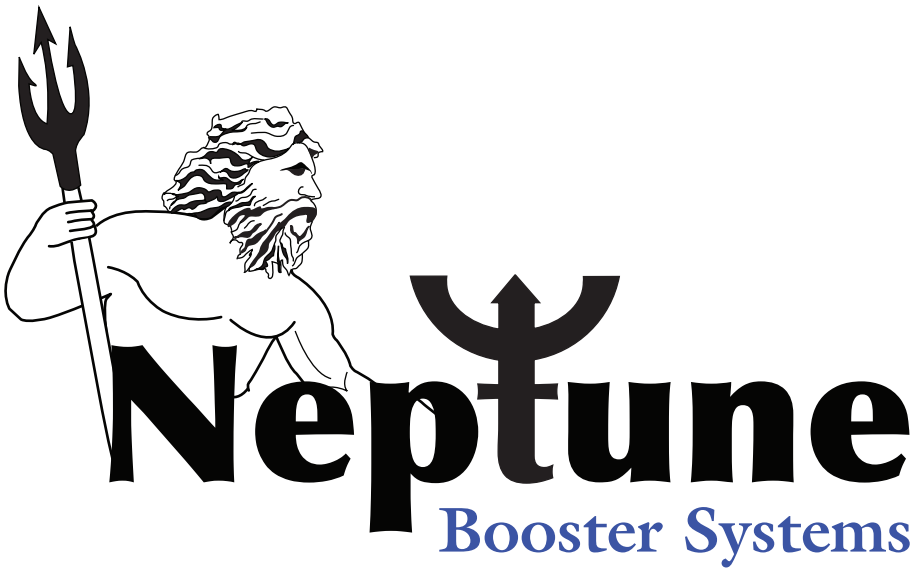
AMERICAN-MARSH PUMPS
"DURABILITY BY DESIGN SINCE 1873"

Edition 1
25 October 2011

Series 1000
Model: Neptune Booster Systems



Installation, Operation & Maintenance Manual For Series 1000 Neptune Booster Systems

Engineered Process Group

Water Systems Group

www.american-marsh.com

IOM Manual: 077-0407-000
Series 1000: Neptune Booster Systems

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SAFETY CONSIDERATIONS

The American-Marsh Neptune Booster System has been designed and manufactured for safe operation. In order to ensure safe operation, it is very important that this manual be read in its entirety prior to installing or operating the system. American-Marsh Pumps shall not be liable for physical injury, damage or delays caused by a failure to observe the instructions for installation, operation and maintenance contained in this manual.

Remember that every pump has the potential to be dangerous, because of the following factors:

- Parts are rotating at high speeds
- High pressures may be present
- High temperatures may be present
- Highly corrosive and/or toxic chemicals may be present

Paying constant attention to safety is always extremely important. However, there are often situations that require special attention. These situations are indicated throughout this book by the following symbols:

⚠DANGER

DANGER - Immediate hazards which WILL result in severe personal injury or death.

⚠WARNING

WARNING – Hazards or unsafe practices which COULD result in severe personal injury or death.

⚠CAUTION

CAUTION – Hazards or unsafe practices which COULD result in minor personal injury or product or property damage.

Maximum Lifting Speed: 15 feet/second.

If in a climate where the fluid in the system could freeze, never leave liquid in the booster system. Drain the system completely. During winter months and cold weather, the liquid could freeze and damage the system components.

Do not run the equipment dry or start the pump without the proper prime (flooded system).

Never operate the pump(s) for more than a short interval with the discharge valve closed. The length of the interval depends on several factors including the nature of the fluid pumped and its temperature. Contact American-Marsh Engineering for additional support if required.

Never operate the system with a closed suction valve.

Excessive pump noise or vibration may indicate a dangerous operating condition. The pump(s) must be shutdown immediately.

Do not operate the pump and/or the system for an extended period of time below the recommended minimum flow.

It is absolutely essential that the rotation of the motor be checked before starting any pump in the system. Incorrect rotation of the pump(s) for even a short period of time can cause severe damage to the pumping assembly.

If the liquid is hazardous, take all necessary precautions to avoid damage and injury before emptying the pump casing.

Residual liquid may be found in the pump casing, suction and discharge manifolds. Take the necessary precautions if the liquid is hazardous, flammable, corrosive, poisonous, infected, etc.

Always lockout power to the driver before performing pump maintenance.

Never operate the pump without the coupling guard (if supplied) and all other safety devices correctly installed.

Do not apply heat to disassemble the pump or to remove the impeller. Entrapped liquid could cause an explosion.

If any external leaks are found while pumping hazardous product, immediately stop operations and repair.

PUMP IDENTIFICATION

MANUFACTURER

American-Marsh Pumps
185 Progress Road
Collierville, TN 38017
United States of America

TYPE OF PUMP

The American-Marsh Neptune Booster System can consist of many different types of pumps. This manual is intended to cover the integration of these pumping assemblies into a common skid. Individual pump specific Installation, Operation & Maintenance manuals will be supplied in addition to this manual to supplement specific pump construction.

DATE OF MANUFACTURE

The date of manufacture is indicated on the pump data plate.

INSTALLATION, OPERATION & MAINTENANCE MANUAL IDENTIFICATION

Prepared: October 25, 2011 Edition: 01
Revision: Date of Revision:

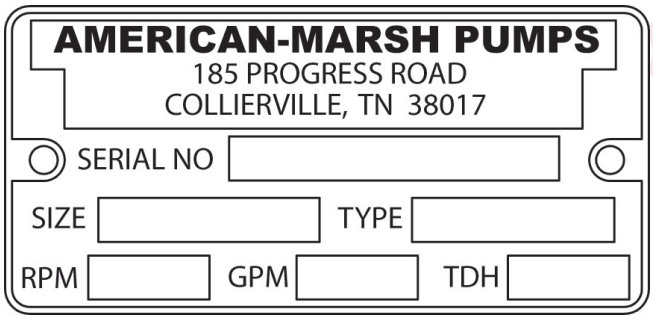


FIGURE 1 – Pump Data Plate

SERIAL NUMBER:	Serial Number of pump unit (issued by Production Control)
SIZE:	Size designation of pump (3x4-10)
TYPE:	Pump type (REF, REC or REI)
RPM:	Speed of pump
GPM:	Rated capacity of pump
TDH:	Rated Total Dynamic Head of pump

WARRANTY

American-Marsh Pumps guarantees that only high quality materials are used in the construction of our pumps and that machining and assembly are carried out to the highest standards.

The pumps are guaranteed against defective materials and/or faulty craftsmanship for a period of one year from the date of shipment unless specifically stated otherwise.

Replacement of parts or of the pump itself can only be carried out after careful examination of the pump by qualified personnel.

The warranty is not valid if third parties have tampered with the pump and/or if the pump warranty seal has been removed without PRIOR written consent.

This warranty does not cover parts subject to deterioration or wear and tear (mechanical seals, pressure and vacuum gauges, rubber or plastic items, bearings, etc.) or damage caused by misuse or improper handling of the pump by the end user.

Parts replaced under warranty become the property of American-Marsh Pumps.

Contact the American-Marsh Pumps' factory:

American-Marsh Pumps
185 Progress Road
Collierville, TN 38017
United States Of America

Phone: (901) 860-2300
Fax: (901) 860-2323
www.american-marsh.com

GENERAL INSTRUCTIONS

The pump and motor unit must be examined upon arrival to ascertain any damage caused during shipment. If damaged immediately notify the carrier and/or the sender. Check that the goods correspond exactly to the description on the shipping documents and report any differences as soon as possible to the sender. Always quote the pump type and serial number stamped on the data plate.

The pumps must be used only for applications for which the manufacturers have specified:

- The construction materials
- The operating conditions (flow, pressure, temperature, etc.)
- The field of application

In case of doubt, contact the manufacturer.

HANDLING AND TRANSPORT

METHOD OF TRANSPORT

The Neptune Booster System must be transported in the horizontal position.

INSTALLATION

During installation and maintenance, all components must be handled and transported securely by using suitable slings. Handling must be carried out by specialized personnel to avoid damage to the pump and persons. The lifting rings attached to various components should be used exclusively to lift the components for which they have been supplied.

⚠CAUTION

Maximum lifting speed: 15 feet/second

STORAGE

SHORT-TERM STORAGE

Normal packaging is designed to protect the pump during shipment and for dry, indoor storage for up to two months or less. The procedure followed for this short-term storage is summarized below:

Standard Protection for Shipment :

1. Loose unmounted items, including, but not limited to, oilers, packing, coupling spacers, stilts, and mechanical seals are packaged in a water proof plastic bag and placed under the coupling guard. Larger items are packaged and metal banded to the base plate. All parts bags and cartons are identified with the American-Marsh sales order number, the customer purchase order number, and the pump item number (if applicable).

2. Inner surfaces of the bearing housing, shaft (area through bearing housing), and bearings are coated with Cortec VCI-329 rust inhibitor, or equal.

Note: Bearing housings are not filled with oil prior to shipment.

3. Regreasable bearings are packed with grease (Royal Purple NLGI#2).

4. After a performance test, if required, the pump is tipped on the suction flange for drainage (some residual water may remain in the casing). Then, internal surfaces of ferrous casings, covers, flange faces, and the impeller surface are sprayed with Calgon Vestal Labs RP-743m, or equal. Exposed shafts are taped with Polywrap.

5. Flange faces are protected with plastic covers secured with plastic drive bolts. 3/16 in (7.8 mm) steel or 1/4 in (6.3 mm) wood covers with rubber gaskets, steel bolts, and nuts are available at extra cost.

6. All assemblies are bolted to a wood skid which confines the assembly within the perimeter of the skid.

7. Assemblies with special paint are protected with a plastic wrap.

8. All assemblies having external piping (seal flush and cooling water plans), etc. are packaged and braced to withstand normal handling during shipment. In some cases components may be disassembled for shipment. The pump must be stored in a covered, dry location.

LONG-TERM STORAGE

Long-term storage is defined as more than two months, but less than 12 months. The procedure American-Marsh follows for long-term storage of pumps is given below. These procedures are in addition to the short-term procedure.

Solid wood skids are utilized. Holes are drilled in the skid to accommodate the anchor bolt holes in the base plate, or the casing and bearing housing feet holes on assemblies less base plate. Tackwrap sheeting is then placed on top of the skid and the pump assembly is placed on top of the Tackwrap. Metal bolts with washers and rubber bushings are inserted through the skid, the Tackwrap, and the assembly from the bottom of the skid and are then secured with hex nuts. When the nuts are "snugged" down to the top of the base plate or casing and bearing housing feet, the rubber bushing is expanded, sealing the hole from the atmosphere. Desiccant bags are placed on the Tackwrap. The Tackwrap is drawn up around the assembly and hermetically (heat) sealed across the top. The assembly is completely sealed from the atmosphere and the desiccant will absorb any entrapped moisture. A solid wood box is then used to cover the assembly to provide protection from the elements and handling. This packaging will provide protection up to twelve months without damage to mechanical seals, bearings, lip seals, etc. due to humidity, salt laden air, dust, etc. After unpacking, protection will be the responsibility of the user. Addition of oil to the bearing housing will remove the inhibitor. If units are to be idle for extended periods after addition of lubricants, inhibitor oils and greases should be used.

Every three months, the shaft should be rotated approximately 10 revolutions.

INSTALLATION & ALIGNMENT

SYSTEM RECEIPT

When the Neptune Booster System is received it is very important that the system and components are checked for signs of damage during shipment.

INSTALLATION

BASE PLATE INSTALLATION

NEW GROUTED BASE PLATES

1. The pump foundation should be located as close to the source of the fluid to be pumped as practical. There should be adequate space for workers to install, operate, and maintain the pump. The foundation should be sufficient to absorb any vibration and should provide a rigid support for the pump and motor. Recommended mass of a concrete foundation should be three times that of the pump, motor and base. Note that foundation bolts are imbedded in the concrete inside a sleeve to allow some movement of the bolt.

2. Level the Neptune Booster System base plate assembly. If the base plate has machined coplanar mounting surfaces, these machined surfaces are to be referenced when leveling the base plate. This may require that the pump and motor be removed from the base plate in order to reference the machined faces. If the base plate is without machined coplanar mounting surfaces, the pump and motor are to be left on the base plate. The proper surfaces to reference when leveling the pump base plate assembly are the pump suction and discharge flanges. DO NOT stress the base plate. Do not bolt the suction or discharge flanges of the system to the piping until the base plate foundation is completely installed. If equipped, use leveling jackscrews to level the base plate. If jackscrews are not provided, shims and wedges should be used (see Figure 2). Check for levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations, and in the middle edge of the base if the base is more than five feet long. Do not rely on the bottom of the base plate to be flat. Standard base plate bottoms are not machined, and it is not likely that the field mounting surface is flat.

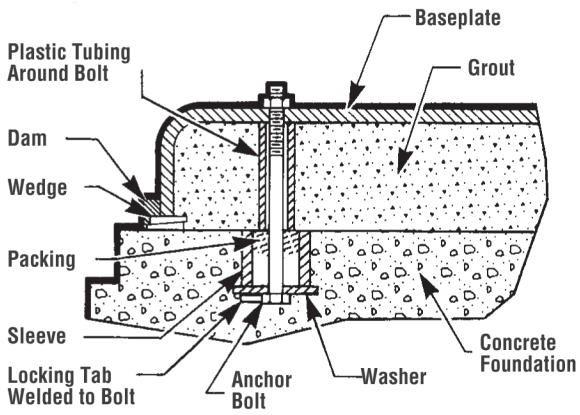


FIGURE 2 – Base Plate Foundation

3. After leveling the system, base plate, tighten the anchor bolts. If shims were used, make sure that the base plate was shimmed near each anchor bolt before tightening. Failure to do this may result in a twist of the base plate, which could make it impossible to obtain final alignment. Check the level of the base plate to make sure that tightening the anchor bolts did not disturb the level of the base plate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the base plate. Continue adjusting the jackscrews or shims and tightening the anchor bolts until the base plate is level.

4. Check initial alignment. If the pump and motor were removed from the base plate proceed with step 5 first, then the pump and motor should be reinstalled onto the base plate using American-Marsh's Factory Preliminary Alignment Procedure, and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the base plate or if they were not removed from the base plate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.015 in (0.38 mm) FIM (Full Indicator Movement) parallel, and 0.0025 in/in (0.0025 mm/mm) FIM angular. If this is not the case first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment, and by moving the pump for horizontal alignment.

5. Grout the base plate. A non-shrinking grout should be used. Make sure that the grout fills the area under the base plate. After the grout has cured, check for voids and repair them. Jackscrews, shims and wedges should be removed

from under the base plate at this time. If they were to be left in place, they could rust, swell, and cause distortion in the base plate.

6. Run piping to the suction and discharge of the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant loads.

7. Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.002 in (0.05 mm) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet. When satisfactory alignment is obtained the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. American-Marsh recommends no more than 0.002 in (0.05mm) parallel, and 0.0005 in/in (0.0005 mm/mm) angular misalignment.

8. Operate the pump for at least an hour or until it reaches final operating temperature. Shut the pump down and recheck alignment while the pump is hot. Piping thermal expansion may change the alignment. Realign pump as necessary.

PIPING CONNECTION – SUCTION & DISCHARGE MANIFOLDS

All piping must be independently supported, accurately aligned and preferably connected to the pump by a short length of flexible piping. The pump should not have to support the weight of the pipe or compensate for misalignment. It should be possible to install suction and discharge bolts through mating flanges without pulling or prying either of the flanges. All piping must be tight. Pumps may air-bind if air is allowed to leak into the piping. If the pump flange(s) have tapped holes, select flange fasteners with thread engagement at least equal to the fastener diameter but that do not bottom out in the tapped holes before the joint is tight.

⚠WARNING

Piping Forces: Take care during installation and operation to minimize pipe forces and/or moments on the pump casing.

SUCTION PIPING

To avoid NPSH and suction problems, suction pipe sizes must be at least as large as the pump suction connection. Never use pipe or fittings on the suction that are smaller in diameter than the pump suction size. An ideal piping configuration should have a minimum of 10 pipe diameters between the source and the pump suction manifold. In most cases, horizontal reducers should be eccentric and mounted with the flat side up as shown in figure 6 with a maximum of one pipe size reduction. Never mount eccentric reducers with the flat side down. Horizontally mounted concentric reducers should not be used if there is any possibility of entrained air in the process fluid. Vertically mounted concentric reducers are acceptable. In applications where the fluid is completely deaerated and free of any vapor or suspended solids, concentric reducers are preferable to eccentric reducers.

Avoid the use of throttling valves and strainers in the suction line. Start up strainers must be removed shortly after start up. When the pump is installed below the source of supply, a valve should be installed in the suction line to isolate the pump and to permit pump inspection and maintenance. However, never place a valve directly on the suction nozzle of the pump.

Refer to the American-Marsh Pump Engineering Manual and the Centrifugal Pump IOM Section of the Hydraulic Institute Standards for additional recommendations on suction piping.

DISCHARGE PIPING

Install a valve in the discharge line. This valve is required for regulating flow and/or to isolate the pump for inspection and maintenance.

When fluid velocity in the pipe is high, for example, 10 ft/s (3 m/s) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

COUPLING

A direction arrow is cast on the front of the casing and on the Bearing Housing. Make sure the motor rotates in the same direction before coupling the motor to the Pump.

It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge the impeller which may cause serious damage to the pump. All RE pumps turn clockwise as viewed from the motor end or, conversely, counterclockwise when viewed from the suction end.

The coupling should be installed as advised by the coupling manufacturer. Pumps are shipped without the spacer installed.

If the spacer has been installed to facilitate alignment, then it must be removed prior to checking rotation. Remove protective material from the coupling and any exposed portions of the shaft before installing the coupling.

SYSTEM INTEGRATION

After the system has been mounted and supported properly the step of wiring the panel into the building's power supply can be started.

1. Ensure that the Neptune Booster System disconnect is in the OFF position.
2. Ensure that each H-O-A (Hand-Off-Auto) switch is in the OFF position as well. This will stop a pump within the system from energizing accidentally.
3. Have a qualified electrician route power to the system control panel. Be sure that local electrical codes are followed as they can vary greatly region to region.
4. Grout the Neptune Booster System skid to the concrete foundation with a non-shrink grout as specified above.
5. Route Neptune Booster System thermal relief valves, if equipped, to the appropriate floor drain.
6. If American-Marsh supplied an optional, remotely mounted hydro-pneumatic tank, install the tank in a suitable location and connect it to the Neptune Booster System with the supplied remote connection.

⚠CAUTION

The hydro-pneumatic tank is shipped from the factory with the isolation valve in the closed position. The hydro-pneumatic tank MUST be pre-charged to system pressure with air PRIOR to opening the isolation valve and admitting fluid.

PUMP OPERATION

ROTATION CHECK

It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge and damage the impeller, casing, shaft and shaft seal.

PRE START-UP CHECKS

Prior to starting the pump it is essential that the following checks are made.

- Pump and Motor properly secured to the base plate
- All fasteners tightened to the correct torques
- Coupling guard in place and not rubbing
- Rotation check, see above

THIS IS ABSOLUTELY ESSENTIAL.

- Shaft seal properly installed
- Seal support system operational
- Bearing lubrication
- Bearing housing cooling system operational
- Impeller clearances properly set
- Pump instrumentation is operational
- Pump is primed
- Rotation of shaft by hand

As a final step in preparation for operation, it is important to rotate the shaft by hand to be certain that all rotating parts move freely, and that there are no foreign objects in the pump.

ENSURING PROPER NPSHA

Net Positive Suction Head – Available (NPSHA) is the measure of the energy in a liquid above the vapor pressure. It is used to determine the likelihood that a fluid will vaporize in the pump. It is critical because a centrifugal pump is designed to pump a liquid, not a vapor. Vaporization in a pump will result in damage to the pump, deterioration of the Total Differential Head (TDH), and possibly a complete stopping of pumping.

Net Positive Suction Head – Required (NPSHR) is the decrease of fluid energy between the inlet of the pump, and the point of lowest pressure in the pump. This decrease occurs because of friction losses and fluid accelerations in the inlet region of the pump, and particularly accelerations as the fluid enters the impeller vanes. The value for NPSHR for the specific pump purchased is given in the pump data sheet, and on the pump performance curve.

For a pump to operate properly the NPSHA must be greater than the NPSHR. Good practice dictates that this margin

should be at least 5 ft (1.5 m) or 20%, whichever is greater.

Ensuring that NPSHA is larger than NPSHR by the suggested margin will greatly enhance pump performance and reliability. It will also reduce the likelihood of cavitation, which can severely damage the pump.

MINIMUM FLOW

Minimum continuous stable flow is the lowest flow at which the pump can operate and still conform to the bearing life, shaft deflection and bearing housing vibration limits. Pumps may be operated at lower flows, but it must be recognized that the pump may not conform to one or more of these limits. For example, vibration may exceed the limit set by the ASME standard. The size of the pump, the energy absorbed, and the liquid pumped are some of the considerations in determining the minimum flow.

Typically, limitations of 10% of the capacity at the best efficiency point (BEP) should be specified as the minimum flow. However, American-Marsh has determined that several pumps must be limited to higher minimum flows to provide optimum service. To confirm what minimum flows are required please contact the American-Marsh engineering department.

Note: "Minimum intermittent flow" value of 50% of the "minimum continuous flow" as long as that flow is greater than the "minimum thermal flow."

All pumps also have a "Minimum Thermal Flow." This is defined as the minimum flow that will not cause an excessive temperature rise. Minimum Thermal Flow is application dependent.

Do not operate the pump below Minimum Thermal Flow, as this could cause an excessive temperature rise. Contact an American-Marsh Sales Engineer for determination of Minimum Thermal flow.

STARTING THE SYSTEM

1. Open all system isolation valves to the full open position. This includes all suction and discharge isolation valves. It is very important to leave the suction valve open while the pump is operating. Any throttling or adjusting of flow must be done through the discharge valve. Partially closing the suction valve can create serious NPSH and pump performance problems.

⚠WARNING

Never operate pump with both the suction and discharge valves closed. This could cause an explosion.

2. Slowly open the Neptune Booster System supply from the building.

3. A standard centrifugal pump will not move liquid unless the pump is primed. A pump is said to be "primed" when the casing and the suction piping are completely filled with liquid. Open discharge valve a slight amount. This will allow any entrapped air to escape and will normally allow the pump to prime, if the suction source is above the pump. When a condition exists where the suction pressure may drop below the pump's capability, it is advisable to add a low pressure control device to shut the pump down when the pressure drops below a predetermined minimum.

4. All cooling, heating, and flush lines must be started and regulated.

5. Open all petcocks on pumps and system manifolds to allow air to bleed from the system.

6. Turn the Neptune Booster System panel disconnect to the ON position.

7. Jog PUMP # 1 in order to confirm correct rotation. If rotation is incorrect take corrective action as required.

8. Jog PUMP # 2 in order to confirm correct rotation. If rotation is incorrect take corrective action as required.

9. Continue this action to confirm that all system pumps have correct rotation.

10. Turn PUMP # 1 H-O-A switch to the HAND position. Bleed air from the Pressure Reducing Valve (PRV), if supplied, at the highest point on the valve by opening any fitting.

11. Turn PUMP # 1 H-O-A switch to OFF position.

12. Turn PUMP # 2 H-O-A switch to the HAND position. Bleed air from the Pressure Reducing Valve (PRV), if supplied, at the highest point on the valve by opening any fitting.

13. Continue this action to confirm that all system PRV's have all air bled from system.

14. After all air is bled from the Neptune Booster System, place the system into operation by placing all H-O-A switches to AUTO position.

REDUCED CAPACITY

Avoid running a centrifugal pump at drastically reduced capacities or with discharge valve closed for extended periods of time. This can cause severe temperature rise and the liquid in the pump may reach its boiling point. If this occurs, the mechanical seal will be exposed to vapor, with no lubrication, and may score or seize to the stationary parts. Continued running under these conditions when the suction valve is also closed, can create an explosive condition due to the confined vapor at high pressure and temperature. Thermostats may be used to safeguard against over heating by shutting down the pump at a predetermined temperature.

Safeguards should also be taken against possible operation with a closed discharge valve, such as installing a bypass back to the suction source. The size of the bypass line and the required bypass flow rate is a function of the input horsepower and the allowable temperature rise.

REDUCED HEAD

Note that when discharge head drops, the pump's flow rate usually increases rapidly. Check motor for temperature rise as this may cause overload. If overloading occurs, adjust your set points on your system panel.

OPERATION IN SUB-FREEZING CONDITIONS

When using the pump in sub-freezing conditions where the pump is periodically idle, the pump should be properly drained or protected with thermal devices which will keep the liquid in the pump from freezing.

OPERATION

⚠CAUTION

American-Marsh Neptune Booster Systems are tested and adjusted PRIOR to shipment. System pressure set points are factory adjusted based on specifications supplied to American-Marsh Pumps at time of order. Confirmation of proper system operation is the responsibility of the end user.

⚠CAUTION

Failure to properly vent the complete Neptune Booster System could result in erratic or sluggish operation due to air trapped in the system PRV's.

WITH HYDRO-PNEUMATIC TANK

When the H-O-A switches are placed in the AUTO position the lead pump will run continuously to maintain the system set pressure as entered into the Neptune Interactive Display (NID).

To adjust the low pressure suction set point, confirm the system pressure with the lead pump running (PUMP # 1). The low suction pressure transducer is typically set at the factory at 5 PSI OFF and 20 PSI ON. The pressure transducer setting can be adjusted as needed based on field conditions.

When system flow demand increases beyond the pump design point Neptune Booster System pressure will begin to decrease.

The low system set point is typically set at the factory at 10 PSI below the system set pressure. The low system transducer setting can be adjusted as needed based on field conditions.

When the Neptune Booster System pressure reaches the predetermined user defined set point, the lag pumps starts in response to the lower pressure. The lag pump will run as required until flow demand decreases and Neptune Booster System pressure rises above the user defined set point. When the Neptune Booster System pressure reaches the user defined set point the lag pump will shutdown automatically and the lead pump will continue to run. During periods of low system demand or shut-off operation both pumps can be provided with a thermal relief valve for pump protection.

WITHOUT HYDRO-PNEUMATIC TANK

When the H-O-A switches are placed in the AUTO position the hydro-pneumatic tank pressure switch sequences the lead pump under no flow condition. The tank fills to capacity and the hydro-pneumatic tank pressure starts to increase. This increase in hydro-pneumatic tank pressure will stop the lead pump when the user defined set point is reached and after the minimum run time has been satisfied. These parameters are user defined and are entered into the Neptune Interactive Display (NID). The tank will supply demand for the system under lower flow conditions and stop the system from nuisance tripping due to low demand. As the hydro-pneumatic tank pressure continues to drop as system demand continues, the lead pump will start after a minimum time delay. The system pressure trans-

ducer will continue to cycle the lead and lag pumps as required to maintain hydro-pneumatic tank and system demands.

⚠WARNING

System discharge pressure transducer high set point must be lower than the pump shutoff head.

To adjust the low pressure suction set point, confirm the system pressure with the lead pump running (PUMP # 1). The low suction pressure transducer is typically set at the factory at 5 PSI OFF and 20 PSI ON. The pressure transducer setting can be adjusted as needed based on field conditions.

When system flow demand increases beyond the pump design point Neptune Booster System pressure will begin to decrease.

The low system set point is typically set at the factory at 10 PSI below the system set pressure. The low system transducer setting can be adjusted as needed based on field conditions.

SUPPLEMENTAL INFORMATION

PRESSURE REGULATED SYSTEMS

The controller uses a solid state pressure transducer to control the starting and stopping of individual pumps on the Neptune Booster System package. This pressure transducer signal (4-20 milliampere) is connected to the Programmable Logic Controller (PLC) which has user defined start and stop set points. When the system pressure drops below the user defined pressure set point, usually just below the PRV stem setting, the controller causes the next pump to start. Rising system pressure causes the controller to turn the pumps off. This type of a system also utilizes a Pressure Regulating Valve (PRV) for each pump and has a constant speed panel. The controller responds to the system pressure (as adjusted and measured from the discharge pressure transducer) to start and stop the pump or pumps. When the system pressure drops below the user defined set point, usually just below the PRV stem settings, the controller causes the next pump in line to start. When the pressure in the system rises sufficiently, the controller stops the last pump started, after a user defined minimum run period. A low pressure alarm and shutdown is included in the controller logic standard to protect the pump or pumps in the system from running dry and or cavitating due to insufficient suction pressure.

OPERATIONAL H-O-A SWITCHES

CONTROL SELECTOR SWITCH

One selector switch, H-O-A, is included for each motor. The switch includes a "MAN" (Manual, Hand) position, an "OFF"(Safety) position, and an "AUTO" (Automatic Control) position. In the manual position, the Pressure Switch and all automatic control is bypassed so the contactor coil is continuously energized by the selector switch. The Overload Relay contacts also override the manual position to protect the motor.

"OFF" (SAFETY) POSITION

In the "OFF" position, the Motor Contactor coil is de-energized to prevent the motor from running.

"MAN" POSITION (MANUAL CONTROL)

Control power wiring is TAKEN off the incoming power on the load (down-stream) side of the Line Fuses or Circuit Breaker. It is routed to the three position (Auto-Off-Manual) selector switch. In the manual position, the all pressure switches and all automatic control is bypassed so the contactor coil is continuously energized by the selector switch. The Overload Relay contacts also override the manual position to protect the motor. The Minimum Run Timer does not operate with the selector switch in the MANUAL position.

⚠WARNING

Use EXTREME care in operating the system in MANUAL (MAN) position of the control to avoid causing system over pressure.

"AUTO" (AUTOMATIC CONTROL) POSITION

In this position, the motor starter is connected to the appropriate output terminal of the PLC (Programmable Logic Controller) which enables automatic control of the pump motor by the PLC. Note that overload relay operation is independent of the PLC or any other control circuitry to protect the motor.

MOTOR RUNNING LIGHT(S)

The PUMP # 1 Running light activates when ever the motor contactor (starter) for Motor # 1 is closed under either manual or automatic control.

APPENDIX A

Clay-Val Information

CLA-VAL

— MODEL — 90-01/690-01

PRESSURE REDUCING VALVE

The Cla-Val 90-01/690-01 is an automatic control valve designed to reduce higher inlet pressure to a steady lower downstream pressure regardless of changing flow rate and/or varying inlet pressure. It is a hydraulically operated, pilot-controlled, diaphragm type globe or angle valve. When downstream pressure exceeds the pressure setting of the control pilot, the main valve and pilot valve close drip-tight. The control system is very sensitive to slight pressure changes and immediately controls the main valve to maintain the desired downstream pressure. Pressure setting adjustment is made with a single adjusting screw that has a protective cap to discourage tampering.

INSTALLATION

1. Allow sufficient room around the valve assembly to make adjustments and for servicing.
2. It is recommended that gate or line block valves be installed on both ends of the 90-01/690-01 valve assembly to facilitate isolating the valve for maintenance. At a minimum of one pipe diameter apart.

NOTE: BEFORE THE VALVE IS INSTALLED, PIPE LINES SHOULD BE FLUSHED OF ALL CHIPS, SCALE, AND FOREIGN MATTER.

3. Place the valve assembly in the line with flow through the valve in the direction indicated on the inlet plate or by flow arrows. Check all fittings and hardware for proper makeup and that no apparent damage is evident. Be sure main valve cover nuts/bolts are tight. As pressure in some applications can be very high, thorough inspection for proper installation and makeup is strongly recommended.
4. Cla-Val Valves operate with maximum efficiency when mounted in horizontal piping with the cover UP, however, other positions are acceptable. Due to size and weight of cover and internal components of six-inch and larger valves, installation with the cover up is advisable and provides greater accessibility to internal parts for periodic inspection
5. Caution must be taken in the installation of this valve to insure that galvanic and/or electrolytic action does not take place. The proper use of dielectric fittings and gaskets are required in all systems using dissimilar metals.

OPERATION AND START-UP

1. Prior to pressurizing the valve assembly, ensure that the necessary gauges to measure pressure in the system are installed as required by the system engineer. A Cla-Val X101 Valve Position Indicator may be installed in the center cover port to provide a visual indication of the valve movement during start-up.

CAUTION: During start-up and test procedures, a large volume of water may be discharged downstream. Check that the downstream venting is adequate to prevent damage to personnel and equipment. **All adjustments in pressure should be made slowly while under flowing conditions.** If the main valve closes too fast, it may cause surging in upstream piping.
2. If isolation valves (B) are installed in pilot system, open these valves (see schematic).
3. Optional Cla-Val CV Flow Controls (C or S) provide adjustable regulation of flow in and out of the main valve chamber to minimize pulsations that sometime occur at very low flow rates. If CV Controls are installed, loosen jam nut and turn adjustment screw counterclockwise from closed position 3.5 turns for an initial setting.
4. Open the upstream gate or block valve just slightly to allow the main valve assembly and pilot system to fill with liquid.
5. Carefully loosen tube fittings at highest points and bleed air from pilot control system. Carefully loosen the plug at top of main valve cover to bleed air from cover. If an indicator is installed, carefully loosen the air bleed valve at top of indicator. Tighten tube fittings.
6. Open the upstream gate or block valve fully.
7. Slowly open the downstream gate or block valve. Flow should occur and pressure should remain constant.
8. Adjust the CRD Control to desired pressure. To change pressure setting, turn the adjusting screw clockwise to increase pressure, counterclockwise to decrease pressure. There must be liquid flowing through the valve during pressure adjustments. When the desired setting has been made, tighten jam nut and replace cover.
9. To check the operation of the valve, open and close the downstream gate valve. The downstream pressure should remain constant.

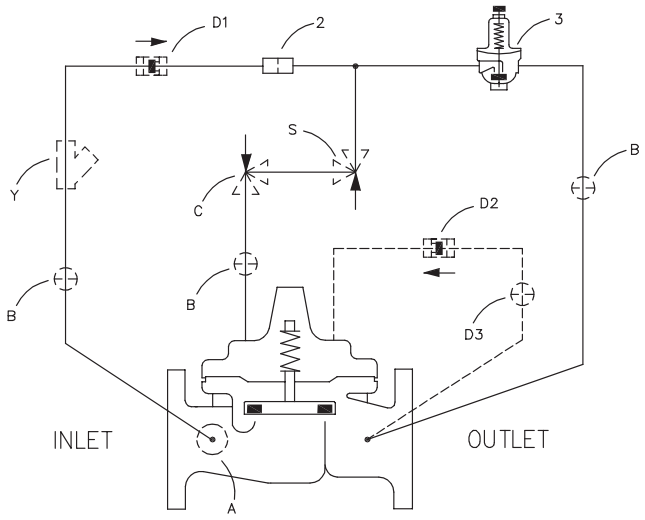
10. If opening and closing speed controls (C or S) are installed in the valve pilot system, fine tune the opening and closing speed of the main valve while performing step 9. Turn the CV adjustment screw clockwise on the opening speed control to make the main valve open slower. Turn the adjustment screw clockwise on the closing speed control to make the main valve close slower. When adjustments have been completed, tighten jam nuts.

MAINTENANCE

1. Cla-Val Valves and Controls require no lubrication or packing and maintenance, however, should be inspected a minimum of once annually.
2. Repair and maintenance procedures of the Cla-Val Hytrol Main Valve and pilot control components are included in a more detailed IOM manual. It can be downloaded from our web site (www.cla-val.com) or obtained by contacting a Cla-Val Regional Sales Office.
3. **When ordering parts, always refer to the catalog number and stock number on the valve nameplate.**

SYMPTOM	PROBABLE CAUSE	REMEDY
Main valve fails to open	No pressure at valve inlet	Check inlet pressure
	Main valve diaphragm assembly inoperative	Disassemble, clean and polish stem, replace detective parts
	Pilot Valve (CRD) not opening: 1. No spring compression 2. Damaged spring 3. Spring guide not in place 4. Yoke dragging on inlet nozzle	 1. Tighten adjusting screw 2. Disassemble and replace 3. Assemble properly 4. Assemble properly
	Flow Control (CV) disc inoperative. Corrosion or excessive scale buildup on stem	Disassemble, clean and polish stem. Replace worn parts
Main valve fails to close	Foreign matter between disc and seat or worn disc. Scale on stem or diaphragm ruptured	Disassemble main valve, remove matter, clean parts and replace defective parts
	Flow Clean Strainer plugged	Remove and clean or replace
	CK2 (isolation valves) closed	Open isolation valves
	Pilot Valve (CRD) remain open: 1. Spring compressed solid 2. Mechanical obstruction 3. Worn disc 4. Yoke dragging on inlet nozzle diaphragm nut 5. Diaphragm damaged or loose diaphragm nut. Leakage from vent hole in cover	 1. Back off adjusting screw 2. Disassemble and remove obstruction 3. Disassemble remove and replace disc retainer assembly 4. Assemble properly 5. Disassemble. replace diaphragm and/or tighten nut
Fails to regulate	Air in main valve cover and/or tubing	Loosen top cover plug and fittings and bleed air
	Pilot Valve (CRD) yoke dragging on inlet nozzle	Assemble properly
	Pilot Valve (CRD) spring not in correct range to control	Check outlet pressure requirements and compare existing spring with Spring Chart

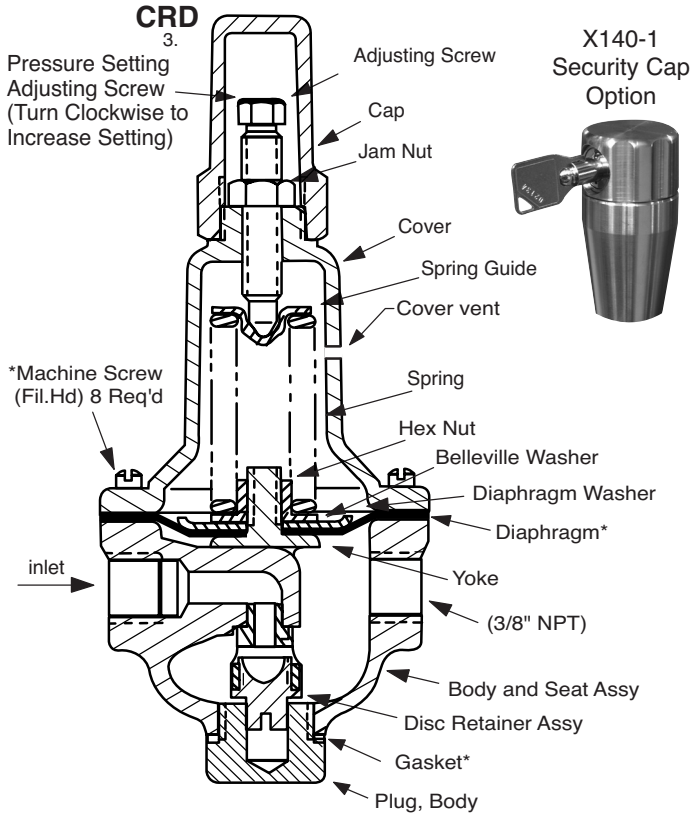
90-01/690-01 SCHEMATIC



BASIC COMPONENTS
1 100-01 Hytrol (Main Valve)
100-20 600 Series Hytrol (Main Valve)
2 X58C Restriction Fitting
3 CRD Pressure Reducing Control

OPTIONAL FEATURES
A X46A Flow Clean Strainer
B CK2 (Isolation Valve)
C Closing Speed Control
D Check Valves with Isolation Valve
S Opening Speed Control
Y X43 "Y" Strainer

CRD
3.

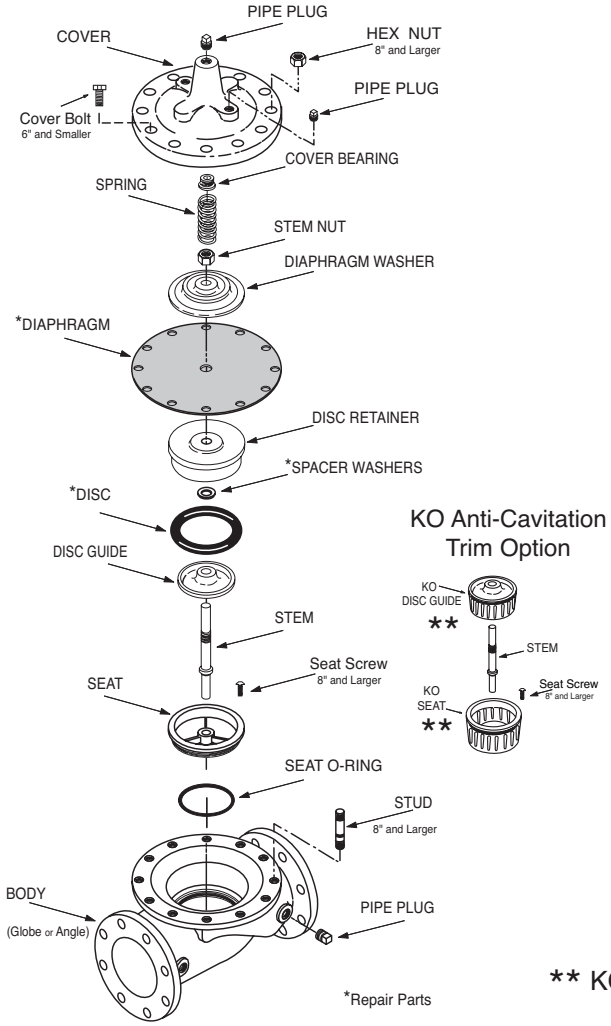


X140-1 Security Cap Option

CRD adjust range (psi)	Spring Color	psi change per turn*
2 - 30	Stainless Steel	3
15 - 75	Red	9
30 - 300	Green	27

* approximate. Use gauge at valve outlet to set

HYTROL MAIN VALVE
1.



KO Anti-Cavitation Trim Option

X58C
2.

X46A
A.

CK2
B.

CV
C.

CDC-1
D.

X43
Y.

** KO ANTI-CAVITATION TRIM CAN BE ADDED TO ANY STANDARD HYTROL VALVE

*SUGGESTED REPAIR PARTS

For a more detailed IOM Manual go to www.cla-val.com or contact a Cla-Val Regional Sales Office.

CLA-VAL P.O. Box 1325 • Newport Beach, CA 92659-0325 • Phone: 949-722-4800 • Fax: 949-548-5441 • E-mail: claval@cla-val.com • Website cla-val.com

APPENDIX B

Vision OPLC Information

For Constant Speed Systems

Vision™ OPLC™

Installation Guide
Vision120™

This guide provides basic information for Unitronics' Vision120™.

General Description

V120 OPLCs are micro-OPLCs, rugged programmable logic controllers that comprise an:

- On-board I/O configuration
- Built-in operating panel containing a graphic LCD screen and a keypad

Communications

- All V120 controllers comprise 2 RS232/485 ports
- Certain models comprise a CANbus port

I/O Options

- On-board I/O configuration
  Model-dependent; may include digital, high-speed, and analog I/Os
- I/O Expansion Modules
  Via I/O expansion port adapter, connect up to 128 additional I/Os per controller

Programming Write both the HMI and Ladder control application using VisiLogic freeware.

The Vision120 User Guide and the product's technical specification sheet contain additional information. These documents are located on the Unitronics' Setup CD. They may also be downloaded from the Technical Library at www.unitronics.com.

Standard Kit Contents

- V120 controller
- Mounting brackets (x2)
- I/O connectors (x2)
- Programming cable + RS232 adapter
- Rubber seal (mounted in back of panel)
- Unitronics' Setup CD
- 5-pin CANbus connector and CANbus network termination resistor (CANbus models)

Danger Symbols

When any of the following symbols appear, read the associated information carefully.

Symbol	Meaning	Description
	Danger	The identified danger causes physical and property damage.
	Warning	The identified danger could cause physical and property damage.
Caution	Caution	Use caution.

- Before using this product, the user must read and understand this document.
- All examples and diagrams are intended to aid understanding, and do not guarantee operation. Unitronics accepts no responsibility for actual use of this product based on these examples.
- Please dispose of this product according to local and national standards and regulations.
- Only qualified service personnel should open this device or carry out repairs.

 Failure to comply with appropriate safety guidelines can cause severe injury or property damage.

- Do not attempt to use this device with parameters that exceed permissible levels.
- To avoid damaging the system, do not connect/disconnect the device when power is on.

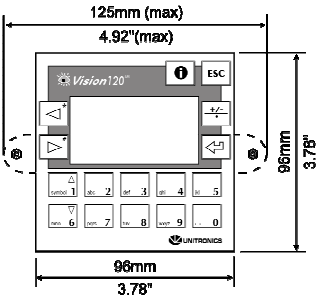
Environmental Considerations

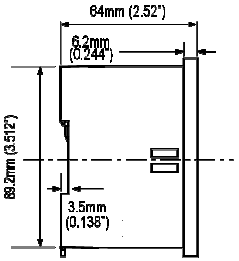
- Do not install in areas with: excessive or conductive dust, corrosive or flammable gas, moisture or rain, excessive heat, regular impact shocks or excessive vibration, in accordance with the standards given in the product's technical specification sheet.

- Ventilation: 10mm space required between controller's top/bottom edges & enclosure walls.
- Do not place in water or let water leak onto the unit.
- Do not allow debris to fall inside the unit during installation.
- Install at maximum distance from high-voltage cables and power equipment.

Mounting

Dimensions





Panel mounting

Before you begin, note that the mounting panel cannot be more than 5 mm thick.

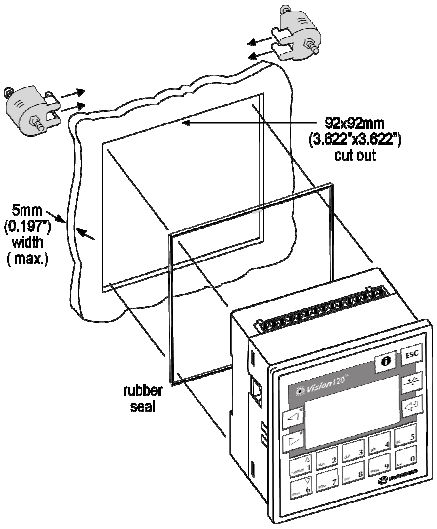
1. Make a panel cut-out measuring 92 x 92 mm (3.622" x 3.622").

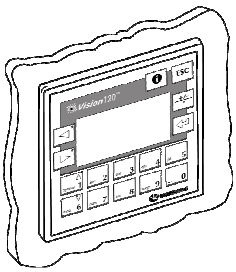
2. Slide the controller into the cut-out, ensuring that the rubber seal is in place.

3. Push the 2 mounting brackets into their slots on the sides of the controller as shown in the figure to the right.

4. Tighten the bracket screws against the panel. Hold the bracket securely against the unit while tightening the screw.

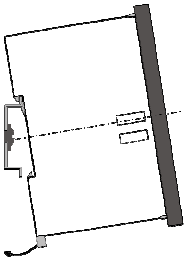
5. When properly mounted, the controller is squarely situated in the panel cut-out as shown in the figure to the right.



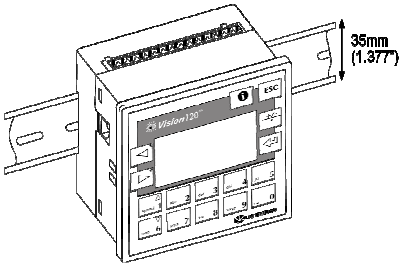


DIN-rail mounting

1. Snap the controller onto the DIN rail as shown in the figure to the right.



2. When properly mounted, the controller is squarely situated on the DIN-rail as shown in the figure to the right.



I/O Modules

The controllers offer an on-board I/O configuration that differs according to the controller model; I/O wiring diagrams are in the controller's technical specification sheet.

Additional I/Os may be integrated into the system via I/O Expansion Modules that you plug into the controller's I/O expansion port. Note that the relevant wiring diagrams are in the module's technical specification sheet, and that an I/O adapter is required for most modules.

Wiring: General

- Do not touch live wires.
- Unused pins should not be connected. Ignoring this directive may damage the device.

Caution

- To avoid damaging the wire, do not exceed a maximum torque of 0.5 N·m (5 kgf·cm).
- Do not use tin, solder, or any substance on stripped wire that might cause the wire strand to break.

Use crimp terminals for wiring; use 26-14 AWG wire (0.13 mm ^{2}–2.08 mm^2).

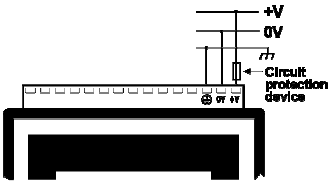
1. Strip the wire to a length of 7±0.5mm (0.250–0.300").
2. Unscrew the terminal to its widest position before inserting a wire.
3. Insert the wire completely into the terminal to ensure a proper connection.
4. Tighten enough to keep the wire from pulling free.

Power Supply

The controller requires an external 12 or 24VDC power supply, according to the controller model. Exact information may be found in the controller's technical specification sheet.

- A non-isolated power supply can be used if a 0V signal is connected to the chassis.

- You must use an external circuit protection device.
- Install an external circuit breaker. Guard against short-circuiting in external wiring.
- Double-check all wiring before turning on the power supply.
- Do not connect either the 'Neutral or 'Line' signal of the 110/220VAC to device's 0V pin.
- In the event of voltage fluctuations or non-conformity to voltage power supply specifications, connect the device to a regulated power supply.



Earthing the Power Supply

To maximize system performance, avoid electromagnetic interference by:

- Mounting the controller on a metal panel.
- Earthing the controller's power supply: connect one end of a 14 AWG wire to the chassis signal; connect the other end to the panel.

Note: The wire used to earth the power supply must not exceed 10 cm in length. If your conditions do not permit this, do not earth the power supply

Communication Ports

This series comprises 2 serial ports that may be set to either RS232 or RS485. Certain models also comprise CANbus ports. Check your controller's technical specifications.

- Turn off power before making communications connections.

Caution

- Signals are related to the controller's 0V; the same 0V is used by the power supply.
- Always use the appropriate port adapters.

Serial Communications

The serial ports are type RJ-11 and may be set to either RS232 or RS485 via jumper as described on page 6. By default, the ports are set to RS232.

Use RS232 to download programs from a PC, and to communicate with serial devices and applications, such as SCADA.

Use RS485 to create a multi-drop network containing up to 32 devices.

Caution

- The serial ports are not isolated. If the controller is used with a non-isolated external device, avoid potential voltage that exceeds ± 10V.

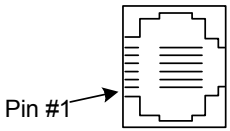
Pinouts

The pinouts below show the signals between the adapter and port.

RS232	
Pin #	**Description**
1*	DTR signal
2	0V reference
3	TXD signal
4	RXD signal
5	0V reference
6*	DSR signal*

RS485	
Pin #	**Description**
1	A signal (+)
2	(RS232 signal)
3	(RS232 signal)
4	(RS232 signal)
5	(RS232 signal)
6	B signal (-)

Controller Port

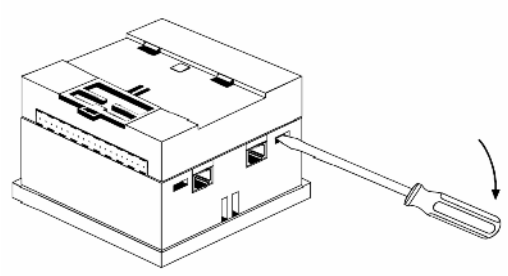


*Standard programming cables do not provide connection points for pins 1 and 6.

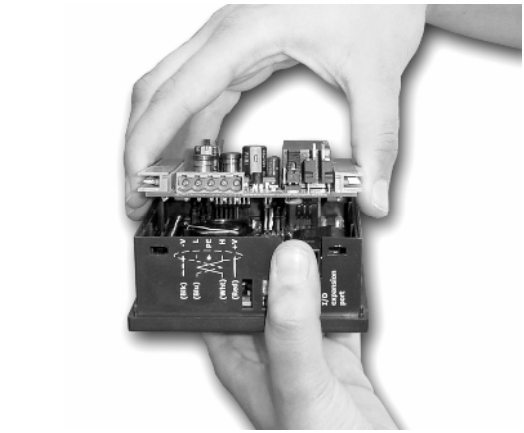
RS232 to RS485: Changing Jumper Settings

- Ports can be set to either RS232 or RS485 according to jumper settings.
- To access the jumpers, you must open the controller, and then remove the module's PCB board. Before you begin, turn off the power supply, disconnect and dismount the controller.
- When a port is adapted to RS485, Pin 1 (DTR) is used for signal A, and Pin 6 (DSR) signal is used for signal B.
- If a port is set to RS485, **and** flow signals DTR and DSR are not used, the port can also be used to communicate via RS232; with the appropriate cables and wiring.

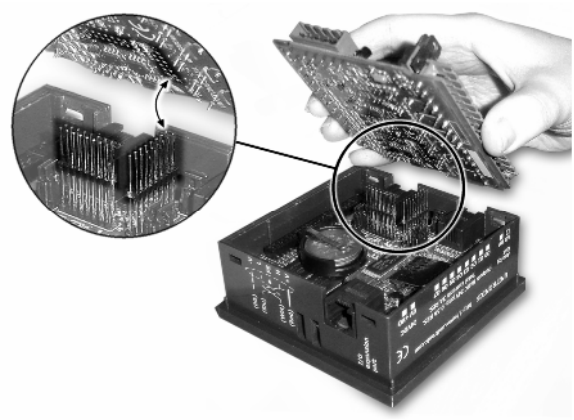
⚠
- Before performing these actions, touch a grounded object to discharge any electrostatic charge.
- Avoid touching the PCB board directly. Hold the PCB board by its connectors.



1. Turn power off before opening the controller.
2. Locate the 4 slots on the sides of the controller.
3. Using the blade of a flat-bladed screwdriver, gently pry off the back of the controller.



4. Gently remove the top PCB board:
   a. Use one hand to hold the top-most PCB board by its top and bottom connectors.
   b. With the other hand, grasp the controller, while keeping hold of the serial ports; this will keep the bottom board from being removed together with the top board.
   c. Steadily pull the top board off.
5. Locate the jumpers, and then change the jumper settings as required. Jumper settings are shown on page 7



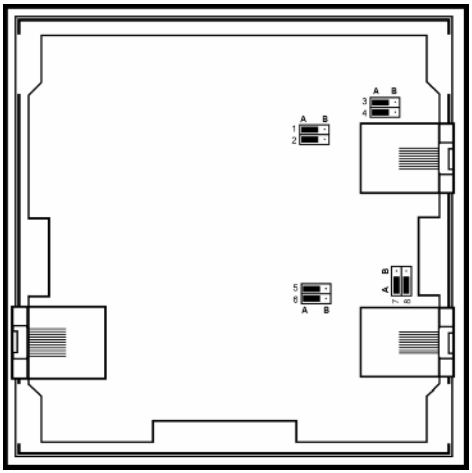
6. Gently replace the PCB board. Make certain that the pins fit correctly into their matching receptacle.
   a. Do not force the board into place; doing so may damage the controller.
7. Close the controller by snapping the plastic cover back in its place. If the card is placed correctly, the cover will snap on easily.

RS232/RS485 Jumper Settings

	Jumper Settings		
	Jumper	**RS232***	**RS485**
COM 1	1	A	B
	2	A	B
COM 2	5	A	B
	6	A	B

RS485 Termination		
Jumper	**ON***	**OFF**
3	A	B
4	A	B
7	A	B
8	A	B

*Default factory setting.



CANbus

These controllers comprise a CANbus port. Use this to create a decentralized control network of up to 63 controllers, using either Unitronics' proprietary CANbus protocol or CANopen.

The CANbus port is galvanically isolated.

CANbus Wiring

Use twisted-pair cable. DeviceNet® thick shielded twisted pair cable is recommended.

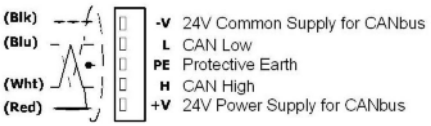
Network terminators: These are supplied with the controller. Place terminators at each end of the CANbus network.

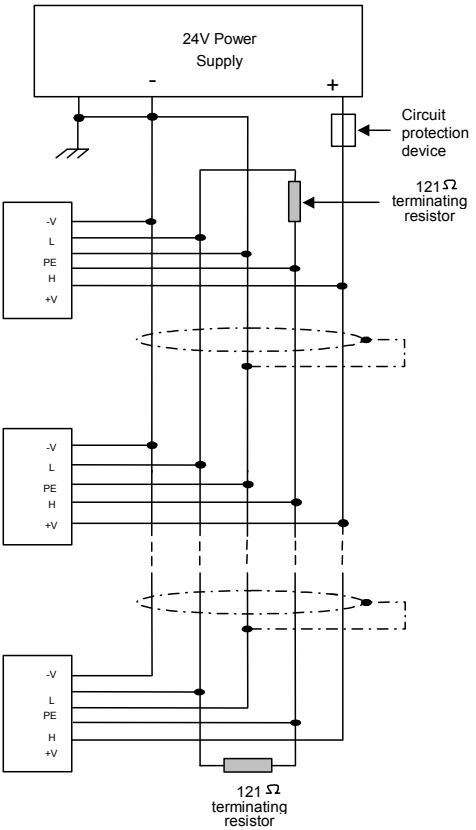
Resistance must be set to 1%, 121Ω, 1/4W.

Connect ground signal to the earth at only one point, near the power supply.

The network power supply need not be at the end of the network

CANbus Connector





5410-1400-5

APPENDIX C

VFDC-4000 Information

For VFD Systems

BOOSTER PUMP

Control Solutions Using Variable Frequency Drives

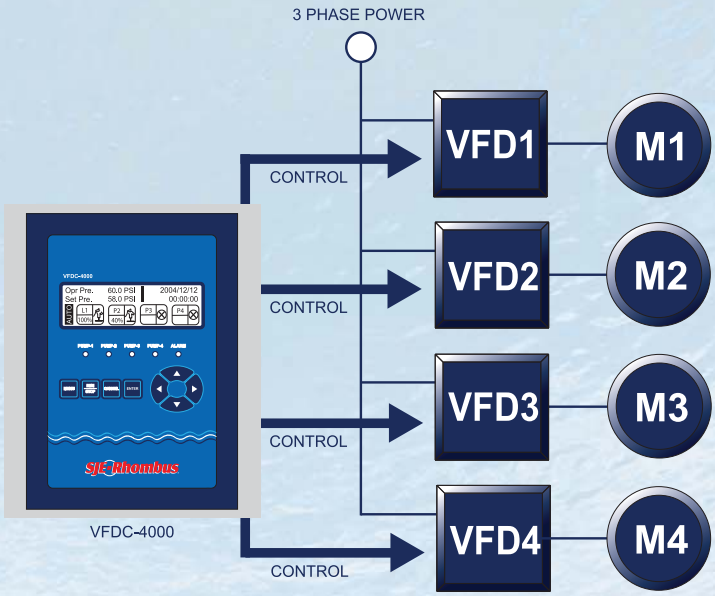
Free Standing Enclosure

VFDC-4000 Controller

SJE-Rhombus®

www.sjerhombus.com

Free Standing Enclosure (optional)



4 Pump Control Configuration

VFDC-4000 Controller Features

VFDC-4000 Controller

- 1 to 4 VFD control
- P.I.D. control
- Graphic screen display with back-light
- System status display
  - Operating pressure
  - Set pressure
  - Auto/Off
  - Time and date
  - Alarm with time and date
- Pump status display
  - Pumps in use
  - Lead pump
  - Pump run/stop
  - Pump speed
  - VFD fault
- Four arrow buttons for easy navigation and setup
- Automatic alternation (cycle-based or time-based)
- Alarm log
- Real time clock
- Scheduled pressure setup function
- Night time operation (runs smaller pump)
- Pressure transmitter setup
- Password protection
- Serial communication
- Idle prevention
- Freeze prevention
- Low pressure alarm
- High pressure alarm
- Low suction pressure/low level

NEMA 1 Wall Mounted Enclosure (standard)

VFDC-4000 Panel Standard Features

- NEMA Type 1 wall mount enclosure (indoor)
- Cooling fan + filter and thermostat for VFD ventilation
- Panel mounted Variable Frequency Drives
- VFDC-4000 pressure booster controller mounted on door
- VFD circuit breakers
- 24 VDC power supply
- 0-200 PSI pressure transducer
- System MAN/OFF/AUTO switch
- MANUAL ON/OFF switches
- Main terminal blocks
- Pump terminal blocks
- Pressure transducer terminal blocks
- Alarm auxiliary contact
- Low water alarm terminal (low suction/level)
- Automatic start on low pressure
- Automatic stop on low pump speed

c UL US LISTED

Wall Mounted Enclosure with Optional Line and Load Reactors

OPTIONS

- Main disconnect
- Line reactors
- Load reactors
- Larger HP VFDs
- Free standing enclosures
- NEMA 12, NEMA 3R, NEMA 4, and NEMA 4X enclosures

Duplex, Triplex, and Quad Plex Models on Reverse Side...

VFDC-4000 Panel Models

APPROX. HP	PUMP MAX AMPS*	DUPLEX	TRIPLEX	QUAD PLEX
208/240V, Single Phase Input / Three Phase Output				
3	11.0	D230-1-11.0	T230-1-11.0	Q230-1-11.0
5	17.5	D230-1-17.5	T230-1-17.5	Q230-1-17.5
7.5	27.0	D230-1-27.0	T230-1-27.0	Q230-1-27.0
10	33.0	D230-1-33.0	T230-1-33.0	Q230-1-33.0
15	46.3	D230-1-46.3	T230-1-46.3	Q230-1-46.3
208/240V, Three Phase Input / Three Phase Output				
3	11.0	D230-3-11.0	T230-3-11.0	Q230-3-11.0
5	17.5	D230-3-17.5	T230-3-17.5	Q230-3-17.5
7.5	27.5	D230-3-27.5	T230-3-27.5	Q230-3-27.5
10	33.0	D230-3-33.0	T230-3-33.0	Q230-3-33.0
15	54.0	D230-3-54.0	T230-3-54.0	Q230-3-54.0
20	66.0	D230-3-66.0	T230-3-66.0	Q230-3-66.0
25	74.8	D230-3-74.8	T230-3-74.8	Q230-3-74.8
30	88.0	D230-3-88.0	T230-3-88.0	Q230-3-88.0
380-480V, Three Phase Input / Three Phase Output				
3	5.5	D480-3-5.5	T480-3-5.5	Q480-3-5.5
5	9.5	D480-3-9.5	T480-3-9.5	Q480-3-9.5
7.5	14.3	D480-3-14.3	T480-3-14.3	Q480-3-14.3
10	17.0	D480-3-17.0	T480-3-17.0	Q480-3-17.0
15	27.7	D480-3-27.7	T480-3-27.7	Q480-3-27.7
20	33.0	D480-3-33.0	T480-3-33.0	Q480-3-33.0
25	37.0	D480-3-37.0	T480-3-37.0	Q480-3-37.0
30	43.5	D480-3-43.5	T480-3-43.5	Q480-3-43.5
40	58.5	D480-3-58.5	T480-3-58.5	Q480-3-58.8
575V, Three Phase Input / Three Phase Output				
3	3.9	D575-3-3.9	T575-3-3.9	Q575-3-3.9
5	6.1	D575-3-6.1	T575-3-6.1	Q575-3-6.1
7.5	9.0	D575-3-9.0	T575-3-9.0	Q575-3-9.0
10	11.0	D575-3-11.0	T575-3-11.0	Q575-3-11.0
15	17.0	D575-3-17.0	T575-3-17.0	Q575-3-17.0
20	22.0	D575-3-22.0	T575-3-22.0	Q575-3-22.0
25	27.0	D575-3-27.0	T575-3-27.0	Q575-3-27.0
30	32.0	D575-3-32.0	T575-3-32.0	Q575-3-32.0
40	41.0	D575-3-41.0	T575-3-41.0	Q575-3-41.0

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APPENDIX D

Pump Specific IOM Manual

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