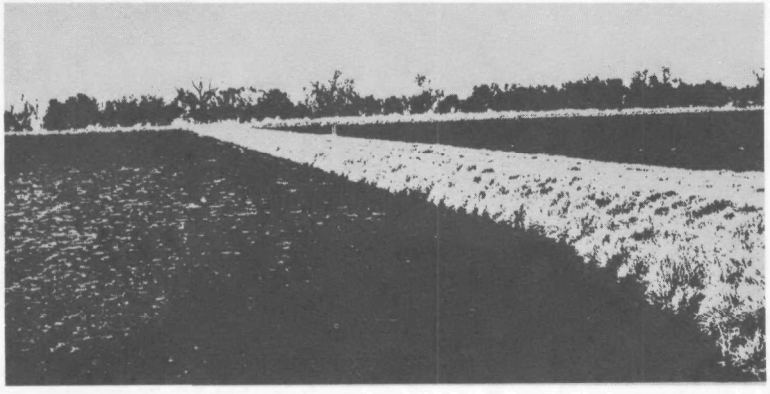
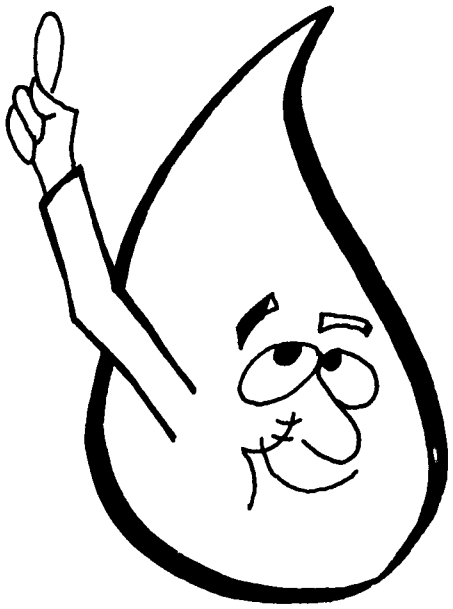
1. The Basics





- Some interesting facts about your wastewater
- Know your process
- The phenomenon of pond life
- How are wastes treated
- Types of ponds
- Stabilization ponds
- Oxidation ponds
- Facultative ponds
- Specialty ponds
- What natural factors affect the process
- How physical factors affect treatment
- How chemical factors affect treatment

1. The Basics

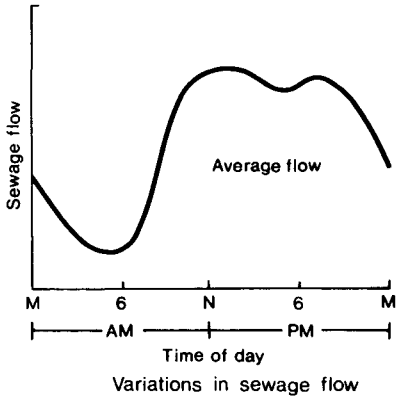


SOME INTERESTING FACTS ABOUT YOUR WASTEWATER

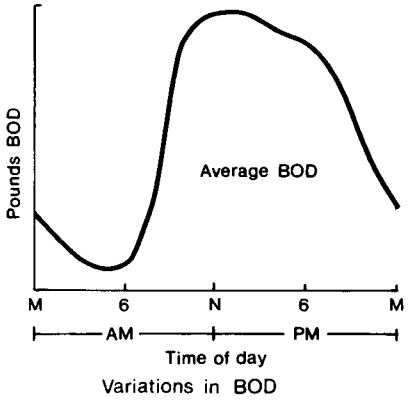
Water is used to carry man's waste products from homes, schools, commercial establishments and industrial enterprises. Water borne wastes are classified as being domestic or industrial.

The type of wastes discharged into the sewage collection system from industrial sources varies widely and may bring on treatment problems for the operator. In general, most contribute a high concentration of organic loading.

Domestic waste is pretty much the same throughout the country. We all cook, eat and clean up pretty much the same and during the same hours. These general habits create a pattern of loading throughout the day as shown in the following diagrams.



Variations in sewage flow



Variations in BOD

The average domestic sewage with well-constructed sewers will provide flows of 75 to 100 gallons containing about 0.2 lbs. or 240 mg/l of BOD per capita (person) per day.

Fresh domestic sewage is usually gray in color, similar to dishwater, with a kind of musty odor. If it becomes septic, it turns black with a strong, foul odor and the pH will be lower. The water temperature is usually a few degrees warmer than pond

temperature but will vary with time of year. The solids are broken down according to their physical characteristics.

Dissolved Solids make up about 40 percent of the total solids and are dissolved in the water like sugar is dissolved in coffee.
Suspended Solids are the remainder of the total solids. Of these, some are settleable when they enter the pond.

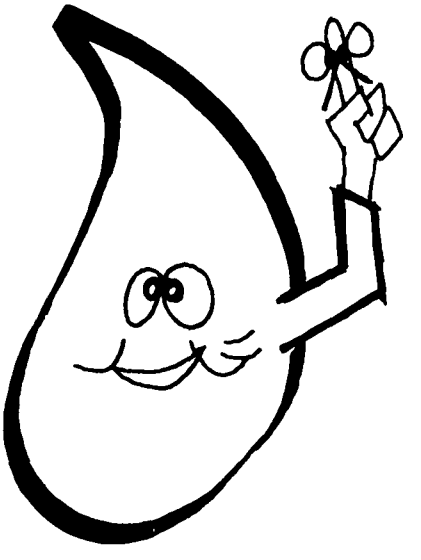
Common tests used to measure these solids are the Imhoff Cone test for settleable solids and a filtration-drying test for suspended solids. Domestic sewage usually contains about 0.2 lb. (0.9 kg) of suspended solids per capita per day, or about the same as BOD. Sewage can be described chemically in that it contains both inorganic and organic compounds.

The inorganic portion comes partly from the original sources from infiltration and from storm waters. Normal domestic sewage contains about 50 percent inorganic and 50 percent organic. The inorganic portion is relatively stable and not easily subject to decay. Inorganics consist of sand, grit, plastics, metal etc. If stormwater is connected to a sewer system or if infiltration occurs, the inorganic portion increases sometimes to troublesome proportions.

The organic portion is subject to decay (bacterial decomposition) containing proteins, carbohydrates and fats. The principal chemical elements are carbon, hydrogen, and oxygen which are often combined with nitrogen, sulfur and phosphorus.

As sewage ages, bacterial activity converts more of the insoluble organics to soluble organics which can then be used as food by the bacteria. The food is then converted into new growth and some by-products such as carbon dioxide and water.

Pollution comes from the organic portion of sewage. If it were to enter our waterways untreated, it would rob the stream of the oxygen needed by primary life forms. Contamination occurs because polluted water carries disease causing germs and bacteria. Therefore, from both an environmental and public health standpoint, it is absolutely necessary to reduce both pollution and contamination to acceptable levels. These levels are measured in terms of biological oxygen demand (BOD_5), dissolved oxygen (DO), pH, suspended solids (SS) and fecal coliform which are described in your Waste Discharge Permit.



KNOW YOUR PROCESS . . . . . .
Because it will provide better treatment and fewer upsets. And when the process becomes upset, you will know what corrections to make and why.

THE PHENOMENON OF POND LIFE

The process that takes place in a pond or lagoon is an interesting one because it is a natural cycle, continuous and a living phenomenon. As with humans, conditions and life are always changing. It is difficult to predict, with certainty, what will be happening. Changes may be due to temperature, weather, changes in the kinds of algae, and other living organisms as well as changes in the types of wastes.

Life in a pond is made up of billions of tiny microscopic plants and animals co-existing and depending on each other. In fact, it is this relationship that makes a pond work. The plant forms are the many different forms of bacteria and algae which can use soluble substances as food by absorbing it through their skin or membrane. The animal forms are higher species of free-swimming creatures who use solid matter and bacteria and algae as food by ingesting it through their mouth.

Paramoecium

Vorticella

The microbiology of a lagoon system is important to its operation. An inexpensive microscope can be used by the operator to identify what is happening in the pond. For example, most of the work is done by microscopic bacteria which utilizes the organic substances as food and under the right conditions will come together, form floc and become heavy enough to settle. Other undesirable bacteria may also form which are stringy (filamentous) and are difficult to settle. These become more numerous at low pH's, 6.5 or lower, or in a carbohydrous waste. Green algae of the Chlorella species are desirable because they are mobile and stay near the surface. Filamentous algae have a bluish-green color and are undesirable. Various other algae with different colors can be found in ponds, such as:

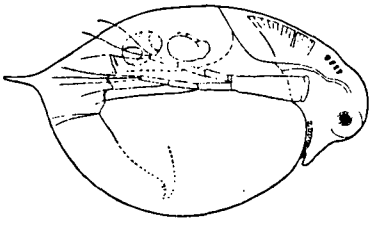
Pyrrophyta - greenish tan to golden brown
Phaeophyta - brown
Rhodophyta - red

The last two are found in marine lagoons. The color change is due to pigmentation.

The Role of Bacteria

Bacteria can be classified as those that must have oxygen to live (aerobic) and those that live in an environment without oxygen (anaerobic). Both types break down complex organic substances into soluble matter which passes through cell walls and is converted into energy, protoplasm and end products which diffuse out through the cell wall into the surrounding liquid. While the intake and conversion processes are much the same, the end products are not. Typical products produced by the aerobic bacteria are carbon dioxide, ammonia and phosphates. These are essential food elements for the oxygen producing algae. The anaerobic bacteria which live in the oxygen starved bottom layer of a pond produce carbon dioxide, hydrogen sulfide, ammonia and other soluble material which is diffused into the water as a gas or is used by the aerobic bacteria as food.

Rotifers and crustaceans are often found in ponds where they survive by feeding on the bacteria and algae. One of the most common forms are Daphnia. Oftentimes they can clean a pond of the green algae.

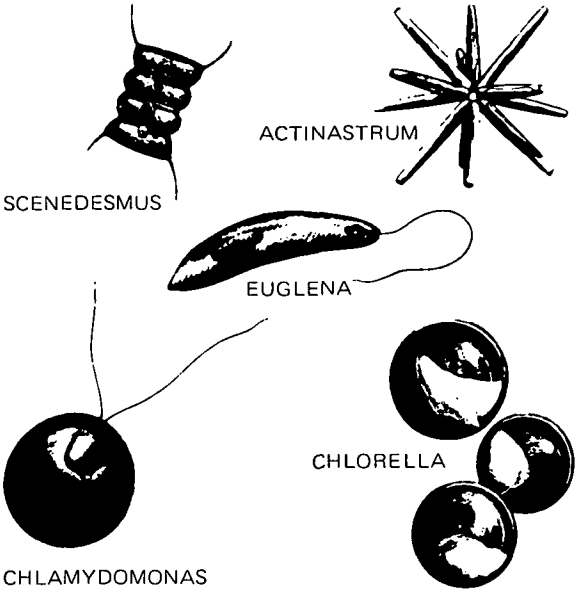


The Role of Algae

As stated earlier, the aerobic bacteria require oxygen for their respiratory system in order to stay alive. This use of oxygen is called **oxygen demand** and any oxygen remaining is measured as free **dissolved oxygen** (DO). Water will hold only a certain amount of dissolved oxygen, at which point it becomes saturated. Saturation is dependent upon water temperature. When more than this given amount is present in the water, the water is said to be supersaturated. Cold water can hold more oxygen than warm water per cubic foot.

The demand for oxygen increases as the bacteria and algae increase. And both the bacteria and algae increase as the food supply increases, i.e.: the organic loading.

There are two sources for oxygen. One source is diffusion of air into the water from the atmosphere. The other source is from algae.



Algae are microscopic plants and live in much the same manner as grass or your garden vegetables. They contain chlorophyll which converts sunlight into energy to degrade complex compounds into simpler products and for growth. This phenomenon is called **photosynthesis**. Other basic requirements are nutrients, principally carbon, nitrogen and phosphorus. And, like your garden vegetables, they grow best under warm temperatures and die off with cold temperatures. The most important role that algae perform in a pond is the production of the major portion of the oxygen.

Since algae need sunlight, they will be found near the surface of a pond. This is called the aerobic layer. The depth of this layer is dependent upon climate and density of algae. It is normally between 6 and 18 inches (15-46 cm), but this layer may extend down to 4 ft. (125 cm) in a well mixed pond. At night, algae will require oxygen in their respiratory system. Thus, when the sun goes down, the algae do not die, but continue to function and consume oxygen, although they have stopped oxygen production. This explains why the dissolved oxygen level will be at its lowest point immediately after sunrise.

There are many forms of algae to be found in ponds, however, two important classifications appear which can be related to the quality of the pond.

1. One is the so-called green algae which gives a pond a green color and indicates a good healthy condition. They are associated with a high pH and with a waste high in nutritional value.

2. The blue-green algae are filamentous and appear when the nutrient and pH levels are low or survive when the higher animal forms such as protozoa devour the green algae. Therefore, the appearance of blue-green algae in a pond is an indication of poor conditions.

Pond loading has a direct bearing on microbial (bacteria and algae) life within a pond.

A. The microbial population will be greatest near the influent and decreases toward the outer edge of a pond.

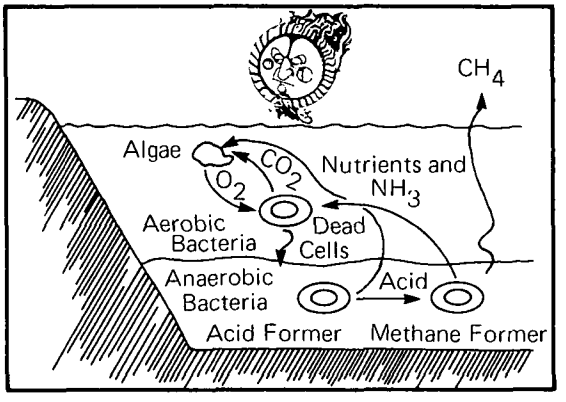
B. At low organic loadings, various protozoa (predators) will appear such as Daphnia and Paramecium, which utilize the algae and bacteria as food. Operationally you would not expect to see any of these forms in a primary cell but, would see them in the polishing pond. There have been cases where the predators have caused a pond to clear up and other cases where predators are found, the pond remains green. This is because blue-green filamentous algae is present, which the predators do not touch.

C. Overloaded ponds create a rapid growth by both bacteria and algae, which in turn creates an oxygen demand that cannot be satisfied by either the algae or wind action. This results in algae die off as seen by floating mats of algae and a decrease in dissolved oxygen. It can easily reach a state where the entire pond will become anaerobic.

One of the biggest problems or deficiencies of oxidation and stabilization ponds is the amount of algae contained in the pond discharge. Algae, in this case, contributes significantly to the suspended solids being discharged to a receiving stream. The most common method used to reduce the amount of algae is to use a draw off point below the algae layer. In the mid-part of the nation, discharge is limited to twice per year when algal content is low and effluent is in the best condition.

There are several other methods available to reduce the algae concentration; rapid sand filtration, submerged rock filters, alum coagulation, mixed media filters, and chlorination. Of the listed methods, all except chlorination will add considerable cost and man-hours for algae removal. Chlorination can effectively kill the algae but, the dead algae cells will release stored organics and thus contribute to the BOD load being discharged. It is true that this BOD is quite stable and inoffensive, but it will decrease the oxygen in the receiving stream.

When wastewater is discharged into a pond, the heavy solids settle out near the inlet where two types of anaerobic bacteria stabilize the organic matter. This is shown in the following simple diagram.

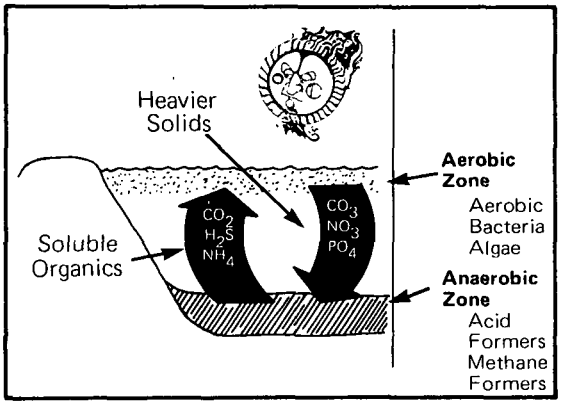


Waste stabilization occurs in two steps:

1. **Acid bacteria** break down the complex organics and use the **soluble matter** as food which is converted into **organic acid**.

2. The organic acid is used as food by the **methane bacteria** which convert the acid into carbon dioxide (CO_2), ammonia (CH_4), hydrogen sulfide (H_2S) and methane gas.

The byproducts of anaerobic decomposition are soluble in water and become food material for the aerobic bacteria and algae. Algae require carbon, nitrogen, nutrients and sunlight. Sufficient sunlight energy may be available in depths from 12 to 18 inches (30 to 46 cm), hence, algae are only found near the surface. When these are available the algae produce free oxygen which is required by the aerobic bacteria. When light energy is not available, such as nighttime or when the surface is covered with ice or duckweed, the algae do not convert the carbon dioxide, therefore no oxygen is produced. The aerobic bacteria in the surface layer, using the free oxygen, feed on the soluble organics in the raw waste as well as the soluble by-products of anaerobic decomposition. In turn they produce some inert material, which settles to the bottom, and dissolved sulfate, nitrate, phosphate and carbonate compounds required as the source of energy by the anaerobic bacteria. Thus, in most ponds the treatment process is a complex interaction between two separate bacterial communities and algae. Each is doing something useful for the other. This is shown below.



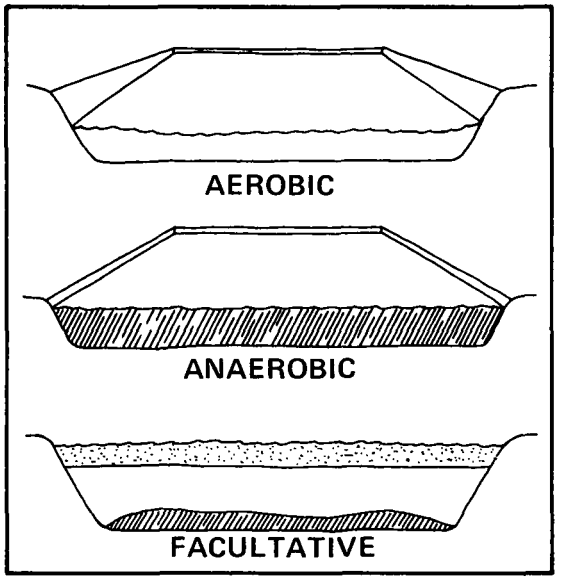
HOW ARE WASTES TREATED

Regardless of the treatment devices used, treatment usually proceeds along similar lines. Settleable solids are removed first either in a pond or in separate primary clarifiers. If the solids are removed from the flow by settling in a primary clarifier, the solids will be handled in separate facilities such as anaerobic digesters. If raw solids enter a pond, the settleable solids will settle out near the inlet and undergo anaerobic decomposition as in an anaerobic digester. This is one reason why the first cell in a series is called a **primary cell**.

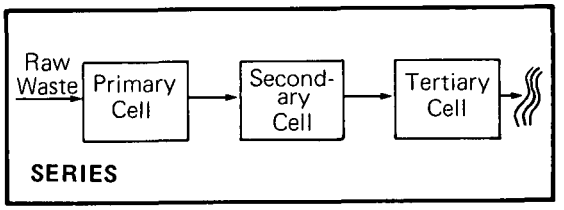
The next step in treatment of wastes is called secondary treatment. This is a biological reaction step in which organic dissolved and suspended matter is oxidized (converted) by bacteria into **stable** end products, thus reducing the BOD and suspended solids. In ponds, this step is usually accomplished in both the primary and secondary cells. A third step in treatment is often designed into a treatment system which involves polishing treated wastewater. These ponds are lightly loaded and used to remove additional BOD and suspended solids. They are referred to as **tertiary** or **polishing** ponds and can be the last cell in a system or as a single pond following conventional secondary treatment.

TYPES OF PONDS

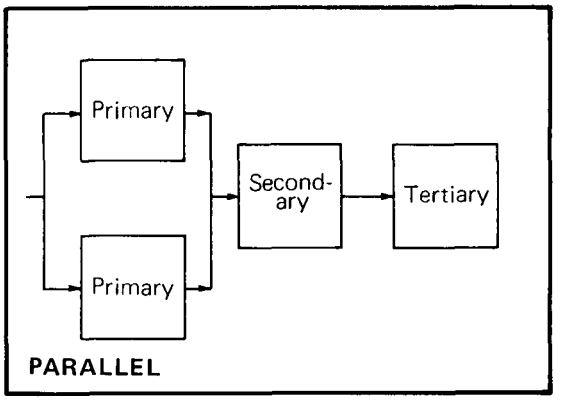
Oxygen demand determines the type of ponds required. Aerobic types have oxygen distributed throughout the water. Anaerobic ponds are devoid of oxygen. Facultative systems have an aerobic surface layer and an anaerobic bottom layer.



Wastewater is treated in various types of ponds or lagoons which are named according to the type of treatment involved. Lagoons are bodies of water confined within natural boundaries, while ponds are shallow and manmade. Treatment usually occurs in two or more ponds called **cells**. These cells are arranged in series with water flowing from one cell into another. For example, in a stabilization pond, influent enters a primary cell, then flows into a secondary cell, then into the polishing cell.



Many systems are arranged so that two or more primary cells can receive the plant flow. In these cases, the plant flow enters a distribution manhole or a box which is gated or valved to divide and direct the flow into the primary cells. This is called parallel operation. Effluent from these cells then follows the usual series pattern to obtain the maximum solids and algae removal prior to discharge. From an operational viewpoint, series operation normally will provide the best treatment if the actual loading is below the design loading. This is because of the detention time. Parallel operation for the primary cells is most often practiced when loadings exceed the design and for winter operation.



Ponds and lagoons are designed as continuous discharge, controlled discharge, or no discharge. Ponds designed and operated as continuous discharge must usually disinfect the plant effluent with chlorine in order to destroy the pathogenic (disease causing) organisms.

Controlled discharge is used when the wastewater is held for long periods of time before discharging. The discharge periods are usually twice a year. The selected period is based on two factors: the condition of the pond contents and the condition of the receiving stream. In general, these ponds discharge

shortly after the ice break up in the spring and shortly after the first frost in the fall. One reason these periods are selected is that the algae mass is at its lowest concentration. Deep ponds often experience a "spring turnover" problem when the ice melts and the pond warms up. This is due to increased biological activity and bottom sludge floating to the surface causing temporary odor problems. Most of the time, this will last between 2 to 15 days.

No discharge ponds are those designed to take advantage of an area's evaporation rate and/or ground percolation. In these cases the rate of evaporation and/or percolation equals or exceeds the inflow rate. Often one of the most difficult operating problems associated with these ponds is controlling water depth to discourage weed growth. This can be helped by deliberately adding water to the pond.

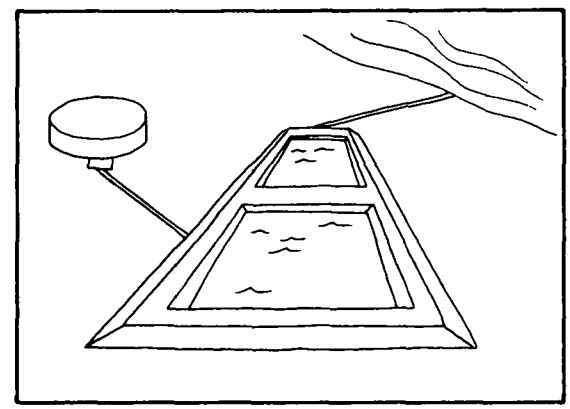
Regardless of type of pond, best operation is only achieved when the entire pond is used. When no water movement occurs in a portion of a pond, a condition called **short-circuiting** results. Short-circuiting can be caused by poor design of inlet and outlet piping arrangements or by uncontrolled growth of water weeds. If either of these conditions occur, they must be corrected.

As mentioned previously, the three major categories of ponds are aerobic, anaerobic, and facultative, other ways of describing them are found in textbooks or are in common use in different parts of the nation.

Some of these definitions are given below. The reader should remember that these are examples of one or more of the above major types.

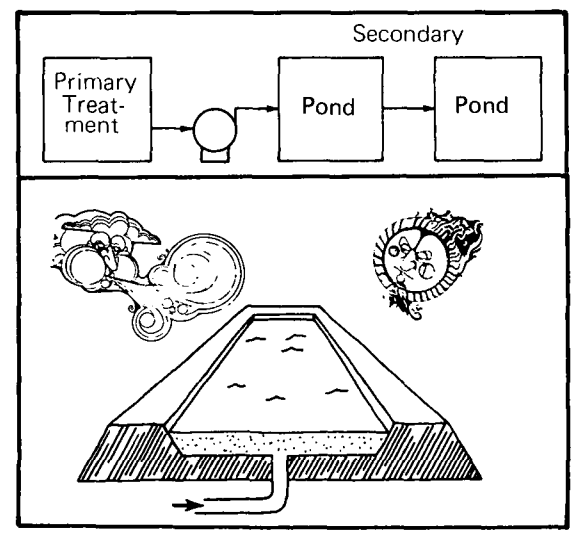
STABILIZATION PONDS

Receive raw untreated wastes and usually consist of two or more cells (individual ponds). The first cell which receives the untreated waste is called a primary cell. The following cell is a secondary cell which is often followed by a polishing cell (or tertiary cell). Stabilization ponds are often designed with two or more primary cells so that they can be operated in parallel to prevent overloading problems.



OXIDATION PONDS

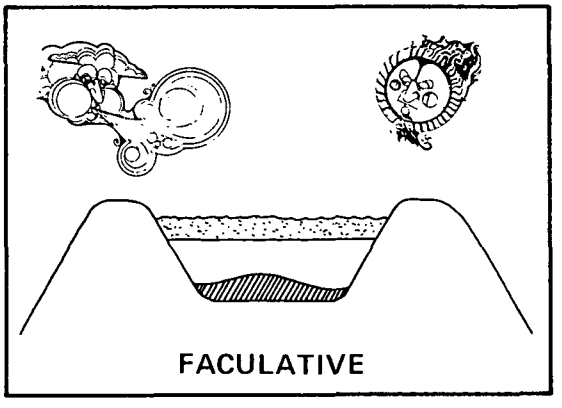
Ponds receiving treated waste and operated in series are called oxidation ponds. These may serve as secondary treatment following a standard primary plant.



Most stabilization and oxidation ponds stabilize organic wastes through a complex natural process involving sunlight, oxygen, water currents, algae and bacterial action. Stabilization and oxidation ponds require large surface areas, shallow depths and long detention times for natural stabilization to occur.

FACULTATIVE PONDS

Facultative ponds are the most common type of ponds used for stabilization and oxidation lagoons. They have two zones of treatment: an aerobic surface layer and an anaerobic bottom layer. Facultative ponds operate with 3 to 8 feet (1 to 2.4 m) of water depth and are usually loaded between 15 and 80 lbs. BOD per acre (17 and 90 kg per ha) per day. Oxygen for aerobic stabilization in the surface layer is provided by algae and wind action. Decomposition of the sludge in the bottom zone takes place anaerobically. The lagoons are usually designed to provide sufficient waste dilution and natural aeration to insure that the surface liquid will remain aerobic.



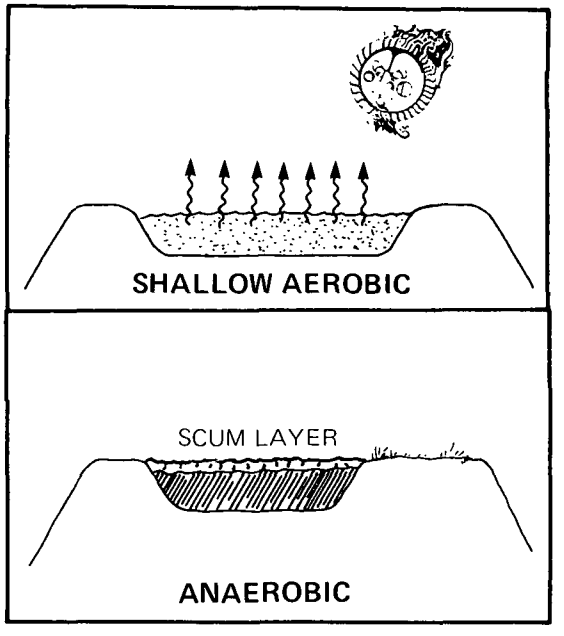
An existing stabilization or oxidation pond can be upgraded by either increasing its detention time or decreasing its surface BOD loading or both. Another method is to deepen the pond and install mechanical aeration. Generally speaking, cold climates may favor the use of compressed air. Intermittent seasonal operation or high oxygen requirements usually favor mechanical aerators or diffused aeration pipelines.

Other ponds are built to serve special purposes.

SPECIALTY PONDS

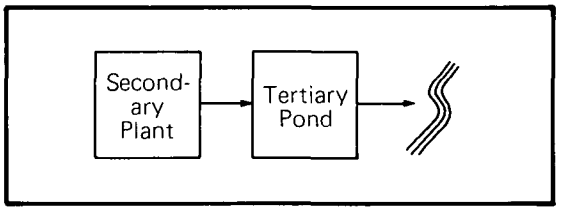
These include high rate aerobic ponds, anaerobic ponds, tertiary ponds, and aerated lagoons.

High Rate Aerobic Ponds are usually limited to applications where a high algal mass is desired for harvesting. The algae is then used as food for cattle. These ponds are shallow (about 12-18 inches [30-46 cm]) and usually loaded from 60 to 200 lbs. of BOD per acre (67 to 224 kg per ha) per day.

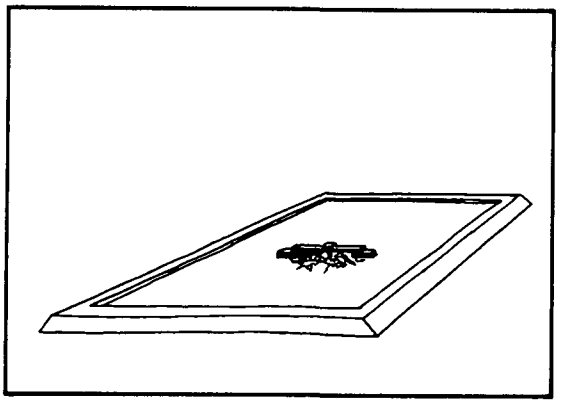


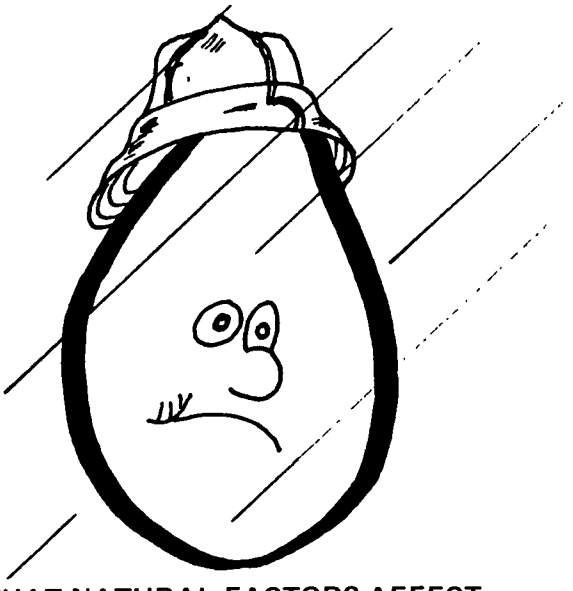
Anaerobic Lagoons are ponds designed to treat high oxygen demand wastes such as slaughterhouse wastes. The organic loads are so high in these ponds that anaerobic conditions prevail throughout. These ponds are similar to anaerobic digesters or septic tanks.

Tertiary Ponds are used for polishing effluents from conventional secondary treatment processes. They are also often used as the last pond of a stabilization or oxidation pond system to remove algae before the effluent is discharged. These ponds are similar to facultative ponds except that they are very lightly loaded, usually less than 15 lbs BOD per acre (17 kg per ha) per day.



Aerated Ponds are employed in those cases where supplemental oxygen is needed due to high organic loadings. For example, when a facultative pond becomes overloaded it uses more oxygen than it produces and turns anaerobic. One method to increase oxygen is to install powered aeration equipment. Many ponds are being designed and operated with aeration systems to permit higher loadings in smaller spaces. These ponds then get essentially all of their oxygen by mechanical means and very little algal mass is formed.





WHAT NATURAL FACTORS AFFECT THE PROCESS

Wind Action

Wind action creates surface mixing on ponds increasing with surface area. Large ponds need riprap on dikes for protection. Wind also tends to remove oxygen from the water when the pond is supersaturated. When the dissolved oxygen is less than saturation, wind action helps to drive oxygen into the water.

Temperature

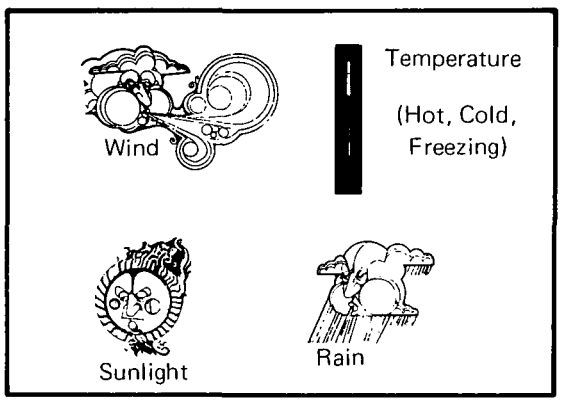
Water will hold more oxygen per cubic foot at a cold temperature than at a warm temperature. As an example, water in the winter time will hold almost twice as much oxygen as in the summertime. However, in colder climates, ice cover prevents adding DO by wind and snow cover prevents algal action for DO production.

Biological activity decreases with temperature, a 10-degree drop in temperature will reduce microbial activity by one-half.

Best conditions are when it is warm with good sunlight and a moderate breeze. This produces the greatest bacterial activity and hence the highest BOD removals from the raw waste.

Normal slow changes in temperature produce long-term seasonal effects such as changes from spring to summer.

Abrupt or sudden temperature changes bring about short-term problems. For example, a sudden rise in temperature causes the bacteria to multiply at a rapid rate causing the oxygen demand rate to increase faster than the slower algae can supply the necessary oxygen. This may result in a more turbid effluent than is normal. A sudden drop in temperature can cause a pond to clear up. This occurs because the algae activity slows down and they settle out. An example of this is a sudden frost in the spring or fall. This is normally the time when ponds with controlled discharge are lowered.



As the weather gets colder and daylight becomes shorter, bacterial and algae activity gradually gets slower. In northern freezing climates during extended cold periods the rate of biological activity becomes quite slow. Ponds located in areas where they are covered with ice may experience a "spring turnover" when the weather warms enough to melt the ice if drastic changes occur. This condition is accompanied by rising chunks of sludge and unpleasant odors which may persist for a month or so. Cold weather also brings about an increase in the concentration of ammonia nitrogen as compared to the warm months.

Example: Jan. 6-10 mg/l
May 3.0-0.1 mg/l

The concentration of phosphorus is greatest during cold weather. On the other hand, suspended solids is lowest during cold weather due to decreased algae activity.

Warm weather brings about a great increase in algae growth. Operators can expect to see clouds of "algae blooms" which stops light penetration and reduces oxygen production. The increase in algae growth also causes an increase in suspended solids plus an increase in oxygen demand (BOD) in the effluent of flow through ponds.

Warm weather increases evaporation rates which will change the detention time and may affect the amount of effluent that is discharged.

The arrival of spring also brings on heavy growth of water weeds which may change the pattern of water movement. Scum mats also form on the surface. Both scum and water weeds form excellent breeding grounds for mosquitoes and other insects.

Periods of heavy rainfall affect pond operations as the increased volume of water coming into the pond dilutes the organic waste, it may change pond temperature, will cause a sudden increase in water depth and may shorten detention time.

Sunlight

Sunlight is indispensable to effective operation of stablization ponds through photosynthesis of algae in producing oxygen.

The percentage of available annual sunlight varies throughout the country which is governed by latitude (which governs seasons), elevation and cloud cover. The amount of available sunlight helps to determine how well

the pond operates and the area and depth needed for proper operation.

The depth of sunlight penetration determines the extent to which the pond volume participates in oxygen production and hence, the optimum pond operating depth. Loss of light by reflection increases up to 30 percent when the surface is roughened by the wind.

Algal density, which varies from season to season and pond to pond, determines the depth of light penetration and intensity. In general, with good algal growth and dispersion, oxygen production will be good up to about 24 inches (60 cm) in depth. Oxygen production does not meet the oxygen demand beyond this depth without vertical mixing by wave action. The pond operator can do much to maintain optimum oxygen production by removing duckweed or other materials that reduce light exposure.

All of the preceding remarks can be related to operation by the following summary.

A. Do not decrease water depth to less than three feet (1 m) for warm weather operation.

B. Keep algal blooms dispersed.

C. Keep pond free from duckweed hyacinth or similar weeds.

HOW PHYSICAL FACTORS AFFECT TREATMENT

Surface Area

Surface area is determined by organic loading (lbs. of BOD per acre per day) and is called the **surface loading rate**. Surface loading determines the type of pond. For example:

- Aerobic Ponds 60-200 lbs. BOD/Acre/Day (67-224 kg per ha)
- Facultative Ponds 15-30 lbs. BOD/Acre/Day (17-35 kg per ha)
- Anaerobic Ponds 200-1000 lbs. BOD/Acre/Day (224-1120 kg per ha)
- Tertiary Ponds 5-15 lbs. BOD/Acre/Day (6-17 kg per ha)

Sometimes surface loading is related to the connected population such as 100 persons per acre per day for facultative systems, but the type of pond will determine the exact figure.

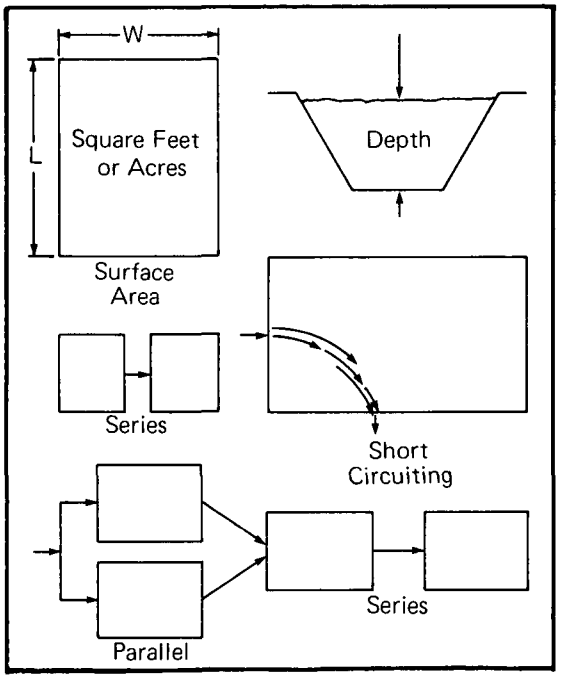
As an example of surface loading, if the organic load is 300 lbs./day, (336 kg/day) on a facultative pond, a minimum of 10 acres (4 hectares) may be required.

Water Depth
Water depth will vary, particularly in ponds that are being filled for the first time or in systems that operate on a seasonal cycle for controlled discharge.

To start a new pond, two feet (0.6 m) of water should be added prior to fresh starting wastewater feed. In controlled discharge systems, primary cell should not drop below three feet (0.9 m).

Maintaining a minimum level is necessary to prevent exposing sludge blankets on the bottom to atmosphere thus preventing odors and also to prevent allowing the pond bottom to dry out and crack.

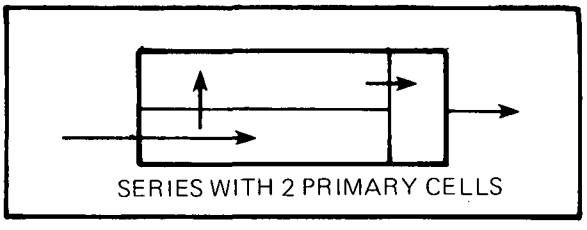
Short Circuiting
Regardless of type of pond, best operation is only achieved when the entire pond is used. When no water movement occurs in a portion of a pond, a condition called **short circuiting** results. Short circuiting can be caused by poor design of inlet and outlet piping arrangements, unlevel bottoms, shape of cells, predominant wind direction, or by uncontrolled growth of water weeds. If any of these conditions occur, they must be corrected. Methods of correction are described in the troubleshooting section. Short circuiting in ponds leads to many problems, including dead spots which reduce the area of effective treatment and also contribute to odor problems and sludge mats.



Series Operation
Series operation, particularly when three or more ponds are used, tends to minimize the amount of algae in the last cell and should result in better quality effluent. As a result, ponds are often operated in series during the warmer months, when algae production is highest.

Series operation during winter leads to special problems when ponds are under an ice cover. The first cell can become overloaded and, when warm weather returns, the cell may be septic and produce unwanted odors and sludge which has floated to the surface.

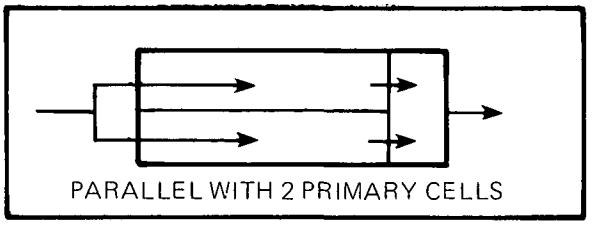
Plants that are designed with at least three cells have the ability to operate the first two as primary cells and during summer months run these in series to minimize algae growth when the flow reaches the secondary cell. Those plants that use controlled discharge during spring and fall find the best results by allowing the first cell to fill to at least three feet (9 m) or more then transfer to the next cell in succession in increments of 6 inches (0.15 m) until the ponds are at maximum or time for discharge arrives.


SERIES WITH 2 PRIMARY CELLS

Parallel Operation

Parallel operation is used to reduce organic loading in the primary cells. Parallel operation is especially advantageous during winter months so that sewage solids can be distributed over a wider area.

Winter month operation in parallel has the advantage of distributing the load over more surface pond area and this is particularly important when ice covers develop and activity is low. Again, for plants with three cells, the first two should be used in parallel and if the system operates on a controlled discharge, primary cells should be filled at the same time once both are at the 3-foot (9 m) depth and then alternately discharge 6 inches (0.15 m) at a time into the secondary cell until it reaches the same depth as both primaries.



PARALLEL WITH 2 PRIMARY CELLS

Recirculation

Recirculation is a means of improving pond conditions. This allows oxygen that has been produced by the algae in one pond, or part of the pond, to be mixed with low oxygen areas of the system. Other advantages include a mixing to help prevent odors and anaerobic conditions in the feed zone.

The most common method of recirculation is to recycle effluent from a secondary cell to the effluent of the primary cell. This method obtains the greatest amount of dissolved oxygen.

HOW CHEMICAL FACTORS AFFECT TREATMENT

Oxygen

Oxygen is necessary for maintaining the life forms in an aerobic pond. It is used by the bacteria to stay alive. Oxygen combines with many substances to form oxides and break up many complex organic molecules into simpler molecules making them more available to the bacteria. Since oxygen is used to oxidize these organics, the DO (dissolved oxygen) will decrease in proportion to the amount of organic material present. This is known as the **oxygen demand** of the waste.

Water will only hold a certain amount of dissolved oxygen. When the amount of air/oxygen entering the water equals the amount leaving the water, it is said to be **saturated**. In ponds containing algae, the water can become super-saturated with oxygen (more oxygen enters water than is used).

Wind also tends to remove oxygen from the water when the pond is super-saturated. When the dissolved oxygen is less than saturation, wind action helps to drive oxygen into the water.

The strength of the waste can be indirectly measured by the biochemical oxygen demand

(BOD) test. The test measures the amount of oxygen used by the bacteria over a 5-day period. If the demand for oxygen is greater than the supply, the aerobic bacteria will die off and anaerobic conditions will develop along with operational problems. Low dissolved oxygen concentrations result in turbid effluents, bad odors, and the growth of filamentous type of bacteria.

Nutrients

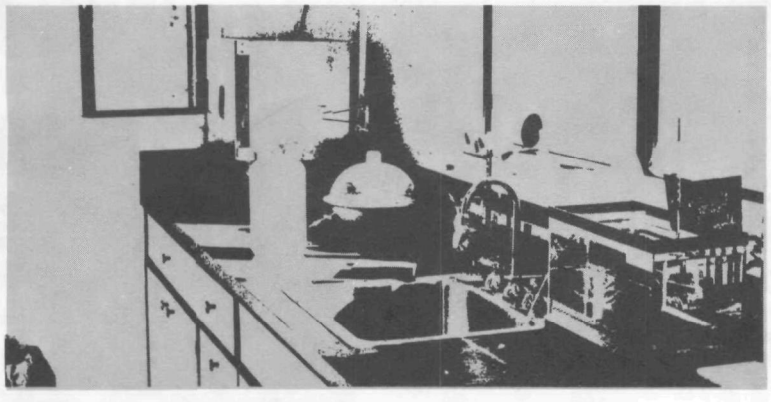
Without a sufficient supply of nutrients (nourishment), the bacteria will not be able to grow and multiply. Although several elements are needed, nitrogen and phosphorus are the principal elements required. Domestic wastes usually contain enough of both. Nitrogen is in the form of ammonia (NH_3).

pH

This test indicates whether a pond is acid or alkaline. Both the aerobic and anaerobic systems require an alkaline environment for best operation. Operators should check pH of the pond effluent to determine if any toxic materials are entering the pond. The pond color is related to pond pH and should help operators to forecast any impending problems. Green shows a high pH (alkaline). Yellowish-green indicates a lowering pH (acidic). Color may not relate to pH when a strong wind stirs up silt from the bottom or highly colored industrial wastes influence the pond's color.

A lowering pH can be corrected by letting the cell rest for a few days. The pH will change throughout the day and will usually be at its lowest in the early morning and highest in the late afternoon, because algae are most active during daylight and cause chemical reactions that drive pH upward. (CO_2 produced by bacteria at night causes the pH to be lowered.)

2. Control Information for Ponds



Sample collection
Types of samples
Sample point locations
Tests and measurements
Important visual indicators
Other daily data

2. Control Information for Ponds

Adequate control of the process is necessary to meet assigned discharge requirements. It is necessary to know the quantity, concentration, and type of waste entering the plant. It is also necessary to know what is happening in the pond and what is going out of the pond. Therefore, there are three major points of measurements: The plant influent, the pond and the plant effluent. Several tests must be run on samples of wastewater taken at each of the major points. These are: Flow, temperature, pH, dissolved oxygen (DO), BOD, suspended solids (SS), fecal coliform, and also chlorine residual when disinfecting with chlorine.

The results of these control tests are often referred to as **control parameters** and are used to determine how well treatment is progressing to predict operational changes and to assess the results of treatment. For continuous flow through systems the following tests, flow, temperature, pH, and chlorine residual, can be easily performed by the operator on a daily basis with simple equipment such as a glass electrode pH meter, DO meter or DO kits, and a colorimetric comparator. BOD, SS, and fecal coliform tests require more time, costly equipment, and technical know-how. A small, part-time operation may therefore elect to collect samples for these tests, but send them to local chemical laboratories for analysis.

Systems that operate on a controlled discharge basis will need to concentrate testing during the period prior to and during discharge as required by their regulatory agency.

Weather is one of the most important factors affecting pond operation. Knowledge of weather conditions will help to explain many things about pond operation.

SAMPLE COLLECTION

The collection of test samples of wastewater is the basis for obtaining accurate test results. **TEST RESULTS ARE ONLY AS GOOD AS THE SAMPLE.** Test samples must be **REPRESENTATIVE** of the waters being sampled. This requires selecting a point that will give a uniform sample. If the sample is to be stored before testing, it must be refrigerated. Sample containers must always be clean before sampling to avoid getting the wrong results. Temperature, pH, residual chlorine, and DO should always be taken immediately to avoid deterioration and should be taken at the same time each day. Occasionally though, it is a good idea to check these parameters at other times during the day to get a feel for the daily changes that occur. For example, if tests are normally run at 8:00 a.m. each morning, then perhaps every two months, take additional tests at 10 a.m., 2 and 4 p.m.

TYPES OF SAMPLES

A grab sample is a single sample taken at no set time or flow. Grab samples are used to measure temperature, pH, DO, fecal coliforms and chlorine residual.

Chosing the correct time to sample may be a problem because grab samples are only representative of conditions at the moment. Raw sewage flow varies in content, as well as

volume, during a typical day. One sample at any time of day cannot possibly be used for compiling data on a whole day's operation. For that matter, neither can three, four, or five samples. It remains for a decision to be made as to how many samples can conveniently be taken in a 24-hour period.

Samples of the pond will yield the most information if taken at sunrise and in mid-afternoon, with separate analyses run on the two samples.

Samples of effluent from controlled discharge ponds should be taken during discharge - perhaps one sample every two hours and combined into one composite sample. Each individual state has guidelines that are specific for their particular situation and should be consulted by the operator.

Composite samples are taken by gathering individual samples at regular intervals over a selected period of time. The individual samples are then mixed together proportionally to the flow at the time of sampling. For example, a composite sample might be made for Tuesday covering the period from 8 a.m. with a sample collected at 8 a.m., 10 a.m., 12, 2 p.m., and 4 p.m. Each individual sample must be refrigerated immediately to avoid deterioration.

At each sampling time the flow must be recorded for use at the end of the sampling period. At the end of the sampling period, remove the samples from the refrigerator. Then, stir each one and pour an amount of the samples proportional to the flow at the time the sample was taken.

Composite samples are needed to test and measure for BOD and suspended solids.

See Appendix B for a sample calculation on compositing.

Automatic Samplers. There are a number of kinds of automatic samplers on the market. Some are battery-powered and self-contained; others must have an external power source. All offer sampling at chosen intervals, some as frequently as every 10 minutes, and compositing of samples on the spot. This equipment is most valuable for sampling raw sewage flow but can be used for effluent as well. Whether this type of equipment should be purchased for waste stabilization ponds would depend, somewhat, on the loading and the ease of getting representative composite samples by hand.

Handling and Preservation of Samples. Sewage samples deteriorate rapidly if subjected to summer temperatures and to some extent, freezing. Exclusion of sunlight is also recommended. For these reasons, collected samples should be transferred to a refrigerator where they can be stored until removed for analysis. A temperature of 40 degrees Fahrenheit (4^{o} Celcius) will prevent deterioration for 24 hours.

Containers used for sample storage need to be kept as clean as possible. Stoppered glass bottles or wide-mouth jars are preferred and are easiest to use for mixing and cleaning.

SAMPLE POINT LOCATIONS

Pond Influent

Samples of the raw wastewater can be obtained from several points:

1. The wet well of the influent pump station. One method is to use a bucket or container attached to a rod. The sample must be taken from a turbulent well-mixed point.

2. A manhole at the inlet diversion control structure.

Ponds

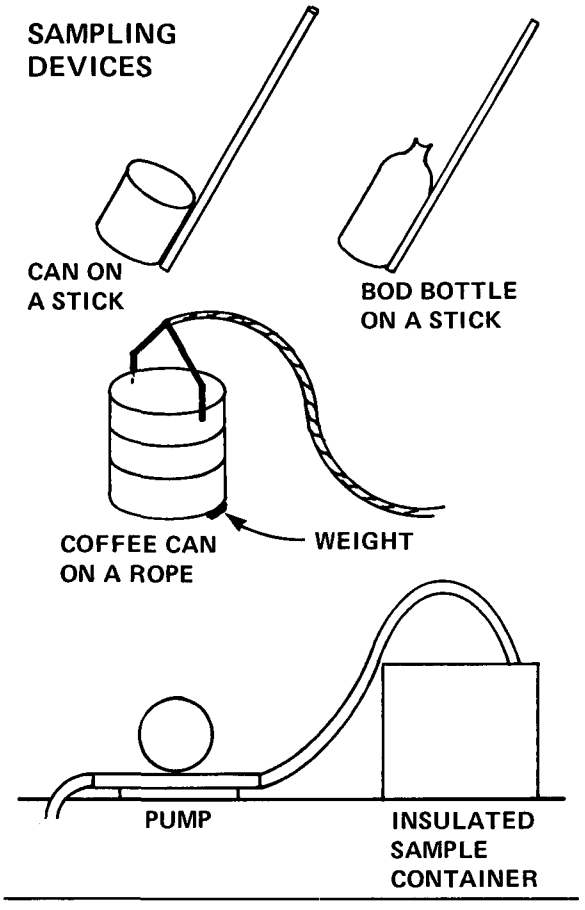
Pond samples should be composited consisting of four equal portions from four corners of the pond.

The sample should be taken eight feet (2.5 meters) out from waters edge and one foot (0.3 meter) below the water surface. This should be done carefully to avoid stirring up material from the pond bottom.

Pond samples should not be taken during or immediately after high winds or storms since solids will be stirred up after such activity.

Pond Effluent

Samples of pond effluent should be taken from the outlet control structure, or a well-mixed point in the outfall channel.



TESTS AND MEASUREMENTS

Test results along with visual indicators are used to operate the lagoon — to keep it alive and healthy. Following is a description of the important tests and measurements and what they do.

Temperature

The temperature of the raw wastewater can be used to detect infiltration and some industrial wastes. A sudden decrease in temperature may indicate warm industrial wastes. Since dissolved oxygen varies with temperature, it is often necessary to know how close to saturation the DO test is when it is run. This can be determined by the following oxygen saturation table.

SOLUBILITY OF OXYGEN IN FRESH WATER

°C	°F	O_2 (PPM)	°C	°F	O_2 (PPM)
0	32.0	14.6	26	78.8	8.2
1	33.8	14.1	27	80.6	8.1
2	35.6	13.8	28	82.4	7.9
3	37.4	13.5	29	84.2	7.9
4	39.2	13.1	30	86.0	7.6
5	41.0	12.8	31	87.8	7.5
6	42.8	12.5	32	89.6	7.4
7	44.6	12.2	33	91.4	7.3
8	40.4	11.9	34	93.2	7.2
9	48.2	11.6	35	95.0	7.1
10	50.0	11.3	36	96.8	7.0
11	51.8	11.1	37	98.6	6.9
12	53.6	10.8	38	100.4	6.8
13	55.4	10.6	39	102.2	6.7
14	57.1	10.4	40	104.0	6.6
15	59.0	10.2	41	105.8	6.5
16	60.8	10.0	42	107.6	6.4
17	61.6	9.7	43	109.4	6.3
18	64.4	9.5	44	111.2	6.2
19	66.2	9.4	45	113.0	6.1
20	68.0	9.2	46	114.8	6.0
21	69.8	9.0	47	116.6	5.9
22	71.6	8.8	48	118.4	5.8
23	73.4	8.7	49	120.2	5.7
24	75.2	8.5	50	122.0	5.6
25	77.0	8.4	51	123.8	5.5

Flow

Flow measurement is necessary for all ponds. Measuring the influent flow tells the operator many things about the operation.

1. It determines hydraulic loading and tells when a pond has reached or exceeded its hydraulic capacity. A hydraulically overloaded pond may not provide complete treatment because the biological activity may not be complete before water leaves the pond.

2. It is the only clue to describing the extent of infiltration.

3. When related to BOD and SS reductions, it describes its effect on overall treatment.

4. It provides the basic data for determining mode of operation (when the operator has these options) such as use of series or parallel operation, retention time, and what operating depth to use.

   Use series operation when flows are below design. Compute hydraulic loadings on basis of gallons per acre per day (Appendix B) or population equivalent.

   Storage capacity and operating depth should be calculated to determine the amount of discharge for intermittent discharge ponds. Drawdown of the pond should not exceed the minimum pond depth of approximately three feet required for weed control. Sample calculations are given in Appendix B.

5. Flows are required to translate BOD and SS test results into pounds per day. These should then also be calculated into loading of pounds per acre per day. Appendix B contains sample calculations. This information is then used with hydraulic loading to determine which operational mode to use, and with DO to determine the need for supplemental aeration.

6. Flow information is required for calculating chemical dosages. Effluent flows are measured as part of the tests for NPDES permit requirements indicating the effect of effluent on receiving waters.

   Periodic checks between influent and effluent flows should be made to determine the extent of either evaporation or exfiltration (loss of water by seepage into soil).

   Some examples of flow measuring devices are Parshall Flumes, V-notch weirs, floats, irrigation flume with markings, and using a pump station wet well with a known depth and recording pumping time multiplied by pump capacity.

   See Appendix C for a more complete discussion of flow measurement, determining the flow, devices.

pH

The pH of the influent and effluent will vary throughout the country among neighboring lagoons, and throughout the day on a given pond. This pH variability is due to several causes: the natural alkalinity and hardness of the water, the type and volumes of commercial and industrial wastes and the pond itself.

The pH of incoming domestic sewage normally is between 6.8 and 7.6. Algal reactions in lagoons can be expected to raise the pH to as high as 9.5 or above. pH is closely tied to the production of oxygen by the algae as they convert inorganic carbon to organic carbon. The combination of organic metabolism, alkalinity and time are needed to produce oxygen. This means that there must be food for the bacteria, enough natural alkalinity and enough detention time. If any of these are missing within the lagoon the pH will start to decrease toward the acid side with a possible drop in DO. Other changes may also occur, such as the disappearance of the green algae and the color of the pond changing to a blue-green.

The pH can be a good indicator of the pond's condition. Some of the abnormal causes for a decreasing pH are septic wastes coming in as a result of low flows, or it may be due to an acid industrial waste. Fluctuations may also be due to normal activity. The pH may be reduced during the night as a result of increased bacterial action and lower algal activity. This will cause the values to be lower at the pond bottom than at the top.

Dissolved Oxygen

Dissolved Oxygen (DO) is a good indicator of the activity of an aerobic lagoon. By watching trends in oxygen levels of the influent the operator can tell something about the strength of the waste load coming in. If the average DO concentration in the pond drops when measured under the same day-to-day conditions, it is an indication that the BOD loading may be increasing and corrective action should be taken. This might include distributing the influent to other ponds, mechanical aeration or the addition of sodium nitrate. The DO level in the cell may be used to determine when a discharge can occur from controlled discharge ponds. This level should be at or near saturation. Use a grab sample and test immediately.

Chlorine Residual

Chlorine residual is a test to determine the amount of chlorine present after the necessary detention time for disinfection (destroy fecal coliform bacteria). The general rule of thumb is to have 0.5 milligrams per liter (mg/L) after a contact time of 1 hour. Use a grab sample and test immediately. The operator should check the NPDES permit for the exact requirement as some states may not require disinfection, others designate a prescribed coliform minimum and others may require dechlorination.

BOD_5

BOD (5-Day Biochemical Oxygen Demand) is a measurement of the amount of oxygen required in a 5-day period by the microorganisms in consuming the organic material in the wastewater.

Basically, BOD indirectly measures the organic strength of the wastewater. It is important to measure the strength of wastewater in coming to determine pond loading in terms of pounds of BOD per acre per day and compare this with the pond design for operational changes such as series or parallel operation. Another use is to measure the impact of the organic strength on the receiving stream and also the amount of BOD reduction received from treatment.

Normal domestic sewage varies from between 150 and 250 milligrams per liter (mg/L) per day and treatment must reduce this to less than the level defined in the plant waste discharge permit.

Understanding BOD

The BOD test has been defined as a method of measuring the amount of dissolved oxygen consumed by living aerobic organisms while feeding on the organic materials in the sample. The test requires:

1. 300 ml of sample to be tested. This may be a diluted or undiluted sample.

2. Controlled temperature at 68 degrees Fahrenheit (20 degrees C).

3. Exclusion of all sunlight.

4. Exclusion of air (stoppered).

5. An initial DO supply, enough to last 5 days, plus 40 to 60 percent excess.

6. A representative group of aerobic organisms.

The test attempts to measure the dissolved oxygen demand on the receiving stream were the raw sewage discharged without treatment or the demand of the treated effluent. From the test results, the effectiveness of treatment in the pond can be determined.

As an example, it is assumed that two BOD tests have been completed. Results on the raw sewage are 200 mg/L and the pond effluent 27 mg/L. What do these results tell the operator and what can be done with the results.

First, observe what happened during the 5 days the tests were being incubated and what the numbers 200 and 27 really stand for.

200 mg/L BOD indicates that the raw sewage carries a potential oxygen demand of 200 pounds of oxygen for every 1,000,000 pounds of raw sewage, the effluent 27 pounds. The question now becomes: What was the difference in the raw and effluent samples to produce the wide difference in oxygen demand? If the requirements for the test are checked it is seen that all 6 of the previously mentioned items were controlled equally, so the difference in the numbers must be associated with an unknown. That unknown is the organic material (food) in the 2 samples. The organisms grew, lived and reproduced in proportion to their food supply. They also used dissolved oxygen in the process - in direct proportion to their numbers and rate of activity.

Since their rate of growth was apparently limited by their food supply, it is noted that BOD is in proportion to the organic materials (food) contained in the sample. Waste treatment in the pond becomes a method of reduction of organic materials (food) which leaves the effluent with a lower biochemical oxygen demand (BOD).

Next, consider the receiving stream. Each plant has been issued a discharge permit stating maximum pounds BOD to be discharged per day. How was this figure arrived at? Each plant places an oxygen demand on the stream by discharging effluent and as the stream follows its course, others are also contributing wastes. The limit says that if the stream is to be given a fair chance to recover before reaching the next known contributor, no more than the stated pounds of BOD can be added from an individual upstream plant.

To fully comprehend the effect of even a low, BOD discharge, requires computation of total pounds BOD discharged.

Example:

Flow: 49,000 gpd

BOD Effluent: 27 mg/L

1. 49,000 gpd x 8.34 lbs/gal = 0.4 million lbs. flow

2. 0.4 million lbs. flow x 27 mg/L BOD = 11 lbs. BOD discharged

The effect on the receiving stream may be illustrated by the following example:

lbs. BOD discharged 11 lbs.

mg/L DO in stream 7.5 mg/L DO

7.5 mg/L DO means 7.5 lbs. DO/1 million lbs. stream flow

11 lbs. BOD divided by 7.5 = 1.5 million lbs. stream flow

1.5 million lbs., divided by 8.34 lbs/gal = 180,000 gal. stream flow

This means there are 11 pounds BOD discharged to a stream carrying 7.5 mg/L DO could entirely strip **180,000** gallons of stream flow of all dissolved oxygen. Actually, the stream, by wave and ripple action, plus algae, is continually replacing the oxygen used, but at a limited rate.

Efficiency of BOD Removal

Last, it is of value to compute the efficiency of removal of BOD by the pond.

Example:

Raw BOD: 200 mg/L

BOD Effluent: 27 mg/L

ppm BOD Removed: 173 mg/L

173 ppm divided by 200 mg/L = .865 x 100 = 86.5% removal of BOD

The pond has reduced the BOD of the raw sewage flow 86.5 percent.

(The preceding illustration was taken from the publication *Operating Waste Stabilization Ponds*, EPA Region VII produced by Kirkwood Community College.)

Suspended Solids

Suspended solids (SS) test measures the dry weight of solids retained on an asbestos or glass fiber or millipore filter and is expressed in milligrams per liter.

Suspended solids removal is as important as BOD removal for preventing stream pollution. In normal domestic sewage the concentration of SS and BOD are nearly the same. Suspended solids are difficult to remove from lagoon effluents due to the high concentration of algae. Equipment required for this test includes a drying oven, a dessicator and a weighing balance.

Tests must always be run on composited samples from both the influent and effluent.

Fecal Coliform

Fecal coliform test indicates the possible presence or absence of pathogens (disease causing organisms). The source of this group of organisms are man, mammals, and birds.

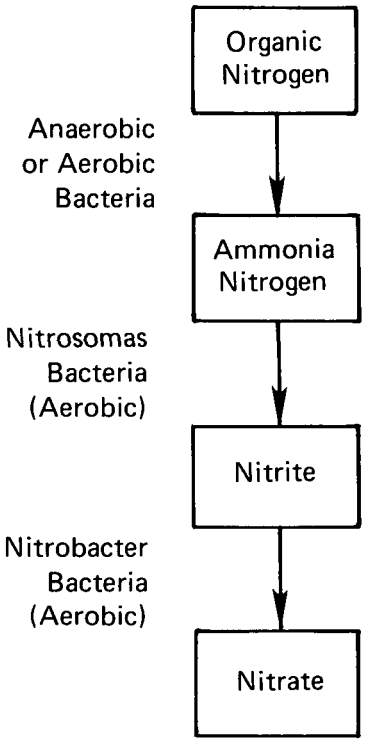
Tests are always run on grab samples collected in a sterile container and must be run within 6 hours of sampling.

Nitrogen

Nitrogen testing may be required of those plants discharging into a lake, reservoir or large body of water. Wastewater contains organic nitrogen which is an essential nutrient for algae. Organic nitrogen is converted to ammonia nitrogen by bacteria as protein is broken down. The ammonia nitrogen is further oxidized to nitrites and then to nitrates by nitrifying bacteria. This latter step is known as **nitrification**. In some cases, it is necessary to remove nitrate in order to control algae growth. Oxygen is removed under anaerobic conditions (the nitrate is a source of oxygen for the anaerobic bacteria), and the nitrate is reduced to nitrogen gas. This step is called **denitrification**.

As an indicator of pollution the presence of ammonia nitrogen indicates polluted waters, the presence of nitrites still shows pollution but nitrates indicate that nitrification has proceeded sufficiently to produce a stable nitrogen compound.

The following diagram illustrates the steps in nitrification.



In most oxidation ponds, nitrification does not appear, at least on a continuing level. The reason for this is explained by the fact that the nitrifying bacteria tend to settle or need to cling to some surface. Therefore, they are not exposed to compounds in solution.

It has been found that concentrations of more than 20 mg/L of nitrogen can be harmful to fish life, therefore, many pond discharges are required to test for total nitrogen.

Some plants are also required to test for nitrates and ammonia. The significance of these tests are:

A. If nitrification is occurring, there will be an increase in nitrate with a corresponding decrease in ammonia-nitrogen.

B. In well-nitrified effluent all of the ammonia nitrogen will be converted to nitrates.

IMPORTANT VISUAL INDICATORS

Color

The color of the pond is directly related to pH and DO. Below are listed the usual general color characteristics.

Dark sparkling green - good; high pH and DO

Dull green to yellow - not so good, pH and DO are dropping; blue-green type algae are becoming predominant

Gray to black - very bad; pond is septic with anaerobic conditions prevailing

Tan to brown - OK if due to a predominance of a type of brown algae. Not good if due to silt or bank erosion.

OTHER DAILY DATA

Weather

Weather has a great influence on the pond's activity as discussed in Chapter I. Records showing such factors as periods of sunshine, cloudiness, weather temperature, period and extent of rainfall and percent of ice cover, often explain what has happened in the pond, the quality of effluent and/or expected storage. For example, in continuous flow systems, for extended cloudy periods of two weeks the operator could expect to see an increase in BOD in the final effluent and a reduction in suspended solids. Weather forecasts are important too, especially for a pond that is near the design loading limit. Increasing BOD in the effluent could indicate to the operator that it is time to change flow patterns; such as to parallel operation for the winter season.

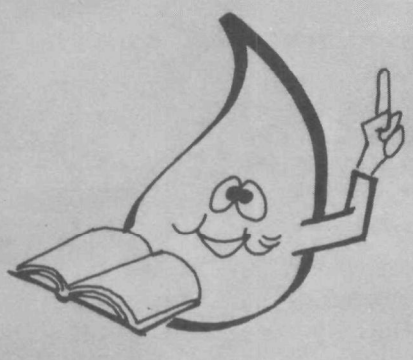
Water Depth

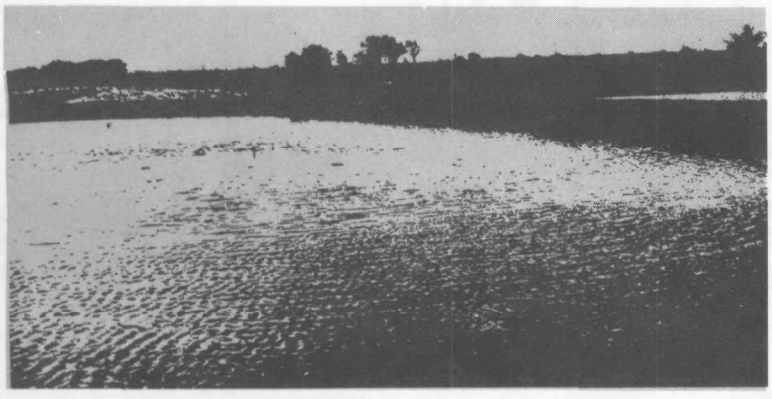
Water depth in continuous flow systems plays an important role in pond operations. Abrupt decreasing changes in water depth can signal a leak or excessive percolation, while a sudden increase may foretell a large spill into the system by a user, or that the collection system is experiencing storm water infiltration. Water depth that remains unchanged can indicate that pipelines are plugged. Water depth changes in controlled discharge systems are normally a part of regular operation and rapid changes are part of the operation procedures.

Ice Cover

Ice cover is important to record as it relates the extent of biological activity and which one is predominant, aerobic or anaerobic. The usual reporting shows percent of pond area covered and how long the ice cover lasts.

3. Operation and Maintenance for Ponds





Operation and maintenance goals for stabilization ponds

Operation and maintenance goals for anaerobic ponds

Operation and maintenance goals for aerated ponds

Plant checklist

Hints to improve operation

Pond cleaning

Starting a pond

Discharge control program for seasonal discharges

3. Operation and Maintenance for Ponds

OPERATION AND MAINTENANCE GOALS FOR STABILIZATION PONDS

1. The pond effluent should:
   a. Meet the NPDES or other regulatory permit levels for BOD and SS for continuous flow systems.
   b. Discharge when it has the best quality and will effect the receiving stream the least.

2. The primary cells should have a deep green sparkling color which indicates high pH and DO.

3. Secondary or final cells should be high in DO and provide an effluent that will meet discharge limits.

4. The surface water should have wave action when wind is blowing. The absence of good wave action may indicate anaerobic conditions or an oily surface.

5. A good pond has no weeds growing in the water nor tall weeds on the bank to stop wave action.

6. Dikes are well seeded above the water line with grasses and kept mowed. This prevents soil erosion and insect problems.

7. Erosion of dikes is prevented at water's edge by the use of riprap, broken concrete rubble or a poured concrete erosion pad.

8. Inlet and outlet structures are clean. No floating debris, caked scum, or other trash that might produce odors or be unsightly.

9. Mechanical equipment is well maintained with the help of a written schedule and records are kept on lubrication and maintenance.

10. A good pond operation includes a schedule for getting things done. An available plant record shows weather data and basic test results such as pH, DO, BOD, SS, and chlorine residuals.

OPERATION AND MAINTENANCE GOALS FOR ANAEROBIC PONDS

1. Anaerobic ponds operate with no DO.

2. A well-operating anaerobic pond is covered entirely with a dense scum blanket which helps to keep the pond anaerobic and minimizes foul odors.

3. Two important operation considerations:

   a. Keep the pond pH at or near neutral (7.0) to keep the bacteria in balance.

   b. Control of odors by maintaining no DO and a heavy scum blanket.

4. Normally, the anaerobic pond is followed by additional treatment, such as

an aerated pond and polishing cells or a discharge to a separate municipal wastewater treatment plant. Records should be kept on:

a. Detention time

b. Load (BOD and SS)

c. Effluent quality (BOD, SS and pH)

d. Pond content information (pH, SS, alkalinity, volatile acids, scum and sludge depth)

5. The major on-site attendance will be needed mostly in:

a. Maintaining mechanical equipment

b. Keeping pipelines, diversion boxes and screens clean

c. Collecting samples

d. Running lab tests

e. Performing housekeeping

OPERATION AND MAINTENANCE GOALS FOR AERATED PONDS

1. Aerated ponds will require the same daily inspections and maintenance used for stabilization ponds plus special attention to the aeration equipment.

2. Maintain a minimum of 1 mg/L DO throughout the pond at heaviest loading periods.

3. Surface mechanical aerators should produce good turbulence and a light amount of froth.

a. Monitor DO at aerated cell outlet daily.

b. Keep logs and large pieces of wood out of the pond to prevent damage to the aerator.

4. For diffused air systems that use a blower and pipelines to diffuse air over entire bottom of pond:

a. Check blower daily

b. Visually inspect aeration pattern for "dead spots" or line ruptures. Repair if necessary to maintain even distribution of air.

c. Measure DO at several points in the pond weekly and adjust air to maintain even distribution.

5. Periodic maintenance must be performed, such as lubrication, adjustment and replacement. The best procedure is to make a checklist of maintenance tasks and frequency from the manufacturer's instructions bulletins.

PLANT CHECKLIST

A checklist is a handy tool for the plant operator to schedule activities. Most of the items are visual observations or maintenance needs that take little time if performed according to schedule. With regular attendance, the operator will develop ways to combine some of the duties. In many installations that are looked after regularly by a conscientious operator, the scheduled items can be accomplished in one to two hours a day, allowing the balance of the time for lab and other duties.

The blank form in the Appendix may be used as a guide.

Following is a sample operation and maintenance checklist for a pond operation. Although it is not a complete list of everything the operator should be observing, it will serve as a guide for setting up a schedule for his or her own plant. The schedule will help the operator organize work in a step-by-step fashion and it will also help relief operators or new personnel who are not familiar with the plant. For the design engineer, a checklist should be developed for the plant and included in the operation and maintenance manual.

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary
Plant Survey							
Drive around perimeters of ponds taking note of the following conditions:							
1. Any buildup of scum on pond surface and discharge outlet boxes.	X						
2. Signs of burrowing animals.	X						
3. Anaerobic conditions. Noted by odor and black color.	X						
4. Water grown weeds.	X						
5. Evidence of dike erosion.	X						
6. Dike leakage.	X						
7. Fence damage.	X						
8. Ice buildup in winter.							X
9. Evidence of short circuiting.	X						
Plan, schedule, and correct problems found. (Use troubleshooting section of this manual for information.)							X
Pretreatment							
1. Clean inlet, screens, and properly dispose of trash.	X						
2. Check inlet flowmeter and float well.	X						

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary
If discharge is once or twice per year, the discharge permit may require the following:							
1. Odor		X					
2. Aquatic plant coverage of pond		X					
3. Pond depth		X					
4. Dike condition		X					
5. Ice cover		X					
6. Flow (Influent)	X						
7. Rainfall (or snowfall)	X						
Note: Each state has requirements for data collected prior to and during discharge that is defined in the plant discharge permit.							
If discharge is continuous, the discharge permit may require the following information:							
1. Weather	X						
2. Flow	X						
3. Condition of all cells	X						
4. Depth of all cells	X						
5. Lagoon effluent:							
a. DO and pH grab sample	X						
b. Chlorine residual	X						
c. BOD and SS run on composited samples							X
d. Fecal coliform							X
e. Record pounds of chlorine remaining and used	X						
Other tests and frequency information will be defined in the individual permit for the plant.							

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary
Mechanical Equipment							
Check mechanical equipment and perform **scheduled** preventive maintenance on the following pieces of equipment according to the manufacturer's recommendations:							
1. Pump stations:							
a. Remove debris	X						
b. Check pump operation	X						
c. Run emergency generator		X					
d. Log running times	X						
e. Clean floats, bubblers, or other control devices		X					
f. Lubricate							X
2. Comminuting devices:							
a. Check cutters		X					
b. Lubricate							X
3. Aerators:							
a. Log running time	X						
b. Check amperage				X			
4. Chlorinators:							
a. Check feed rate	X						
b. Change cylinders							X
5. Flow measuring devices:							
a. Check and clean floats, etc.	X						
b. Verify accuracy				X			
6. Valves and gates:							
a. Check to see if set correctly	X						
b. Open and close to be sure they operate			X				

HINTS TO IMPROVE OPERATION

Flow Regulation

Flow regulation is one of the most helpful operational tools available to a lagoon operator. Without the flexibility of being able to move water around where it is needed the operator would be severely handicapped.

In simple terms, an operator needs options. For example:

Single Cell Ponds:

The only flexibility an operator has in a single cell pond is depth control. The water level may have to be varied based on the season or to control weeds and mosquitoes.

Multiple Cell Ponds:

1. May need to hold wastewater in the primary cell, especially during seasonal discharge operations.
2. May need to move water from cell to cell to correct an oxygen deficiency problem.
3. May need to control liquid depth to get rid of weeds or mosquitoes.
4. May need to isolate a cell that has turned anaerobic or to hold a toxic waste.
5. May need to take advantage of both series and parallel operation to regulate loading.
6. May need to temporarily rest a cell for recovery.

Baffles and Screens

Screens, often homemade, are used around pond surface outlets to keep wind blown weed and surface trash from entering a pipe.

Baffles are quite commonly used for a large variety of purposes.

1. To direct the flow of water, especially around inlets. These may consist of nothing more than pilings of 2" x 8" driven into the pond bottom.
2. To allow selection of depth for pond draw-off and to keep surface scum and trash from entering.
3. To provide a stilling area ahead of a flow measuring device.
4. To reduce the force of a pump discharge.

Dike erosion from wave action can be prevented by using riprap in the form of rocks 3 to 8 inches (8 to 48 centimeters) laid along the water's edge. One unusual method employed is to sink two by six's upright into the lagoon floor extending above the water surface to break up and dissipate the waves. In another case, the lagoon operator had bags filled with a dry mix of sand, gravel and cement. These were laid side by side and stacked to form a system of neat functional riprap protection. Riprap should extend one foot above and below extreme operating levels. Other forms of riprap or bank stabilization include cribbing (snow fence) laid on the bank and reed canary grass. The canary grass is effective on ponds that are deep, have steep slopes and a stable water level. Sodding should be at least 3 inches (7.5 cm) square and placed not more than 3 feet (1 meter) apart.

POND CLEANING

If it becomes necessary to clean a pond the operator should have access to a suction pump, a "mudcat" or other means of removing mud or sludge off the bottom to control pond bottom levels and localized deposit areas. This is seldom necessary except for situations where grit or sand gets into the system. This occurred in a coastal city that had high amounts of infiltration where sewers were laid in sandy soil. Bottom solids can normally be disposed of in the same manner that digested solids are. Advice should be obtained from the consulting engineer and the regulatory agency.

STARTING A POND

Procedures

To Fill Primary Cell

1. Fill primary cell(s) with fresh water from a river or municipal system, if available, to the two-foot level. (Spring or early summer is the best time to startup to avoid low temperature and possible freezing.)

2. Begin the addition of wastewater.

3. Keep pH above 7.5. See Troubleshooting Guide.

4. Check DO daily. See Troubleshooting Guide.

5. If started during warm weather:

    a. Algal blooms usually will appear from 7 to 14 days.

    b. A good biological community will be established in about 60 days. Color will be a definite green as contrasted with blue or yellow-green.

This procedure tends to avoid odorous anaerobic conditions and weed growth during the start-up phase. If it is necessary to start in late fall or winter, level should be brought to 2½-3 feet (0.75-1 meter) and no discharge until late spring.

To Fill Successive Ponds

1. Begin filling when the water level in the first pond reaches 3 feet (1 meter).

2. Add fresh water to a depth of 2 feet (0.6 meters).

3. Begin adding water from previous pond observing the following:

    a. Use top draw-off to achieve good transfer. Do not draw off from a level below the bottom 18 inches (45 cm).

    b. Do not allow the water depth in the previous pond(s) to fall below 3 feet (1 meter).

    c. Equalize water depths in all ponds. This should be done by the following:

        (1) Hold the discharge until all ponds are filled.

        (2) Use effluent box with gates or valves to allow pumping the effluent to any pond in the system if system is designed with this capability.

        (3) Continuously recycle the effluent to the ponds that need the water level raised.

4. Repeat the "3.c." operation using 6-inch (15-cm) increments until ponds are at their operating depth.

5. Finally, start continuous or intermittent discharge, however the system is designed. See the following section.

DISCHARGE CONTROL PROGRAM FOR SEASONAL DISCHARGES

Preparation

1. Make a note of conditions in the stream to receive discharge.

2. Estimate duration of discharge and expected volume.

3. Obtain State Regulation Agency approval.

4. Isolate cell to be discharged. Allow to rest for at least 1 month, if possible.

5. Arrange for daily sample analysis of BOD_5, SS, pH, coliform and nutrients (if required).

6. Plan other work so as to spend full time on control of discharge throughout the period.

7. Sample contents of cell and analyze for DO; note and record turbidity, color and any unusual conditions.

Discharge Procedures

Many northern states use a seasonal discharge. Three or four weeks after ice break-up, the ponds generally return to normal operating conditions. The wastewater in the cells is tested and results are reported to the state. If the wastewater is of a quality suitable for discharging, the operator then follows state guidelines in discharging. The NPDES permit states the discharge quality the operator must maintain.

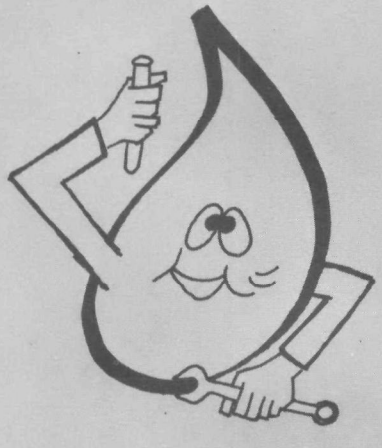
The quality of the receiving stream is usually determined by the State Pollution Control Agency as part of the discharge approval program. When discharge approval is obtained, proceed as follows:

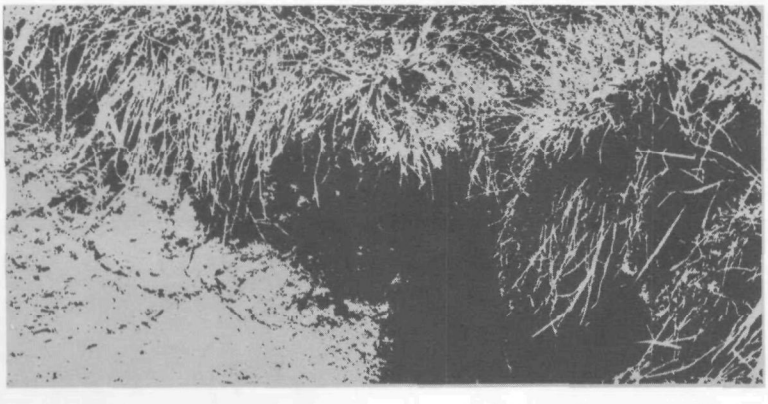
1. Begin the discharge program with the last cell in series.

2. Draw off the discharge from the best level at a time when the discharge is acceptable. Stop the discharge when ponds are upset.

3. Follow testing procedures outlined by your State Regulatory Agency.

4. Troubleshooting for Ponds





- How to control water weeds
- How to control burrowing animals
- How to control dike vegetation
- How to control scum
- How to control odors
- How to control blue-green algae
- How to control insects
- How to obtain best algae removal in the effluent
- How to correct lightly loaded ponds
- How to correct a low dissolved oxygen (DO)
- How to correct overloading
- How to correct a decreasing trend in pH
- How to correct short-circuiting
- How to correct anaerobic conditions
- How to correct a high BOD in the effluent
- How to correct problems in aerated ponds
- How to correct problems in anaerobic ponds

4. Troubleshooting for Ponds

HOW TO CONTROL WATER WEEDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Weeds provide food for burrowing animals, cause short-circuiting problems, stop wave action so that scum can collect and make a nice home for mosquitoes, and odors develop in the still area. Duckweed stops sunlight penetration and prevents wind action thus reducing the oxygen in the pond. Root penetration causes leaks in pond seal.	Poor circulation, maintenance, insufficient water depth.	1. Pull weeds by hand if new growth. 2. Mow weeds with a sickle bar mower. 3. Lower water level to expose weeds, then burn with gas burner. 4. Allow the surface to freeze at a low water level, raise the water level and the floating ice will pull the weeds as it rises. (Large clumps of roots will leave holes in pond bottom, best results are obtained when weeds are young.) 5. Increase water depth to above tops of weeds. 6. Use riprap. Caution: If weeds get started in the riprap, they will be difficult to remove but can be sprayed with acceptable herbicides. 7. To control duckweed, use rakes or push a board with a boat, then physically remove duckweed from pond.

HOW TO CONTROL BURROWING ANIMALS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Burrowing animals must be controlled because of the damage they do to dikes. Rodents such as muskrats and nutria dig partially submerged tunnels into dikes. If the water level is raised, they will burrow further and may go on out the top thus weakening the dike.	Bank conditions that attract animals. High population in area adjacent to ponds.	1. Remove food supply such as cattails and burr reed from ponds and adjacent areas. 2. Muskrats prefer a partially submerged tunnel, if the water level is raised it will extend the tunnel upward and if lowered sufficiently, it may abandon the tunnel completely. They may be discouraged by raising and lowering the level 6-8 inches over several weeks. 3. If problem persists, check with local game commission officer for approved methods of removal, such as live trapping, etc.

HOW TO CONTROL DIKE VEGETATION

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
High weed growth, brush, trees and other vegetation provide nesting places for animals, can cause weakening of the dike and presents an unsightly appearance. Also may reduce wind action on the pond.	Poor maintenance.	1. Periodic mowing is the best method. 2. Sow dikes with a mixture of fescue and blue grasses on the shore and short native grasses elsewhere. It is desirable to select a grass that will form a good sod and drive out tall weeds by binding the soil and "out compete" undesirable growth. 3. Spray with **approved** weed control chemicals. **Note:** Be sure to check with authorities. Some states do not allow chemical usage. All others require that chemicals be bio-degradable. Examples of some herbicides that are used are: Dow Dalapon for cattails Dow Silvex for willows and emergent weeds Ortho Endo-thal for suspended weeds Copper sulfate for filamentous algae Simazine for weeds 4. Some small animals, such as sheep, have been used. May increase fecal coliform, especially to the discharge cell. Practice "rotation grazing" to prevent destroying individual species of grasses. An example schedule for rotation grazing in a 3-pond system would be: Graze each pond area for 2 months over a 6-month grazing season.

HOW TO CONTROL SCUM

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
It is necessary to control scum formations to prevent odor problems and to eliminate breeding spots for mosquitoes. Also, sizeable floating rafts will reduce sunlight.	Pond bottom is turning over with sludge floating to the surface. Poor circulation and wind action. High amounts of grease and oil in influent will also cause scum.	1. Use rakes, a portable pump to get a water jet or motor boats to break up scum formations. Broken scum usually sinks. 2. Any remaining scum should be skimmed and disposed of by burial or hauled to landfill with approval of regulatory agency.

HOW TO CONTROL ODORS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Odors are a general nuisance to the public.	The odors are generally the result of overloading, long periods of cloudy weather, poor pond circulation, industrial wastes or ice melt.	1. Use parallel feeding to primary cells to reduce loading. 2. Apply chemicals such as sodium nitrate, Dibrom or Micro-Aid to introduce oxygen. Application rate: 5-15 percent of sodium nitrate per pound of BOD on a pound-for-pound basis. Or apply 200 pounds sodium nitrate per million gallons. See literature for commercial products. Repeat at a reduced rate on succeeding days. Or use 100 pounds sodium nitrate per acre (112 kg/hectare) for first day, then 50 pounds per acre (56 kg/hectare) per day thereafter if odors persist. Apply in the wake of a motor boat. 3. Install supplementary aeration such as floating aerators, caged aerators, or diffused aeration to provide mixing and oxygen. Daily trips over the lagoon area in a motor boat also helps. **Note:** Stirring the pond may cause odors to be worse for short periods but will reduce total length of odorous period. 4. Recirculate pond effluent to the pond influent to provide additional oxygen and to distribute the solids concentration. Recirculate on a 1 to 6 ratio. 5. Eliminate septic or high-strength industrial wastes.

HOW TO CONTROL BLUE-GREEN ALGAE

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Low pH (less than 6.5) and dissolved oxygen (less than 1 mg/L). Foul odors develop when algae die off.	Blue-green algae is an indication of incomplete treatment, overloading and/or poor nutrient balance.	1. Apply 3 applications of a solution of copper sulfate. a. If the total alkalinity is above 50 mg/L apply 10 pounds of copper sulfate per million gallons in cell (1200 kg/m^3). b. If alkalinity is below 50 mg/L reduce the amount of copper sulfate to 5 pounds per million gallons (600 kg/m^3). **Note:** Some states do not approve the use of copper sulfate since in concentrations greater than 1 mg/L it is toxic to certain organisms and fish. 2. Break up algal blooms by motor boat or a portable pump and hose. Motor boat motors should be air cooled as algae may plug up water cooled motors.

HOW TO CONTROL INSECTS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Insects present in area and larvae or insects present in pond water.	Poor circulation and maintenance.	**Solution for Mosquito Control** 1. Keep pond clear of weeds and allow wave action on bank to prevent mosquitoes from hatching out. 2. Keep pond free from scum. 3. Stock pond with Gambusia (Mosquito Fish). 4. Spray with larvacide as a last resort. Check with state regulatory officials for approved chemicals. (Some that have been used are Dursban, Naled, Fenthion and Abate in dosages of 1 mg/L.) **Solution for Controlling Midges** 1. Stock pond with Gambusia. 2. Spray with approved insecticide. (Fenthion, Abate and Sursban have been used based on directions on the package.)

HOW TO OBTAIN BEST ALGAE REMOVAL IN THE EFFLUENT

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Most of the suspended solids present in a pond effluent are due to algae. Because many single-celled algae are motile and are also very small they are difficult to remove.	Weather or temperature conditions that favor particular population of algae.	1. Draw off effluent from below the surface by use of a good baffling arrangement. 2. Use multiple ponds in series. 3. The use of intermittent sand filters and submerged rock filters may also be used but will require modification and the services of a consulting engineer. 4. In some cases, alum dosages of 20 mg/L has been used in final cells used for intermittent discharge to improve effluent quality. Dosages at or below this level are not toxic.

HOW TO CORRECT LIGHTLY LOADED PONDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Lightly loaded ponds may produce filamentous algae and moss which limits sunlight penetration. These forms also tend to clog pond outlets.	Overdesign, low seasonal flow.	1. Correct by increasing the loading by reducing the number of cells in use. 2. Use series operation.

HOW TO CORRECT A LOW DISSOLVED OXYGEN (DO)

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
A low, continued downward trend in DO is indicative of possible impending anaerobic conditions and the cause of unpleasant odors. Treatment becomes less efficient.	Poor light penetration, low detention time, high BOD loading or toxic industrial wastes. (Daytime DO should not drop below 3.0 mg/L during warm months.)	1. Remove weeds such as duckweed if covering greater than 40 percent of the pond. 2. Reduce organic loading to primary cell(s) by going to parallel operation. 3. Add supplemental aeration (surface aerators, diffusers and/or daily operation of a motor boat). 4. Add recirculation by using a portable pump to return final effluent to the head works. 5. Apply sodium nitrate (see **How to Control Odors** for rate). 6. Determine if overload is due to industrial source and remove it.

HOW TO CORRECT OVERLOADING

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Overloading which results in incomplete treatment of the waste. Overloading problems can be detected by offensive odors, a yellow green or gray color. Lab tests showing low pH, DO, and excessive BOD loading per unit area should also be considered.	Short-circuiting, industrial wastes, poor design, infiltration, new construction (service area expansion), inadequate treatment and weather conditions.	1. Bypass the cell and let it rest. 2. Use parallel operation. 3. Apply recirculation of pond effluent. 4. Look at possible short-circuiting. 5. Install supplementary aeration equipment.

HOW TO CORRECT A DECREASING TREND IN pH

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
pH controls the environment for algae types, as an example, the green chlorella needs a pH from 8.0 to 8.4. pH should be on the alkaline side, preferably about 8.0 to 8.4. Both pH and DO will vary throughout the day with lowest reading at sunrise and highest reading in late afternoon. Measure pH same time each day and plot on a graph.	A decreasing pH is followed by a drop in DO as the green algae die off. This is most often caused by overloading, long periods of adverse weather or higher animals, such as Daphnia, feeding on the algae.	1. Bypass the cell and let it rest. 2. Use parallel operation. 3. Apply recirculation of pond effluent. 4. Check for possible short-circuiting. 5. Install supplementary aeration equipment if problem is persistent and due to overloading. 6. Look for possible toxic or external causes of algae die-off and correct at source.

HOW TO CORRECT SHORT-CIRCUITING

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Odor problems, low DO in parts of the pond, anaerobic conditions and low pH found by checking values from various parts of the pond and noting on a plan of the pond. Differences of 100 percent to 200 percent may indicate short-circuiting. After recording the readings for each location, the areas that are not receiving good circulation become evident. These areas are characterized by a low DO and pH.	Poor wind action due to trees or poor arrangement of inlet and outlet locations. May also be due to shape of pond, weed growth or irregular bottom.	1. Cut trees and growth at least 500 feet (150 m) away from pond if in direction of prevailing wind. 2. Install baffling around inlet location to improve distribution. 3. Add recirculation to improve mixing. 4. Provide new inlet-outlet locations, including multiple inlets. 5. Clean out weeds. 6. Fill in irregular bottoms.

HOW TO CORRECT ANAEROBIC CONDITIONS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Facultative pond that turned anaerobic resulting in high BOD, suspended solids and scum in the effluent in continuous discharge ponds. Unpleasant odors, the presence of filamentous bacteria and yellowish-green or gray color and placid surface indicate anaerobic conditions.	Overloading, short circuiting, poor operation or toxic discharges.	1. Change from a series to parallel operation to divide load. Helpful if conditions exist at a certain time each year and are not persistent. 2. Add supplemental aeration if pond is continuously overloaded. 3. Change inlets and outlets to eliminate short-circuiting. See **How to Correct Short-Circuiting.** 4. Add *recirculation (temporary-use portable pumps)* to provide oxygen and mixing. 5. In some cases temporary help can be obtained by adding sodium nitrate at rates described elsewhere in this manual. 6. Eliminate sources of toxic discharges.

HOW TO CORRECT A HIGH BOD IN THE EFFLUENT

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
High BOD concentrations that are in violation of NPDES or other regulatory agency permit requirements. Visible dead algae.	Short detention times, poor inlet and outlet placement, high organic or hydraulic loads and possible toxic compounds.	1. Check for collection system infiltration and eliminate at source. 2. Use portable pumps to recirculate the water. 3. Add new inlet and outlet locations. 4. Reduce loads due to industrial sources if above design level. 5. Prevent toxic discharges.

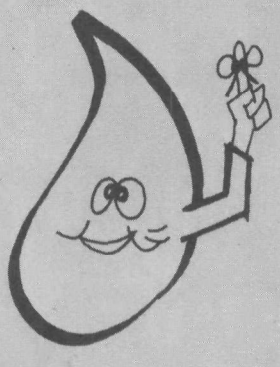
HOW TO CORRECT PROBLEMS IN AERATED PONDS

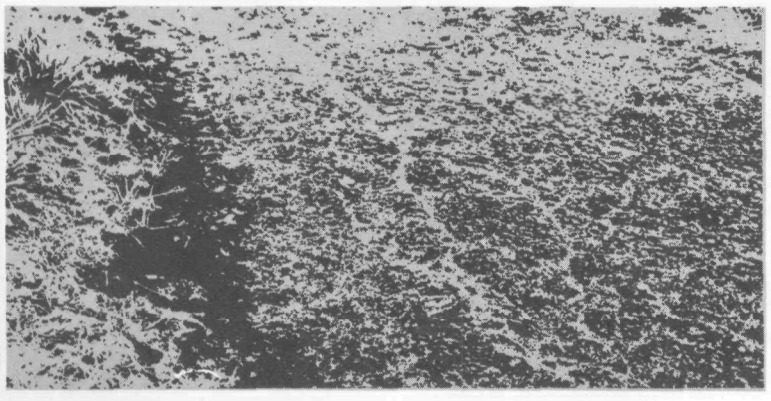
INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Fluctuating DO, fine pin floc in final cell effluent, frothing and foaming, ice interfering with operation.	Shock loading, overaeration, industrial wastes, floating ice.	1. Control aeration system by using time clock to allow operation during high load periods, monitor DO to set up schedule for even operation, holding approximately 1 mg/L or more. 2. Vary operation of aeration system to obtain solids that flocculate or "clump" together in the secondary cell but are not torn apart by excessive aeration. 3. Locate industrial wastes that may cause foaming or frothing and eliminate or pretreat wastes. Examples are slaughter house, milk or some vegetable wastes. 4. Operate units continuously during cold weather to prevent freezing damage or remove completely if not a type that will prevent freeze-up.

HOW TO CORRECT PROBLEMS IN ANAEROBIC PONDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Odors Hydrogen sulfide, (rotten egg) odors or other disagreeable conditions due to sludge in a septic condition.	Lack of cover over water surface and insufficient load to have complete activity which eventually forms scum blanket.	Use straw cast ver the surface or polystyrene planks as a ter ıorary cover until a good surface sludge blar.ket has formed.
Low pH pH below 6.5 accompanied by odors are the result of acid bacteria working in the anaerobic condition.	Acid formers working faster than methane formers in an acid condition.	The pH can be raised by adding a lime slurry of 100 pounds of hydrated lime to 50 gallons (580 kg/200 liters) of water at a dosage rate of 1 pound of lime for every 10,000 gallons (120 g/10,000 liters) in the pond. The slurry should be mixed while being adde l. The best place to put the lime in is at the e. trance to the lagoon so that it is well mixed as it enters the pond.

5. Safety Around Ponds





Public health aspects

5. Safety Around Ponds

PUBLIC HEALTH ASPECTS

Stabilization ponds, like other wastewater treatment facilities, must be treated with caution and respect from a safety and public health standpoint by operators and the general public alike. This means that stabilization ponds must be utilized for their designed purpose only, and not for public recreation.

The relative amount of water surface of stabilization ponds is insignificant in comparison to the many natural bodies of open water in most localities. In some areas, however, stabilization ponds represent the only sizeable body of water and have been sources of attraction to children as well as adults for recreation purposes. Incidents of boating, ice-skating, extensive waterfowl hunting and even swimming in ponds have been reported. Recreational use should be discouraged and safety practices encouraged for several important reasons.

First, even though the efficiency of bacterial removal as measured by the MPN method is very high, the possibility of contamination or infection from pathogenic organisms does exist when one comes in contact with wastewater in a stabilization pond.

Second, although most stabilization ponds attain a depth of only 5 feet, there is still sufficient depth to drown a person. Also, clay liners used in sealing ponds become very sticky when water is added. Should anyone fall in the pond, this clay liner would make it extremely difficult for anyone to get out.

Another factor to be considered is the existence of mosquitos. However, on a well-maintained pond system, mosquitoes usually are not a nuisance.

According to studies made by the U.S. Public Health Service, the density of the mosquito population is directly proportional to the extent of weed growth in the ponds. Where weed growth in the ponds and along the water line of the dikes is negligible and where wind action on the pond is not unduly restricted, the production of mosquitoes in stabilization ponds is low.

To discourage use of the ponds for recreation the entire area should be fenced and warning signs displayed.

Personal Hygiene

It is in the interest of your health and the health of your family that this list of Do's and Don'ts for personal hygiene is made. Use it, don't abuse it!

1. Never eat your lunch or put anything into your mouth without first washing your hands.

2. Refrain from smoking while working in manholes, on pumps or other parts of the operation where hands may become contaminated.

3. Don't wear your coveralls or rubber boots in your car or home.

4. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.

5. Keep your fingernails cut short and clean as they are excellent carriers of dirt and germs.

Safety

Sewer Maintenance Safety Precautions

1. Remove and replace heavy manhole covers carefully and only with the proper tools.

2. Descend into any manhole cautiously to guard against defective steps or rungs.

3. See part regarding noxious gases that may be found in sewers.

Pumping Station and Stabilization Pond Safety Precautions

1. Maintain a high level of good housekeeping. This involves keeping floors, walls and equipment free from dirt, grease and debris. Keep tools properly stored when not in use.

2. Keep walkways clean and free from slippery substances. If ice forms on walks, apply salt or sand or cover with earth or ashes than can be removed later.

3. Be especially cautious when working with an electrical distribution system and related facilities. Never work on electrical equipment and wire with wet hands or when clothes or shoes are wet. Always wear appropriate safety gloves for electrical work. Never use a switchbox for anything other than a switchbox.

4. Keep all personnel safety conscious by reminding them of specific safety instructions. Such instructions should include information on how to contact the nearest medical center and fire station, rescue techniques, resuscitation and first aid techniques.

5. Make certain that a sufficient number of capable personnel with proper equipment are assigned and present whenever it is necessary to perform any hazardous work.

6. A life preserver must be used when using a boat on stabilization ponds. Also, never work alone around the ponds because of the danger of drowning and other accidents. One of the requirements for a pond operator should be that he can swim at least 100 feet in normal work clothing.

7. Sufficient fire extinguishers (Underwriter's Laboratories approved) should be placed in readily accessible locations.

Body Infection and Disease Safety Precautions

1. Treat all cuts, skin abrasions and similar injuries promptly. When working with wastewater, the smallest cut or scratch is potentially dangerous and should be cleaned and treated immediately with a 2 percent solution of tincture of iodine.

2. See a doctor for all injuries.

3. Provide first aid training for all personnel.

4. Be innoculated for waterborne diseases, particularly typhoid and para-

typhoid fever. Keep a record of all immunizations in an employee health record to assure yourself of receiving up-to-date boosters, etc.

5. In laboratory work, use pipet bulbs rather than the mouth so as not to introduce contamination to the mouth. Don't drink water from laboratory glassware. Paper cups should be provided in laboratories for drinking purposes. Never prepare food in a laboratory.

Noxious Gases, Explosive Mixtures and Oxygen Deficiency

1. The principal gas hazards associated with wastewater treatment are accumulations of **sewer gas** and its mixture with other gases or air which may cause death or injury through explosion or by asphyxiation as a result of oxygen deficiency. The term sewer gas is generally applied to the mixture of gases in sewers and manholes containing high percentages of carbon dioxide, varying amounts of methane, hydrogen, hydrogen sulfide and low percentages of oxygen. Such mixtures sometimes accumulate in sewers and manholes where organic matter has been deposited and has undergone decomposition. The actual hazards from sewer gas exist in the explosive amount of methane, hydrogen sulfide or in oxygen deficiency. Hydrogen sulfide is toxic at very low concentrations and one's sensitivity to the odor is quickly deadened.

2. **Chlorine gas**, which is irritating to the eyes, respiratory tract and other mucous membranes, may settle in low, still areas. The gas forms an acid in the presence of moisture. The gas escapes by leakage from cylinders and feed lines and finds its way to these places.

Safety Equipment

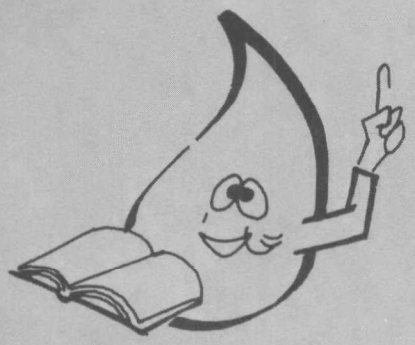
The types of safety equipment which a wastewater facility should have are as follows:

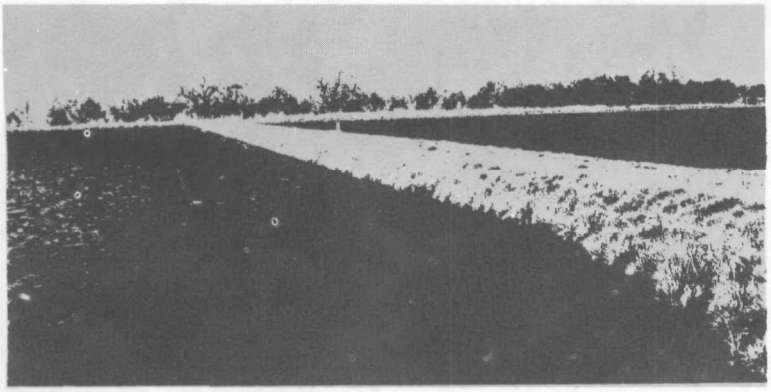
1. Detection equipment (for gases and oxygen deficiencies).
2. Masks (self-contained air packs for oxygen deficiencies).
3. Safety harnesses, lines and hoists.
4. Proper protective clothing, footwear and head gear.
5. Ventilating equipment.
6. Nonsparking tools.
7. Communications equipment.
8. Portable air blower.
9. Explosion-proof lantern and other safe illumination.
10. Warning signs and barriers.
11. Emergency first aid kits.
12. Proper fire extinguishers.
13. Eye wash and shower stations in laboratory areas.
14. Safety goggles for work in laboratories and other dangerous areas.

Additional Sources of Information

- New York Manual, Ch. 14
- WPCF, MOP No. 1, Safety in Wastewater Works
- Texas Manual, Ch. 35
- Sacramento State Home-Study Course, Ch. 12

Appendices





- **A** Glossary of terms
- **B** Formulas and problems
- **C** Flow measuring devices
- **D** Design considerations from an operation and maintenance viewpoint
- **E** Case histories
- **F** Metric equivalents
- **G** References and suggested resource material
- **H** Plants visited
- **J** Checklist form

A Glossary of terms

ACRE-FOOT – A volume term referring to that amount of liquid, 1 acre in area, 1 foot deep. (43,560 cubic feet)

AERATED POND – A wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.

AEROBIC – A condition characterized by the presence of free dissolved oxygen in the aquatic environment.

AEROBIC BACTERIA – Bacteria that require free dissolved oxygen for growth.

AEROBIC STABILIZATION – The stabilization of organic matter through metabolism into more complex matter by bacteria in the presence of dissolved oxygen.

ALGAE – Primitive one- or many-celled plants, usually aquatic, that produce their food by photosynthesis.

ALGICIDE – Any substance or chemical applied to kill or control algal growths.

ANAEROBIC BACTERIA – Bacteria which grow in the absence of free dissolved oxygen and must obtain their oxygen by chemically breaking down organic compounds which contain combined oxygen.

ANAEROBIC DECOMPOSITION – The breakdown of complex organic matter by bacteria in the absence of dissolved oxygen.

AQUATIC VEGETATION – That vegetation which will grow in or near water.

BACTERIA – A group of microscopic organisms lacking chlorophyll and organic nutrients as a food source.

COLIFORM GROUP – A group of bacteria that inhabit the intestinal tract of man, warm blooded animals and may be found in plants, soil and air and the aquatic environment.

DISSOLVED OXYGEN (DO) – Dissolved molecular oxygen usually expressed in mg/L, ppm or percent saturation.

DIURNAL – Having a daily cycle.

EFFLUENT – A liquid flowing out of a chamber, treatment unit or basin.

FACULTATIVE BACTERIA – Those bacteria that can adapt to aerobic or anaerobic conditions. Can utilize dissolved or combined oxygen (oxygen bound in a compound by a chemical action).

FUNGI – Simple or complex organisms without chlorophyll. The simpler forms are one-celled; higher forms have branched filaments and complicated life cycles. Examples are molds, yeasts and mushrooms.

GRAB SAMPLE – A single sample not necessarily taken at a set time or flow. An instantaneous sample.

HYDRAULIC LOADING – The volume of flow per day per unit area.

INFLUENT – That liquid entering a process unit or operation.

INORGANIC MATTER – Chemical substances of mineral origin.

MILLI – An expression used to indicate 1/1000 of a standard unit of weight, length or capacity (metric system).

milliliter (ml) - 1/1000 liter (L)

milligram (mg) - 1/1000 gram (g)

millimeter (mm) - 1/1000 meter (m)

MILLIGRAMS PER LITER (mg/L) – A unit of concentration on weight/volume basis, milligrams per liter. Equivalent to ppm when speaking of water or wastewater.

ORGANIC LOADING – The number of pounds of BOD added to treatment unit per day.

OXYGEN AVAILABLE – That part of the oxygen available for aerobic stabilization of organic matter. Includes dissolved oxygen and that available in nitrites or nitrates, peroxides, ozone and certain other forms of oxygen.

OXYGEN DEPLETION – The loss of oxygen from water or wastewater due to biological, chemical or physical action.

pH – Expresses the intensity of acidity or alkalinity of a liquid.

PHOTOSYNTHESIS – A process in which chlorophyll-containing plants produce complex organic (living) materials from carbon dioxide, water and inorganic salts, with sunlight as the source of energy. Oxygen is produced in this process as a waste product.

POPULATION EQUIVALENT – The calculated population which would normally contribute the same amount of biochemical oxygen demand as the wastewater. A common base is 0.2 lb. (0.09 kg) of 5-day BOD per capita per day.

SETTLEABLE SOLIDS – Those solids which will settle out when a sample of sewage is allowed to stand quietly for a one-hour period.

SHORT-CIRCUITING – The hydraulic conditions in a tank, chamber or basin where time of passage is less than that of the normal flow-through period.

SLUDGE BANKS – The accumulation of solids including silt, mineral, organic and cell mass material that is produced in an aquatic system.

STABILIZATION – The process of reducing a material using a biological and chemical means to a form that does not readily decompose.

STANDARD METHODS – Methods of analysis prescribed by joint action of the American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF).

SUPERSATURATION – The situation in which water holds more oxygen at a specified temperature than normally required for saturation.

SUSPENDED SOLIDS – The concentration of insoluble materials suspended or dispersed in waste or used water. Generally expressed in mg/L on a dry weight basis. Usually determined by filtration methods.

TOTAL SOLIDS – Refers to the solids contained in dissolved and suspended form in water. Determined on weighing after drying at 103 degrees Celsius.

VOLATILE SOLIDS – The quantity of solids in water that represent a loss in weight upon ignition at 550 degrees Celsius.

B Formulas and problems

SYMBOLS

A	=	Area	L	=	Length	V	=	Volume
B	=	Base (length of)	P	=	Perimeter	Vel	=	Velocity
C	=	Circumference	Q	=	Flow	W	=	Width (length of)
D	=	Diameter	R	=	Radius	π	=	Pi = (3.14)
H	=	Height (length of)	S	=	Side (length of)	/	=	Per (as gallons/day)

LENGTH CONVERSION FACTORS

1 foot = 12 inches

1 yard (yd) = 3 feet (ft)

1 rod = 5½ yards = 16½ ft

1 chain = 4 rods = 66 ft

1 mile = 5,280 feet = 1,760 yds

1 nautical mile = 6,076 feet

.001 kilometer = 1 meter = 100 centimeters = 1,000 millimeters

AREA CONVERSION FACTORS

1 square foot (ft^2) = 144 sq inches ($inch^2$)

1 square yard (yd^2) = 9 sq ft (ft^2)

1 square rod (rd^2) = 272¼ sq ft (ft^2)

1 acre = 43,560 sq ft (ft^2)
= 4,840 sq yds

1 square mile = 640 acres or 1 section

1 hectare = 10,000 square meters = 0.1 square kilometers

CALCULATION OF AREAS

1. Square of Rectangle = L x W
2. Triangle = 1/2 B x H
3. Trapezoid = $\frac{(B_1 + B_2) \times H}{2}$
4. Circle:
   a. $A = \pi R^2$
   b. $A = \frac{\pi D^2}{4}$
   c. $A = 0.785\ D^2$

CALCULATION OF VOLUMES

VOLUME CONVERSION FACTORS

1 cubic foot (ft^3) = 1,728 cu in (in^3)
= 7.5 gallons
1 cubic yard (yd^3) = 27 cu ft (ft^3)
1 acre-foot = 43,560 cu ft (ft^3)
= 325,851 gallons
1 gallon (gal) = 231 cu in (in^3)
= 4 quarts

0.001 cubic meters = 1 liter = 1,000 cubic centimeters = 1,000 milliliters

1. Rectangular Solids $V = L \times W \times H$

2. Cylinders: a. $V = \pi R^2 \times H$

   b. $V = 0.785 D^2 \times H$

   c. $V = \frac{\pi D^2 \times H}{4}$

3. Cones $V = \frac{\pi R^2 \times H}{3}$

4. Pyramids $V = \frac{A \times H}{3}$ (A = Area of Base)

WEIGHT CONVERSION FACTORS

1 gal = 8.34 lbs of water
1 cu ft = 62.4 lbs of water
1 ft of water = 0.434 psi
0.001 kilograms (kg) = 1.0 g = 1,000 mg
1 ton (metric) = 1,000 kg

1 psi $= \frac{1}{0.433}$ ft

= 2.31 ft of water

VELOCITY

1. Velocity $= \frac{\text{Distance}}{\text{Time}}$

   a. mile per hour $= \frac{\text{mile}}{\text{hour}}$

   b. ft per min $= \frac{\text{feet}}{\text{minute}}$

   c. ft per sec $= \frac{\text{feet}}{\text{second}}$

   Velocity (ft per sec)

   $$= \frac{\text{Flow Rate } (ft^3 \text{ per sec})}{\text{Cross Sectional Area } (ft^2)}$$

2. Gal per min (gpm)
   = cu ft per sec x 60 sec per min
   x 7.5 gal per ft^3
   OR
   gpm = ft^3 per sec x 60 sec per min
   x 7.5 gal per ft^3

VELOCITY CONVERSION FACTORS

1 cu ft per sec (cfs) = 7.5 gal per sec (gps)
= 450 gal per min (gpm)

1 gal per sec = 0.133 cu ft per sec (cfs)
= 7.98 ft^3 per min

COMMONLY USED FORMULAS

1. Gal/day (gpd) = gal/min (gpm)
   x 1,440 min/day
   = gal/hr (gph)
   x 24 hrs/day

2. Million Gal/Day (mgd) $= \frac{\text{gal/day}}{1{,}000{,}000}$
   $= \frac{\text{gpd}}{1{,}000{,}000}$

3. Pounds/Day (lbs/day) = (BOD,TSS,SVS,Cl_2,etc.)

   lbs/day = milligrams/liter
   x million gal/day
   x 8.34 lbs/gal
   OR
   lbs/day = mg/L x mgd
   x 8.34 lbs/gal
   OR
   lbs/day = population equivalent
   x population equivalent factor

4. Population Equivalent (BOD or TSS)

   $= \frac{\text{Daily Loading in Pounds}}{\text{Population Equivalent Factor}}$

5. **Volume in Gallons**

   a. Rectangular Tank

   $V = L \times W \times H \times 7.5 \text{ gal/ft}^3$

   b. Circular Tank

   $V = \pi R^2 \times H \times 7.5 \text{ gal/ft}^3$
   $V = 0.785D^2 \times H \times 7.5 \text{ gal/ft}^3$

6. Efficiency (% of Removal) $= \frac{\text{(influent - effluent)}}{\text{influent}} \times 100$

7. Organic Loading on Primary Cell

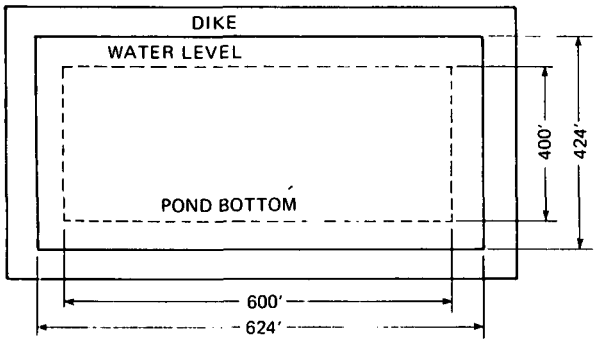
   $= \frac{\text{influent lbs of BOD/day}}{\text{acres (primary)}}$

8. Storage Volume of a Pond
   = avg surface area (ft^2)
   x design operation depth (ft)
   x 7.5 gal/ft^3

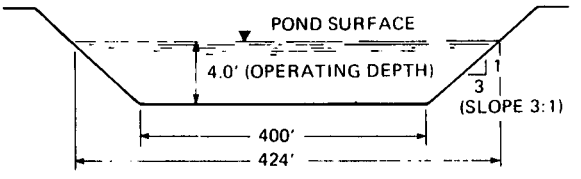
9. Daily Rise in Inches

   $= \frac{\text{total flow/day (gal)} \times \text{design operating depth (inches)}}{\text{volume of pond (gal)}}$

SAMPLE PROBLEM



PLAN



PROFILE

Essential Data:

Avg Influent Flow Rate	=	250,000 gpd
Avg Influent BOD_5	=	380 mg/L
Avg Effluent BOD_5	=	190 mg/L
Population Served	=	2,000 persons
Industry Served	=	One (BOD unknown)

CALCULATIONS

A. **Find the Operating Surface Area of Pond (Acres)**

Surface Area in Sq Ft (SF)
= L x W
= 424' x 624' = 264,576 SF
One Acre
= 43,560 SF
Area
= 264,576 SF ÷ 43,560 SF/Acre
= 6.07 Acres
Answer
= 6.07 Acres
Rounded Off
= 6.1 Acres

B. **Find the Volume of Pond (Gallons)**

Volume = L x W x d

Since the pond has sloped sides, the cross-horizontal area decreases with depth. To calculate the volume of the pond, the average horizontal area is required.

Average Horizontal Area

$$= \frac{\text{Surface (area)} + \text{Bottom (area)}}{2}$$

Surface A = 264,576 SF
Bottom A = 600 x 400 = 240,000 SF

$$\text{Avg Area} = \frac{264{,}576 \text{ SF} + 240{,}000 \text{ SF}}{2}$$

$$= 252{,}288 \text{ SF}$$

$V = h\ (A_{\text{avg horiz}}) = 4(252{,}288)$
$= 1{,}009{,}152$ CF

1 CF = 7.5 gal

Volume in Gal
= 1,009,152 CF x 7.5 gal/CF
= 7,568,640 gal
One mg = 1,000,000 gal
Number mg = 7,568,640 ÷ 1,000,000
Number MG = 7.56864 mg
Rounded Off = 7.6 mg

C. **Calculate the Pounds of BOD_5 /Day (Influent)**

lbs BOD/day
= 8.34 x concentration (ppm)
x flow (mgd)
= 8.34 x 380 x 0.25
= 792 lbs/day

D. **Calculate the Removal Efficiency (Based on BOD Reduction)**

$$\text{Efficiency} = \frac{\text{BOD in - BOD out}}{\text{BOD in}} \times 100\%$$

$$= \frac{380 \text{ mg/L} - 190 \text{ mg/L}}{380 \text{ mg/L}} \times 100\%$$

= 50%

E. **Calculate the Organic (BOD) Loading (lbs BOD/Acre/Day)**

Loading = lbs BOD/day
÷ Surface Area (Acres)
= 792 ÷ 6.1 = 130
= 130 lbs BOD/Acre/Day

Note: Most stabilization ponds are designed for an organic loading of 15-30 lbs BOD/acre/day—this pond is overloaded at 130 lbs BOD/acre/day.

F. **Calculate the Population Loading (Number of Persons/Acre)**

Population Loading
= 2,000 persons ÷ 6.1
= 328 persons/acre

G. **Find the Population Equivalent**

Because industry increases the strength of the waste by adding organic materials, it is sometimes desirable to determine the **equivalent** population served, or the number of people that would be equal to the industry's effect.

Assume equivalent organic loading
= 0.2 lbs BOD/day/person

Total number lbs BOD arriving at pond
= 792 lbs/day

Equivalent population
= 792 lbs BOD/day
÷ 0.2 lbs BOD/person/day
= 3,960 persons

There are only 2,000 persons being served by this pond but because of the industry, the bond is being loaded as if there were 3,960 persons contributing waste. In essence, the industry load is equivalent to 3,960 minus 2,000 = 1,960 persons.

H. **Theoretical Retention Time (Days)**

Time = Volume of Pond
÷ Average Daily Flow
= 7.6 mg ÷ .25 mgd
= 30.4 days

Note: Most stabilization ponds are designed for a population loading of 100 persons per acre. The population loading in this example does not indicate as severe an overload condition as does the BOD loading figure. This is due to the fact that industry is adding organic material, thus increasing the BOD loading, but the contributing population remains the same.

C Flow measuring devices

RUNNING TIME OF PUMPS IN A LIFT STATION

Flow is calculated by multiplying the total minutes logged on each pump by the volume the pump will pump in one minute. The volume that the pump can pump in one minute can be computed as shown below.

Measure Change in Level of a Tank (Wet Well) Being Pumped in a Measured Time

$$\frac{\text{(in sq ft)} \quad \text{(in ft)}}{\text{area of tank} \times \text{change in level} \times 7.5} = \text{gpm}$$
$$\text{minutes pumped}$$

Example:

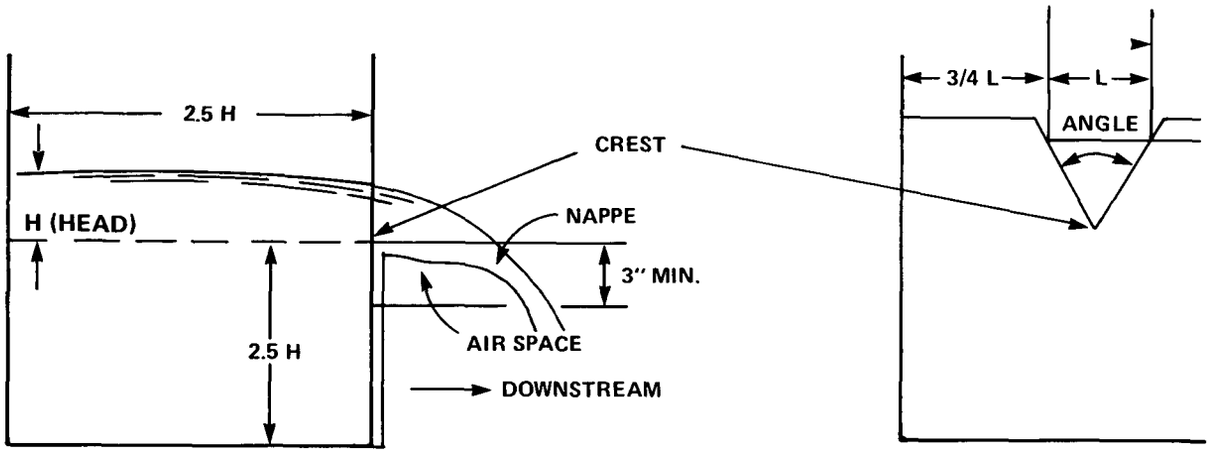
$$\frac{(25 \text{ sq ft}) \times (3 \text{ ft}) \times 7.5}{41 \text{ minutes}} = 13.9 \text{ gpm}$$

Knowing the pumping rate in gallons per minute, records can be maintained as in the following table in order to calculate the daily flow.

PUMP RUNNING TIME AND FLOW RECORD

DATE

	PUMP NO. 1			PUMP NO. 2			Total		
Date	Reading (Hours)	Minutes (Hours x 60)	Minutes/ Day	Reading (Hours)	Minutes (Hours x 60)	Minutes/ Day	Mins. 1+2	(Gal) Minutes	Flow (Gal)
Start	00.0	0	-	0.0	0	-	0	-	-
1	12.2	732	732	17.5	1,050	1,050	1,782	13.9	24,769
2	25.7	1,542	810	33.5	2,010	960	1,770	13.9	24,603
3	39.7	2,382	840	51.5	3,090	1,080	1,920	13.9	26,668
4	50.9	3,054	672	68.1	4,086	996	1,668	13.9	23,185
5									
6									



V-NOTCH WEIR

The weir has the advantage of simplicity. To determine flow it is only necessary to measure the head of water above the crest of the weir. The sharp-crested weir may be a metal plate up to 1/4" (6 mm) in thickness. V-notch flow measurement weirs are usually constructed with either a 60-degree or 90-degree notch. The 60-degree V-notch weir is generally installed for measuring flows in the lower ranges.

The V-notch beveled weir is usually installed in a concrete flow structure which allows grit and heavy organic solids to settle out. This creates a condition that requires frequent cleaning and flushing of the flow channel. The V-notch of the weir catches and holds trash and debris. This requires frequent cleaning. The edges of the notch of the weir should be beveled on the downstream side to form a "sharp" crest or edge of about a 45-degree or more angle on the upstream side.

1. Confirm angle of "V" notch.

2. The measurement of head on the weir should be taken as the difference in elevation between the notch and the water surface at a point upstream from the weir a distance of at least 2 times and preferably 4 times the maximum head on the crest.

3. Liquid depth below crest should be at least 2.5 x head. The distance from the sides of the weir to the sides of the approach channel should never be less than 2H, where "H" is the head of the water above the notch.

4. Liquid downstream of weir plate should be no higher than 3" below crest of weir. Air should circulate freely both under and on the sides of the nappe.

5. Flow over weir is related to head (H) reading.

   Example: 90-degree V-Notch Weir

   1-1/2" head

   From table flow would be 6.05 gpm.

DISCHARGE FROM TRIANGULAR V-NOTCH WEIRS

Head (H) in Inches	Flow in Gallons Per Minute 90° Notch	60° Notch	Head (H) in Inches	Flow in Gallons Per Minute 90° Notch	60° Notch
1	2.19	1.27	6-3/4	260	150
1-1/4	3.83	2.21	7	284	164
1-1/2	6.05	3.49	7-1/4	310	179
1-3/4	8.89	5.13	7-1/2	338	195
2	12.4	7.16	7-3/4	367	212
2-1/4	16.7	9.62	8	397	229
2-1/2	21.7	12.5	8-1/4	429	248
2-3/4	27.5	15.9	8-1/2	462	267
3	34.2	19.7	8-3/4	498	287
3-1/4	41.8	24.1	9	533	308
3-1/2	50.3	29.0	9-1/4	571	330
3-3/4	59.7	34.5	9-1/2	610	352
4	70.2	40.5	9-3/4	651	376
4-1/4	81.7	47.2	10	694	401
4-1/2	94.2	54.4	10-1/2	784	452
4-3/4	108	62.3	11	880	508
5	123	70.8	11-1/2	984	568
5-1/4	139	80.0	12	1,094	632
5-1/2	156	89.9	12-1/2	1,212	700
5-3/4	174	100	13	1,337	772
6	193	112	13-1/2	1,469	848
6-1/4	214	124	14	1,609	929
6-1/2	236	136	14-1/2	1,756	1,014

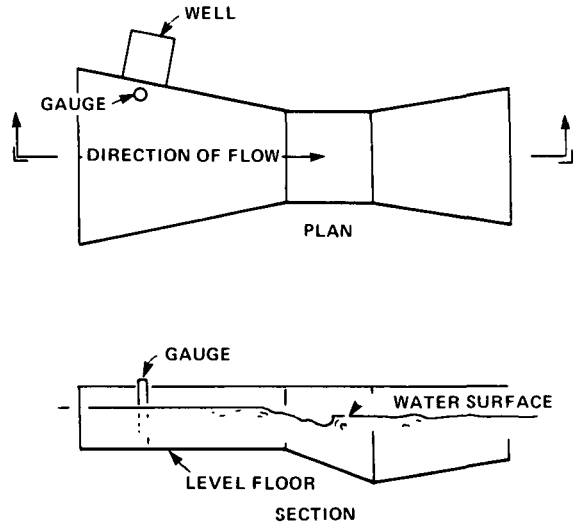
DISCHARGE OVER RECTANGULAR WEIR WITH STANDARD END CONTRACTIONS
DISCHARGE -- GALLONS PER MINUTE (gpm)

Head (H) Inches	Length of Weir (L) Inches										
	2	4	6	8	10	12	15	18	24	36	60
1/4	1	2	2	3	4	5	6	7	10		
1/2	2	4	6	9	11	13	16	19	26		
3/4	4	8	12	16	19	23	29	35	46		
1	6	12	18	24	30	36	45	54	72	108	180
1/4		17	25	33	42	50	63	76	100	150	250
1/2		22	33	44	55	66	83	99	132	197	330
3/4		28	42	55	69	83	104	124	166	248	415
2		34	51	68	85	101	127	152	202	303	505
1/4			61	81	101	121	152	183	242	363	605
1/2			71	95	118	142	178	213	284	426	710
3/4			82	109	136	164	205	246	328	492	820
3			93	124	155	187	233	280	374	561	935
1/4				140	176	210	264	316	420	630	1,050
1/2				157	197	235	294	353	470	705	1,180
3/4				174	218	261	326	392	522	783	1,310
4				190	239	287	358	431	574	861	1,430
1/4					262	314	392	472	628	942	1,570
1/2					285	343	429	515	686	1,030	1,710
3/4					310	374	465	559	748	1,120	1,860
5					334	403	500	605	806	1,210	2,010
1/4						433	540	650	866	1,300	2,160
1/2						464	580	695	928	1,390	2,320
3/4						496	620	745	992	1,480	2,480
6						528	660	791	1,050	1,850	2,640
1/4							701	842	1,120	1,680	2,800
1/2							743	893	1,190	1,790	2,980
3/4							785	934	1,260	1,890	3,150
7							830	1,000	1,330	1,990	3,320
1/4							875	1,050	1,400	2,100	3,500
1/2							920	1,100	1,470	2,200	3,680
3/4								1,160	1,540	2,310	3,850
8								1,210	1,620	2,430	4,050
1/4								1,270	1,700	2,550	4,250
1/2								1,340	1,780	2,670	4,450
3/4								1,400	1,860	2,790	4,650
9								1,460	1,940	2,910	4,850
1/4									2,020	3,030	5,050
1/2									2,100	3,150	5,250
3/4									2,180	3,270	5,450
10									2,270	3,400	5,670
1/2									2,450	3,680	6,120

PARSHALL FLUME

The parshall measuring flume is widely used to measure sewage flows because of its simplicity and its freedom from difficulties with sand or suspended solids.

The head over the crest of a Parshall Flume can be measured by placing a gauge stick in the sewage at the float in the flow channel or at the pipe leading to the float well and then taking a reading off the free-flow discharge chart.



FREE FLOW DISCHARGE - PARSHALL FLUME - GALLONS PER MINUTE

Head in Inches	3 Inches	6 Inches	9 Inches	12 Inches	18 Inches
1-3/16	10.3	22.4	40.0	-	-
1-13/16	22.4	44.9	76.3	-	-
2-3/8	36.7	71.6	116.9	157.1	229.0
3	51.6	103.3	166.1	219.9	318.7
3-5/8	69.0	139.2	219.9	287.3	422.0
4-3/16	68.0	175.1	278.0	359.0	534.0
4-13/16	104.0	215.5	341.1	444.3	659.0
5-3/8	130.0	260.0	404.0	534.0	790.0
6	152.0	310.0	476.0	624.0	925.0
6-5/8	180.0	359.0	552.0	727.0	1,073.0
7-3/16	202.0	413.0	628.0	826.0	1,225.0
7-13/16	233.0	467.0	714.0	934.0	1,387.0
8-3/8	257.0	525.0	799.0	1,046.0	1,553.0
9	294.0	588.0	889.0	1,158.0	1,728.0
9-5/8	315.0	651.0	978.0	1,280.0	1,912.0
10-3/16	357.0	714.0	1,073.0	1,400.0	2,096.0
10-13/16	378.0	781.0	1,171.0	1,530.0	2,289.0
11-3/8	420.0	853.0	1,274.0	1,661.0	2,491.0
12	448.0	925.0	1,377.0	1,795.0	2,692.0
13-3/16	-	1,077.0	1,594.0	2,074.0	3,119.0
14-3/8	-	1,234.0	1,822.0	2,370.0	3,564.0
15-5/8	-	1,400.0	2,060.0	2,675.0	4,035.0

If readings are to be recorded in gallons per day, multiply the answer in gpm by 1440.

Sample Calculations for Compositing

If the average flow rate is 50,000 gpd, the flow in gpm is:

$$\frac{50{,}000 \text{ gpd}}{1{,}440 \text{ min/day}} = 35 \text{ gpm}$$

Size of composite sample needed = 2,500 to 3,000 ml (sample size is dependent on type of test run).

A. Average size of sample for 24-hour composite (24 samples, each taken on the hour):

$$\frac{2{,}500 \text{ to } 3{,}000 \text{ ml}}{24 \text{ hourly samples}} = 105 \text{ to } 125 \text{ ml}$$

Sizing an individual sample based on the rate of flow at that instant:

$$\frac{105 \text{ to } 125 \text{ ml}}{35 \text{ gpm}} = \text{approx. } 3 \text{ to } 4 \text{ ml/gpm}$$

Example: Flow rate = 30 gpm;
Sample size = 4 x 30 = 120 ml

Note: It is safer to take too much than not enough, 504 ml/gpm is used. After thoroughly mixing the **total combined** *sample, the excess amount can be discarded.*

B. Average size of sample for NPDES composite (four 2-hour samples for an 8-hour composite, samples taken at 10 a.m., 12 noon, 2 p.m., and 4 p.m.):

$$\frac{2{,}500 \text{ to } 3{,}000 \text{ ml}}{\text{Four 2-Hour Samples}} = 625 \text{ to } 750 \text{ ml}$$

Sizing an individual sample based on the rate of flow at that instant. Consider that daytime flow rates will usually be greater than the average daily flow rate. Estimate that the daytime flow rate is approximately 40 gpm:

$$\frac{625 \text{ to } 750 \text{ ml}}{40 \text{ gpm}} = \text{approx. } 16 \text{ to } 19 \text{ ml/gpm}$$

Note: In this case, you might want to take 20 ml/gpm since this is an easier number to multiply by.

Example: Flow rate = 50 gpm;
Sample size = 20 x 50 = 1,000 ml

D Design considerations from an operation and maintenance viewpoint

Operating experience at many pond installations shows the need to pay attention to several important areas when designing ponds for optimum operational control.

Conservative design in this instance should reflect operational flexibility above that required at the moment. These considerations should include:

1. The capability to move water around within the system. The advantages of this provision include premixing the pond's contents with the incoming wastewater which provides oxygen to the incoming waste and assures a more completely mixed environment in the feed zone area. Two methods are available; using portable pumps or pond recirculation. The latter has been successfully used in California.

2. The use of multiple inlets and outlets to improve pond circulation.

3. The use of interpond transfer pipes with valves or gates to permit individual pond level control and to redistribute loading. This interpond flexibility will permit the operator to operate cells at those water levels which will give the best treatment. Operators with this capability will need to experiment with pond levels until the best plant effluent is obtained. For example, a primary cell might operate best at an 8-foot water depth, while the final cell is 3 feet.

4. A well-designed outlet structure which will permit control of pond depths and also the rate of discharge.

5. The use of reliable continuous-flow measuring devices such as V-notch or Cipoleti weirs or float-actuated electrically-timed recorders.

E Case histories

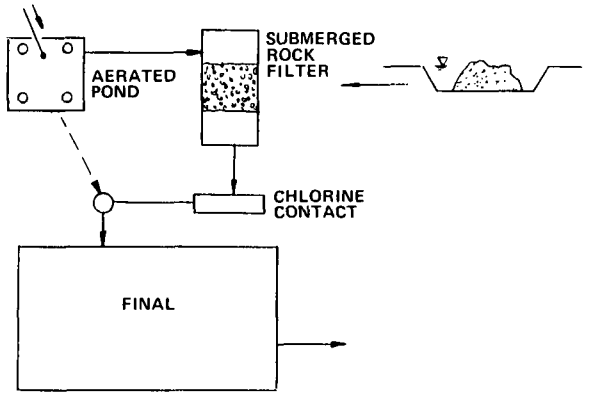
CASE 1 – COLORADO

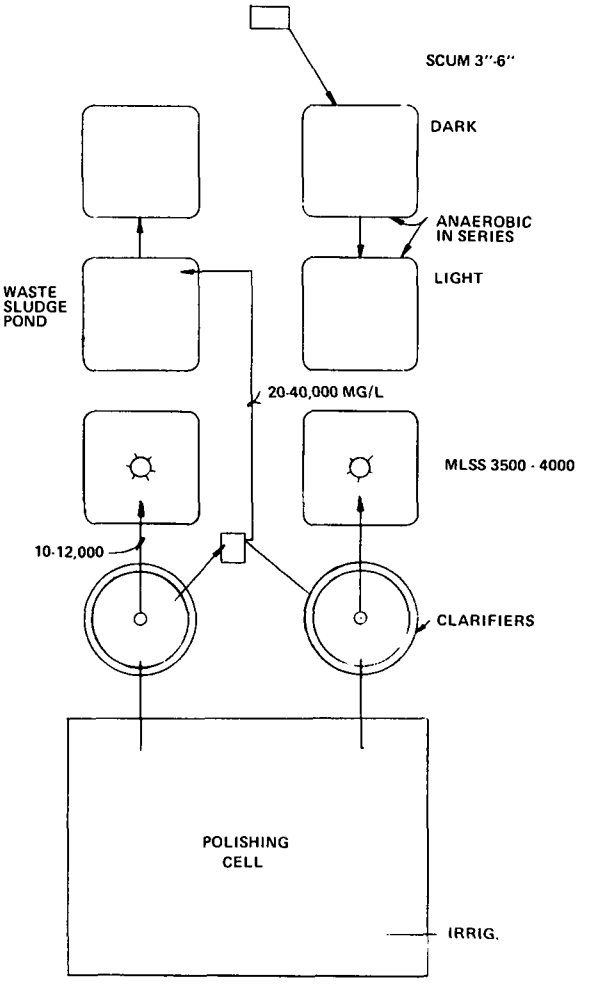
This plant in Colorado was visited because of rock filter built for algae removal. Filter will be discontinued because it does not work.

General impression of plant was that it was poorly-attended, if at all. Although a new facility, it had a goodly start on water weed growth but no cover on dikes. Dikes were showing signs of erosion. Algae growth in ponds OK.

Plant was designed for continuous discharge but had not needed to do so yet.

The filter will be abandoned because of plugging. Rock size too small, ranging from 2" to sand. Filter was uncovered and odorous. Evidence of spiders and midges.



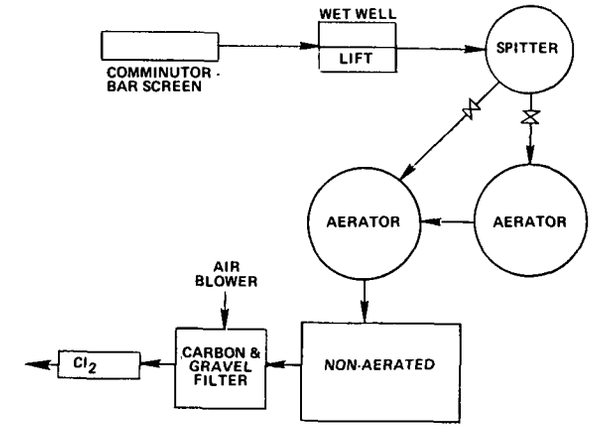


CASE 2 – COLORADO

Another plant in Colorado also has a different rock filter following the last cell and prior to chlorination.

This filter has an air blower used to keep the filter aerobic. However, the filter is not working, again due to plugging problems.

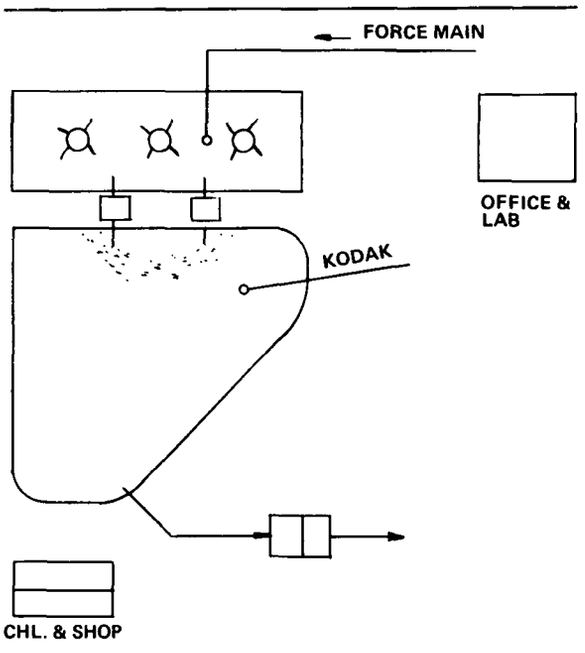
General comment on both filters would be to use larger rock (5 to 6" in diameter) as determined by O'Brian. Reference No. 6.



CASE 3 – COLORADO

This system shows evidence of being well run by a Certified IV Operator. Good algal growth in both ponds. Cells do not have the capability to control or vary the water level. Plant is continuous discharge into a nearby river. The lagoon receives both domestic sewage and pretreated industrial waste from a Kodak plant.

Domestic waste is discharged into the primary aerated cell, then into the secondary cell. The secondary cell also receives Kodak waste. Effluent is chlorinated prior to discharge. The effluent shows evdience of a high solids carryover (algae).



CASE 4 – COLORADO

Although this is a larger plant combining extended aeration and an oxidation pond system, it deserves a discussion because it is a well-run facility meeting its NPDES discharge requirements. Undoubtedly, its reason for success is that the operator knows the basics of the process and it is well attended. Daily operation and maintenance schedules are in force and carefully adhered to. An established wasting and lab testing program is also followed.

CASE 5 – COLORADO

(Anaerobic/Aerobic Lagoon)

This complex treats animal wastes from a livestock feed lot and the treated effluent is used for field irrigation. The raw waste enters an influent diversion structure, then flows through two anaerobic lagoons in series. The effluent is discharged into a complete-mix activated sludge process consisting of two aerated basins and two final clarifiers. Effluent from the clarifiers is discharged into a

polishing lagoon. Return sludge is about 10,000 to 12,000 mg/L. Excess sludge ranging from 20,000 to 40,000 mg/L is pumped to a sludge holding basin. The solids level in the aerator is held between 3,500 and 4,000 mg/L.

A good scum blanket existed on both anaerobic ponds and there was an absence of bad odors. Operators said, however, that severe odors developed when starting a new pond. This condition held until a scum blanket was formed, usually about 1 month.

CASE 6 – COLORADO

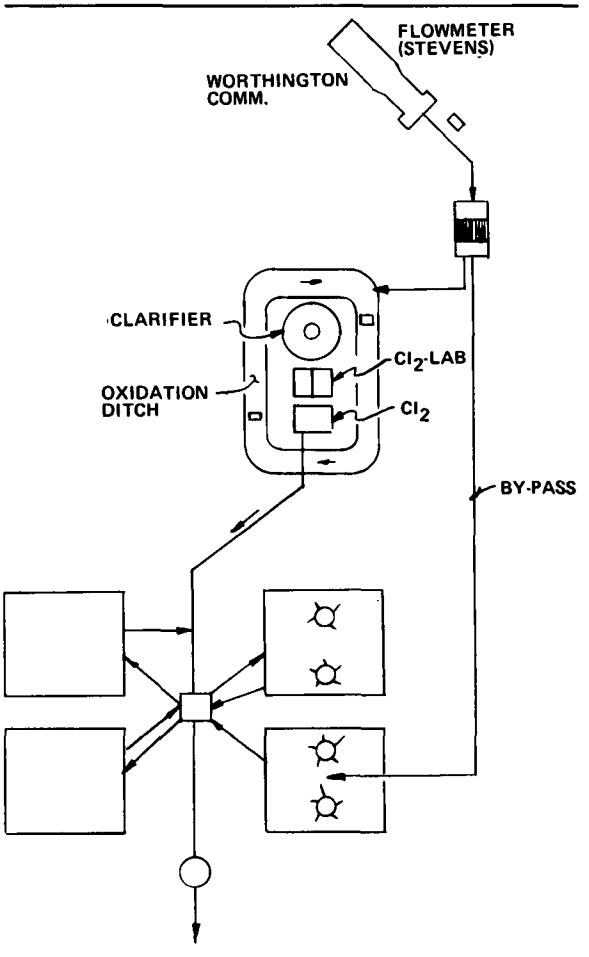
The operator of this plant has an operational checklist that is worth mentioning. The treatment system is an oxidation ditch followed by lagoons as shown in the figure.

Daily Operational Checklist

1. Checks comminutor for operation to make sure nothing is clogged.
2. Reads flowmeter, checks press and rewinds (sets totalizer to 76,000) at 11:00 a.m. each day.
3. Checks second bar screen and cleans. Takes screenings to small landfill.
4. Checks and lubricates each cage aerator.
5. Checks sludge blanket.
6. Inspects cells.
7. Takes samples at outfall manhole and influent structure. Performs tests.
8. Checks Cl_2 feed rate. Keeps it between 7 and 12 lbs/day.

Other Duties

1. Wastes (2 times per week).
2. Isolates comminutor, greases, flushes comminutor and channel return to service.
3. Mows dike grass, pulls weeds.
4. Counts number of threads on valve stem when changing flow pattern.



CASE 7 – KANSAS

An overload in the primary cell was corrected by diverting all flow into Cell No. 2 and routing water from Cell No. 3 back to the primary cell for additional oxygen and dilution.

Low DO, following melting of the ice cover, was corrected by adding 50 to 100 pounds of sodium nitrate per acre.

CASE 8 – KANSAS

Anaerobic conditions in the primary cell were corrected by diverting part of influent flow into the second cell and adding water to keep both cells above a 3' level. Duckweed growth is controlled by applying 2-4D in oil solution.

CASE 9 – KANSAS

Excessive foam in aerated pond, which was corrected by adding 1 quart of coconut oil.

CASE 10 – CALIFORNIA

Algae Control Using Phase Isolation

The facility at Woodland, California, has successfully shown that algae can be removed from the final discharge cell by starving it. The following represents their conclusions and observations.

Summary and Conclusions

Based upon 15 months of successful field scale operation, during which an average of 1.2 mgd has been treated to exceed the 1977 discharge requirements for BOD and suspended solids, it can be justifiably stated that the concept of "phase isolation" works under Woodland conditions.

It was not the scope of this investigation to ascertain **why** it works, but only if it **does** work. It appears that the reasons as to **why** it works are quite complex and is a fit subject for investigation by someone with sufficient technical resources.

Observations

1. Spectrophotometer determinations for suspended solids correlates reasonably well with "Standard Methods" in the upper range, but gives an "optimistic" low reading in the low range. However, a low reading on the spectrophotometer shows that it is the proper time to start testing by "Standard Methods." A plant operator, by viewing the phase isolation effluent in a glass jar, can rapidly learn when it is time to start laboratory tests because of its clarity.

2. Low suspended solids measurements and low BOD measurements generally accompany each other and when they do not, it was always proved to be a laboratory error.

3. During periods of rainfall or high wind, the colloidal silt of the unlined ponds would give a "high" reading on the suspended solids. A large population of waterfowl would also cloud the contents of the pond because of their bottom feeding habits.

4. Waterfowl and shorebirds preferred the phase isolation pond and the pond into which it discharged over the adjacent four 12-acre facultative ponds.

5. Attached filamentous algae at times obscured as much as 85 percent of the surface of the phase isolation pond, but caused no difficulty - in fact, the pond appeared to clear up quicker under these conditions. Filamentous algae and suspended algae do not appear to be compatible and generally it was observed that one excludes the other.

6. The algae precipitate out more rapidly on some occasions than on others. The fastest clearing up time was 2 days after shut-off of influent. At times the algae would not mix with the residual contents of the phase isolation pond, but would precipitate in the vicinity of the influent discharge pipe.

7. During the phase isolation period, inflow must be absolutely and totally shut off. A small leak can sustain the algae bloom in the pond and in every instance when the pond did not seem to be clearing as rapidly as was expected, it was found that leaking influent was the cause. Once the leak was stopped, the pond then got back on schedule.

8. Inflow and discharge should be accomplished in as short a time as practical to minimize pond area needs and to hasten the clearing of the pond.

Summary

Extremely good effluent has been obtained from the pond receiving overflow from the facultative ponds even though algae content of the influent has been high. The secret seems to be in taking advantage of a cycle the final pond goes through when the algae settles out leaving effluent with a quality that is well within the regulatory limits of 30/30, BOD/SS.

The facultative ponds with approximately 60 days detention time discharge into the final pond until the level is 3 to 4 feet deep. Flow is stopped and the condition of the contents are observed until maximum clarity is reached then the pond is drawn down to a level about 2 feet deep and the cycle is repeated.

By using this system, effluent quality has been measured at 4 mg/L BOD and 12 mg/L SS for sustained periods. The cycle for discharging has varied from a minimum of 4 days to approximately 20 days. More information on this project is given in an article in **Water and Sewage Works**, December 1975, p. 42.

F Metric equivalents

METRIC CONVERSION TABLES

Recommended Units

Description	Unit	Symbol	Comments	English Equivalents
Length	meter	m	*Basic SI unit*	39.37 in. = 3.28 ft = 1.09 yd
	kilometer	km		0.62 mi
	millimeter	mm		0.03937 in.
	centimeter	cm		0.3937 in.
	micrometer	μm.		$3.937 \times 10^{-3} = 10^{3}$A
Area	square meter	m^2		10.744 sq ft = 1.196 sq yd
	square kilometer	km^2		6.384 sq mi = 247 acres
	square centimeter	cm^2		0.155 sq in.
	square millimeter	mm^2		0.00155 sq in.
	hectare	ha	The hectare (10,000 m^2) is a recognized multiple unit and will remain in international use.	2.471 acres
Volume	cubic meter	m^3		35.314 cu ft = 1.3079 cu yd
	cubic centimeter	cm^3		0.061 cu in.
	liter	l	The liter is now recognized as the special name for the cubic decimeter	1.057 qt = 0.264 gal = 0.81×10^{-4} acre-ft
Mass	kilogram	kg	*Basic SI unit*	2.205 lb
	gram	g		0.035 oz = 15.43 gr
	milligram	mg		0.01543 gr
	tonne	t	1 tonne = 1,000 kg	0.984 ton (long) = 1.1023 ton (short)
Time	second	s	*Basic SI unit*	
	day	day	Neither the day nor the year is an SI unit but both are important.	
	year	yr or a		
Force	newton	N	The newton is that force that produces an acceleration of 1 m/s^2 in a mass of 1 kg.	0.22481 lb (weight) = 7.5 poundals

Recommended Units

Description	Unit	Symbol	Comments	English Equivalents
Velocity				
linear	meter per second	m/s		3.28 fps
	millimeter per second	mm/s		0.00328 fps
	kilometers per second	km/s		2.230 mph
angular	radians per second	rad/s		
Flow (volumetric)	cubic meter per second	m^3/s	Commonly called the cumec	15,850 gpm = 2.120 cfm
	liter per second	l/s		15.85 gpm
Viscosity	poise	poise		0.0672 lb/sec-ft
Pressure	newton per square meter	N/m^2	The newton is not yet well-known as the unit of force and kgf cm^2 will clearly be used for some time. In this field the hydraulic head expressed in meters is an acceptable alternative.	0.00014 psi
	kilonewton per square meter	kN/m^2		0.145 psi
	kilogram (force) per square centimeter	kgf/cm^2		14.223 psi
Temperature	degree Kelvin	K	*Basic SI unit*	$\frac{5F}{9} - 17.77$
	degree Celsius	C	The Kelvin and Celsius degrees *are identical*. The use of the Celsius scale is recommended as it is the former centigrade scale.	
Work, energy, quantity of heat	joule	J	1 joule = 1 N-m	2.778×10^{-7} kw hr = 3.725×10^{-7} hp-hr = 0.73756 ft-lb = 9.48×10^{-4} Btu
	kilojoule	kJ		2.778 kw-hr
Power	watt	W	1 watt = 1 J/s	
	kilowatt	kW		
	joule per second	J/s		

Application of Units

Description	Unit	Symbol	Comments	English Equivalents
Precipitation, run-off, evaporation	millimeter	mm	For meteorological purposes it may be convenient to measure precipitation in terms of mass/unit area (kg/m^3). 1 mm of rain = 1 kg/sq m	
River flow	cubic meter per second	m^3/s	Commonly called the cumec	35.314 cfs
Flow in pipes, conduits, channels, over weirs, pumping	cubic meter per second	m^3/s		
	liter per second	l/s		15.85 gpm
Discharges or abstractions, yields	cubic meter per day	m^3/day	1 l/s = 86.4 m^3/day	1.83 X 10^{-3} gpm
	cubic meter per year	m^3/yr		
Usage of water	liter per person per day	l/person day		0.264 gcpd
Density	kilogram per cubic meter	kg/m^3	The density of water under standard conditions is 1,000 kg/m^3 or 1,000 g/l	0.0624 lb/cu ft

Application of Units

Description	Unit	Symbol	Comments	English Equivalents
Concentration	milligram per liter	mg/l		1 ppm
BOD loading	kilogram per cubic meter per day	kg/m^3 day		0.0624 lb/cu-ft day
Hydraulic load per unit area; e.g. filtration rates	cubic meter per square meter per day	m^3/m^2 day	If this is converted to a velocity, it should be expressed in mm/s (1 mm/s = 86.4 m^3/m^2 day).	3.28 cu ft/sq ft
Hydraulic load per unit volume; e.g. biological filters, lagoons	cubic meter per cubic meter per day	m^3/m^3 day		
Air supply	cubic meter or liter of free air per second	m^3/s l/s		
Pipes diameter	millimeter	mm		0.03937 in.
length	meter	m		39.37 in. = 3.28 ft
Optical units	lumen per square meter	$lumen/m^2$		0.092 ft candle/sq ft

☆ U.S. GOVERNMENT PRINTING OFFICE: 1975-630-902

G References and suggested resource material

1. *Stabilization Pond Operation and Maintenance Manual*

   Minnesota Pollution Control Agency
   1935 West County Road B2
   Roseville, Minnesota 55113

2. *Operating Waste Stabilization Ponds - Course Manual for Operator Training*

   EPA No. T0077046-01
   Iowa Department of Environmental Quality
   Kirkwood Community College
   Cedar Rapids, Iowa

3. Palmer, C. Mervin, *Algae in Water Supplies: An Illustrated Manual on the Identification, Significance, and Control of Algae in Water Supplies*, PHS Pub. 657, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, reprinted 1962, 93 pp. National Technical Information Service Number PB 216 459.

4. *Operation of Wastewater Treatment Plants* (Chapters 9, 13 and 14)

   Department of Civil Engineering
   Sacramento State College
   6000 Jay Street
   Sacramento, California 95819

5. *Wastewater Treatment Ponds*

   EPA 430/9-74-011

6. *Upgrading Wastewater Stabilization Ponds to Meet New Discharge Standards* (Pages 15, 21, 31 and 8)

   Proceedings of a Symposium at Utah State University, 1974

   Utah Water Research Laboratory
   College of Engineering
   Utah State University
   Logan, Utah 84322

7. *Standard Methods for the Examination of Water and Wastewater*, 14 Edition (Note algae plates in color.)

   Water Pollution Control Federation
   2626 Pennsylvania Avenue, Northwest
   Washington, D. C. 20037

8. *Manual of Wastewater Operations* (Chapters 16 and 21)

   Texas State Department of Health
   Austin, Texas

H Plants visited

Lafayette, Oregon	Polishing ponds following a package plant.
Dundee, Oregon	Two-cell stabilization pond.
Bay City, Oregon	Two-cell stabilization pond.
Greeley, Colorado	Two-cell anaerobic pond followed by a complete-mix activated sludge plant, plus a sludge lagoon and a polishing pond.
Windsor, Colorado	Two-cell stabilization pond.
Louisville, Colorado	Four-cell polishing pond following an extended aeration facility.
Sunnyvale, California	Waste stabilization pond followed by an algae removal system which includes air flotation and multi-media filters.
Woodland, California	Oxidation ponds utilizing phase isolation for algae removal.
Modesto, California	Oxidation ponds.
Turlock, California	Oxidation ponds.
Eudora, Kansas	Three-cell stabilization pond.
Shawnee County, Kansas	Two-cell stabilization pond.
Topeka Truck Plaza, Kansas	Aerated lagoon ahead of stabilization pond.
Shawnee County Sewer Dist. No. 8, Kansas	Two-cell aerated pond.
City of Topeka, Kansas (Pauline Plant)	Three-cell stabilization pond.

Page 1-5 Right Column - last paragraph

- Ammonia (CH_4), ... is in error

Ammonia = ~~NH_4Cl~~ NH_3

Methane = CH_4

J Checklist form

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary