



The Pump People®

VERTICAL TURBINE PUMPS

INSTALLATION,
MAINTENANCE &
OPERATION
INSTRUCTIONS



PERFORMANCE

QUALITY

SERVICE

TRUST

Table of Contents

Terms and Conditions of Sale	4
1 Introduction and safety	5
1.1 Marking and approvals	5
1.2 Safety	5
1.2.1 Explanation of designations (safety terminology and symbols)	5
1.2.2 General guidelines	5
1.2.3 Safety labels.....	6
1.2.4 Safety data sheets (SDSs).....	8
1.2.5 Personal Protective Equipment (PPE)	8
1.2.6 Noise level data.....	8
1.2.7 Acceptable Temperature Range	8
1.2.8 Rigging and lifting.....	8
2 Transport and storage	9
2.1 Transport and handling requirements	9
2.2 Rigging and lifting.....	9
2.3 Receipt, inspection, and damage reporting	9
2.4 Unpacking	9
2.5 Storage (short term and long term, inside and outside).....	10
2.6 Disposal of packaging materials	10
2.7 Pre-Installation checklist	10
3 Product description	10
3.1 Configuration.....	10
3.1.1 Pump, driver, baseplate or soleplate, coupling, etc.	11
3.2 Nomenclature	11
3.2.1 Nameplate information	11
3.2.2 Pump.....	12
3.2.3 Parts	12
3.3 Auxiliaries.....	12
3.4 Support systems	12
4 Installation	12
4.1 Factory support requirements (field engineer, technician).....	14
4.2 Location.....	14
4.3 Foundation	14
Figure 4-1 – Recommended Anchor Bolt Size and Grouting.....	15
4.4 Rigging and lifting.....	15
4.4.1 Lifting locations and procedures	16
Figure 4-2 – Barrel Lifting.....	17
Figure 4-3 – Bowl Lifting	17
Figure 4-4 – Cast Head Lifting	17
Figure 4-5 – Fabricated Head Lifting	17
4.5 Piping and connections	18
4.5.1 Piping, general guidelines	18
4.5.2 Nozzle loads.....	20
4.5.3 Check valves	20
4.5.4 Strainers.....	20
4.6 Alignment	21
4.6.1 Auxiliary (driver, coupling, etc.).....	21

Figure 4-6 – Hollow Shaft Driver Coupling.....	23
Figure 4-7 – Motor Shaft and Seal Housing Runout.....	26
Figure 4-8 – Pump Shaft Runout	26
4.7 Impeller adjustment.....	26
Figure 4-9 – Enclosed and Semi-Open Impellers	26
Table 4-1 – Impeller Running Clearance Setting	26
4.8 Lubrication, priming, and cooling systems	28
4.8.1 Line shaft lubrication	28
Table 4-2 – Recommended Enclosing Tube Oil	29
4.8.2 Priming	29
4.8.3 Cooling system.....	29
4.9 Electrical.....	29
4.10 Control, monitoring, and alarm equipment (hardware)	29
5 Commissioning, start-up, operation, and shut-down	30
5.1 Lubrication.....	30
5.2 Rotation	30
5.3 Guarding	30
5.4 Checklist – start-up	30
5.4.1 System flushing.....	31
5.4.2 Priming	31
5.4.3 Shaft sealing settings and adjustments (mechanical seals, packing, etc.)	32
5.5 Start-up, operation, and shut-down.....	33
5.5.1 Minimum continuous flow	33
5.5.2 Lubrication system settings.....	33
5.5.3 Drive system settings	34
5.5.4 Valve settings and operation (timing).....	34
5.5.5 Condition monitoring	34
5.5.6 Vibration	35
5.5.6.1 Allowable Limits	35
Table 5-1 – Allowable Vibration Limits per HI 9.6.4	35
Table 5-2 – Allowable Vibration Limits per API 610.....	36
5.5.6.2 Alarm and Trip Settings.....	36
5.5.7 Performance testing/verification.....	36
5.5.8 Bearing temperature	36
6 Maintenance	36
6.1 Schedule	37
Table 6-1 – Recommended Maintenance Intervals	37
6.1.1 Cold weather maintenance	37
6.2 Recommended spare parts.....	37
6.3 Consumables	37
6.4 Required tools and fixtures	38
6.5 Fastener torques, rotation direction, and sequence	38
Table 6-2 – Recommended Fastener Torque Values.....	38
6.6 Pump decontamination	39
6.7 Disassembly.....	39
6.8 Inspection.....	41
6.8.1 Acceptance criteria.....	41
6.8.2 Shaft straightening	41
6.9 Assembly.....	41
6.9.1 Clearances	41

Table 6-3 – Wear Ring Minimum Clearance	42
6.10 Impeller re-adjustment	42
Figure 6-1 – Semi-Open Impeller Performance Verse Running Clearance	43
6.11 Seal maintenance and assembly	43
6.11.1 Mechanical seal	43
6.11.2 Packing box.....	44
6.11.3 Tension assembly	45
Figure 6-2 – Tube Size & Setting Depth Verse Required Tube Tension.....	46
6.12 Auxiliary equipment.....	46
7 Troubleshooting guide	47
7.1 Hydraulic performance	47
7.1.1 Pressure and flow	47
7.2 Mechanical	48
7.2.1 Vibration and noise	48
7.2.2 Wear and corrosion.....	48
7.2.2 Bearing temperature	48
7.3 Electrical, instrumentation, and controls	48
8 Parts listing and sectional drawings.....	49
9 Certification	68

TERMS AND CONDITIONS OF SALE

The following general Terms and Conditions of Sale (the "Terms") are applicable to the provision of all goods supplied and/or services rendered ("Goods") by National Pump Company ("Seller") to any purchaser thereof ("Buyer").

1. **GENERAL.** These Terms, together with any quotation, proposal, acknowledgement or invoice from Seller, constitute the complete and exclusive statement of the terms of the agreement governing the sale of Goods by Seller to Buyer, unless otherwise agreed by Seller in writing. These Terms supersede all other communications, negotiations, and all prior oral or written statements, regarding the subject matter hereof.

If an order for Goods ("Order") is deemed to be an offer by Buyer, then Seller's acceptance of such offer is expressly conditioned on Buyer's assent to the Terms. Any additional, different or conflicting terms proposed by Buyer in any Order, acceptance, confirmation, specifications or otherwise are hereby rejected and objected to by Seller and will not be binding in any way on Seller. Seller reserves the right in its sole discretion to refuse Orders.

2. **WARRANTY; LIMITATION OF REMEDY.** Seller warrants that its manufactured Goods are free from defects in workmanship and meet Seller's specifications at the time of shipment (under the conditions of proper storage, installation by a licensed well-driller or contractor, normal use, and regular service and maintenance) for a period of 12 months from the date of shipment of the goods by Seller or 18 months from the date of manufacture of the goods by Seller, whichever occurs sooner. All claims under this warranty with respect to any Goods must be made in writing and delivered to Seller within 30 days after the defect is discovered (or should have been discovered).

Seller's obligation under this warranty is expressly limited to replacing or repairing, free of charge, F.O.B. point of manufacture, any defective part of its manufactured Goods; however, Seller shall have no liability except where it is shown to the satisfaction of Seller that the defect resulted from breach of this warranty. All parts claimed defective must be delivered to Seller, freight or express prepaid, unless otherwise agreed by Seller in writing.

Seller's warranty does not cover those parts of its manufactured Goods that are not manufactured by Seller except to the extent that the seller of such parts extended its warranty to Seller as the purchaser of such parts.

SELLER MAKES NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, IN FACT OR IN LAW, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WHETHER OR NOT THE PURPOSE OR USE HAS BEEN DISCLOSED TO SELLER IN SPECIFICATIONS, DRAWINGS OR OTHERWISE, AND WHETHER OR NOT SELLER'S PRODUCTS ARE SPECIFICALLY DESIGNED AND/OR MANUFACTURED BY SELLER FOR BUYER'S PURPOSE OR USE.

IT IS EXPRESSLY AGREED THAT THE ABOVE STATES BUYER'S EXCLUSIVE REMEDY for any breach of warranty and for any claim for personal injury, property damage or commercial loss, whether sounding in contract, tort, strict liability or negligence based on any defect in such Goods.

3. **LIMITATION OF LIABILITY. IN NO EVENT SHALL SELLER BE LIABLE, WHETHER BY WAY OF INDEMNITY OR BREACH OF CONTRACT OR STATUTORY DUTY OR REASON OF TORT, FOR ANY LIQUIDATED, DIRECT, INDIRECT, SPECIAL, CONSEQUENTIAL, INCIDENTAL, PUNITIVE OR EXEMPLARY DAMAGES OR LOSS OF PROFIT, SAVINGS, REVENUE, INCOME, BUSINESS, PRODUCTION, OPPORTUNITY OR REPUTATION ARISING OUT OF OR RELATED TO THE ORDER OR THE GOODS WHETHER FORESEEABLE OR UNFORESEEABLE OR KNOWN OR UNKNOWN.** The foregoing limitation of liability shall be effective without regard to Seller's acts or omissions or negligence or strict liability in performance or non-performance hereunder.

Except as otherwise provided by law, in no event shall Seller's liability under any Order or these Terms exceed the amount paid by Buyer under such related Order.

4. **DELIVERY; LIMITATION OF LIABILITY AND REMEDY.** Unless otherwise specified on any Order or as agreed by Seller in writing, all shipments are F.O.B. Seller's plant and all risk of loss with respect to any Goods shipped shall pass to Buyer when such Goods are delivered to the carrier at Seller's plant. Shipping dates are approximate and are based upon the prompt receipt of all necessary information. Seller shall not be liable for damages or delays in delivery or failure to manufacture or deliver due, directly or indirectly, to (a) causes beyond its reasonable control; (b) acts of God, acts of Buyer, acts of any civil or military authority, fires, labor disputes, earthquakes, floods or other weather conditions, accidents, epidemics, wars, riots or other civil disturbances, or delays in transportation; or (c) delays or defaults by Seller's suppliers or subcontractors or other inability to obtain necessary labor, fuel, materials, components or manufacturing facilities. In the event of any such delay, the date of delivery shall be extended for a period equal to the time lost by reason of the delay.

Delivery dates cannot be altered by Buyer without Seller's written consent. Any extension of the delivery date by Buyer will be subject to storage charges as determined by Seller, interest charges as set forth below, and any applicable price increases.

Goods produced by Seller in compliance with the Order requirements which cannot be shipped solely due to missing information from Buyer, including but not limited to carrier arrangements, will be charged an additional 10% of the Order value within 5 business days after Seller notifies Buyer of same.

5. **PRICE AND PAYMENT.** The price of Goods sold shall be Seller's price in effect for such Goods on the date of shipment of such Goods. Unless otherwise agreed by Seller in writing, prices quoted do not include freight, insurance, installation costs, special packaging or any sales, use, excise, VAT or similar taxes. Taxes imposed by any federal, state, county, city or municipal law on the Goods will be added to the invoice unless a fully completed and executed tax exemption certificate is received by Seller with the Order. Unless otherwise agreed by Seller in writing, payment terms are net thirty (30) days from the date of Seller's invoice in U.S. dollars. **BUYER SHALL PAY A LATE CHARGE OF ONE AND ONE-HALF PERCENT (1.5%) PER MONTH ON ALL AMOUNTS NOT PAID WHEN DUE.** Buyer waives its right to set-off against claims it may have against Seller and acknowledges that it may not suspend its payment obligations to Seller.

Seller reserves the right to withhold shipment or to require other adequate assurances of performance of Buyer's payment obligations as Seller in its discretion may require, notwithstanding any Order confirmation issued by Seller. Buyer shall be liable for all expenses, including attorneys' fees, relating to the collection of past due amounts.

6. **SECURITY INTEREST.** Buyer hereby grants Seller a security interest in and a lien upon all Goods sold to Buyer by Seller and the proceeds therefor (including any insurance proceeds), which security interest shall continue until all such Goods are fully paid for in immediately available funds. Buyer, upon Seller's demand, will execute and deliver to Seller such instruments as Seller requests to protect and perfect such security interest. Buyer shall have no right to sell, encumber or dispose of the Goods until Seller receives full payment for such Goods.

7. **CANCELLATION; RETURN OF GOODS.** Buyer may not cancel any Order except upon reasonable advance written notice and upon payment to Seller of Seller's cancellation fee, which shall include all costs and expenses incurred by Seller prior to the receipt of the cancellation notice including, but not limited to, all commitments to its suppliers and subcontractors, all fully burdened labor and overhead expended by Seller, and a reasonable profit charge. Such cancellation fee could equal the quoted total price of the Order. Seller's determination of such cancellation fee shall be conclusive.

Return of Goods shall be in accordance with Seller's most current return authorization process and shall be subject to a minimum fifteen percent (15%) restocking fee.

8. **SUBSTITUTION.** Seller reserves the right to substitute materials and/or modify specifications of an Order to the extent required to comply with any governmental law or regulation.
9. **AMENDMENTS; CHANGES.** The Terms may be amended, modified or waived only as agreed by Seller and Buyer in writing. No changes to an Order may be made by Buyer unless approved by Seller in writing.

10. **FAIR LABOR STANDARDS.** Seller represents that any Goods to be delivered hereunder will be produced in compliance with the requirements of the Fair Labor Standards Act of 1938, as amended.

11. **EXPORT REGULATIONS.** The marketing, sale, use, export and release of the Goods are subject to applicable export laws and regulations of the United States and other countries. Buyer agrees to comply with all such applicable laws and regulations, including without limitation, U.S. Export Administration Regulations, regulations of the U.S. Office of Foreign Asset Control, the U.S. Foreign Corrupt Practices Act and comparable laws and regulations of other countries. Buyer shall be responsible for any breach of this Section.

12. **GOVERNING LAW.** These Terms and any Order hereunder shall be construed in accordance with the laws of the State of Ohio, without regard to conflicts of law principles. Any dispute arising hereunder shall be resolved in the federal or state courts of the State of Ohio, as applicable. The rights and obligations of Seller and Buyer shall not be governed by the U.N. Convention on Contracts for the International Sale of Goods.

13. **WAIVER OF JURY TRIAL. EACH OF SELLER AND BUYER IRREVOCABLY WAIVES ANY AND ALL RIGHT TO TRIAL BY JURY IN ANY LEGAL PROCEEDING ARISING OUT OF OR RELATED TO THESE TERMS OR ANY ORDER HEREUNDER.**

14. **MISCELLANEOUS.** The section titles in these Terms are for reference only and shall not limit or restrict the interpretation or construction of the Terms. Seller's failure to insist, in any one or more instances, upon Buyer's performance of any of the Terms, or to exercise any rights conferred by the Terms, shall not constitute a waiver of any such right to insist upon such performance or exercise such rights in the future. The partial or complete invalidity of any one or more provisions of these Terms shall not affect the validity or continuing force and effect of any other provision.

1 Introduction and safety

The length of the satisfactory service obtained from the equipment will, in part, depend on proper installation and maintenance. This instruction manual is provided to present the basic information for operation, installation, inspection and maintenance. Due to the many variations and custom designed units, it is impossible to cover every design variation or contingency which may arise. However, the basic information contained herein will cover most questions.

1.1 Marking and approvals

When required, pumping units that are certified in specific standards will be marked to reflect those standard with which they conform. For example, pumps that are NSF certified will be tagged with a specific NSF nameplate tag to show their conformance with the standard. Additional information about nameplates can be found in section 3.2.

1.2 Safety

Legal requirements and local regulations may differ substantially with regard to particular safety requirements and may be regularly modified by relevant authorities without notice. As a consequence, applicable laws and regulations should be consulted to ensure compliance.

1.2.1 Explanation of designations (safety terminology and symbols)

These user instructions contain specific safety markings where nonobservance of an instruction would cause hazards. The specific safety marking are as follows:



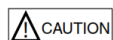
This symbol indicates electrical safety instruction where noncompliance will involve a high risk to personal safety or the loss of life.



This symbol indicates safety instruction where noncompliance would affect personal safety and could result in a loss of life.



This symbol indicates “hazardous and toxic fluid” safety instructions where noncompliance would affect personal safety and could result in loss of life.



This symbol indicates safety instruction where noncompliance will involve some risk to safe operation and personal safety and/or would damage the equipment or property.

Note:

This symbol indicates important information for the user.

1.2.2 General guidelines



THESE INSTRUCTIONS SHOULD BE KEPT AT THE POINT OF OPERATION AT ALL TIMES TO ENSURE SAFETY AND HEALTH OF THE PUMPING EQUIPMENT.

These instructions are intended to facilitate familiarization with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. The instructions may not reflect all current legal requirements and local regulations; ensure that such requirements and regulations are observed by all, including those installing the product. Always coordinate repair activity with operations personnel, and follow all plant safety requirements and applicable safety and health laws/regulations.



THESE INSTRUCTIONS SHOULD BE READ PRIOR TO INSTALLING, OPERATING, USING OR MAINTAINING THE EQUIPMENT.

Information in these instructions is believed to be reliable and correct. Despite efforts to provide sound and necessary information, the contents of this manual may appear insufficient and is not guaranteed as to its completeness of accuracy.

Products are manufactured to exacting international quality management system standards as certified and audited by external quality assurance organizations. Products are manufactured in accordance with all local, state, and federal laws and ordinances. Incorrect replacement of parts from other suppliers and third party accessories may affect performance and safety of the products. Modification of products or removal of original components may impair the safety of these products while in use. Failure to properly select, install, or use authorized parts and accessories is considered misuse. Damage or failure caused by misuse is not covered by any manufacturer warranty.

If the conditions of service including but not limited to pumping fluid, operation temperature, or pump capacity are changed, it is recommended that the user obtain written agreement before operating the product.

1.2.3 Safety labels

1.2.3.1 Personnel Qualification and Training

All personnel involved in the operation, installation, inspection, and maintenance of the unit must be qualified to carry out the work involved. If the personnel in question do not already possess the necessary knowledge and skill, appropriate training and instruction must be provided.

If required, the operator may commission the manufacturer/supplier to provide applicable training.

Always coordinate repair activity with operations and health and safety personnel, and follow all plant safety requirements and applicable safety and health laws and regulations.

1.2.3.2 Safety Action

This is a summary of conditions and actions to prevent injury to personnel and damage to the environment and to equipment.



DANGER

NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER.

Refer to the applicable manufacture's specific manual for additional details and safety notes.



GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL.



DRAIN THE PUMP AND ISOLATE PIPEWORK BEFORE DISMANTLING THE PUMP

The appropriate safety precautions should be taken where the pumped liquids are hazardous or under pressure.



HANDLING COMPONENTS

Many precision parts have sharp corners, thus wearing appropriate safety gloves and equipment is required when handling these components. To lift heavy pieces above 25 kg (55 lb), use a crane appropriate for the mass and in accordance with current local regulations.



THERMAL SHOCK

Rapid changes in the temperature of the liquid within the pump can cause thermal shock that can result in damage or breakage of components and should be avoided.



APPLYING HEAT TO DISASSEMBLE A PUMP

If heat is used to disassemble a pump, then it must be applied with great care. For example, there may be occasions when the impeller has either been shrunk to fit onto the pump shaft or has become difficult to remove due to corrosive products. Before applying heat to remove an impeller, ensure any residual hazardous liquid trapped between the impeller and pump shaft is thoroughly drained out through the impeller keyway to prevent an explosion or emission of toxic vapor.

Because impeller design varies, so does temperature, location, and duration of heat application. Contact the manufacturer for help.



HOT (and COLD) PARTS

If hot or freezing components or auxiliary heating supplies can present a danger to operators and persons entering the immediate area, then action must be taken to avoid accidental contact. If complete protection is not possible, the machine access must be limited to maintenance staff only, with clear visual warnings and indicators to those entering the immediate area. Note: Bearing housings must not be insulated and drive motors and bearings may be hot.

If the temperature is greater than 54 °C (130 °F) or below 5 °C (41 °F) in a restricted zone, or exceeds local regulations, action as above shall be taken.



HAZARDOUS LIQUIDS

When the pump is handling hazardous liquids, care must be taken to avoid exposure to the liquid by appropriate setting of the pump, limiting personnel access, and by operator training. If the liquid is flammable and/or explosive, strict safety procedures must be applied.

Gland packing must not be used when pumping hazardous liquids.



PREVENT EXCESSIVE EXTERNAL PIPE LOAD

Do not use pump as a support for piping. Do not mount expansion joints, unless allowed by the manufacturer in writing, so that their force, due to internal pressure, acts on the pump flange.



ENSURE CORRECT LUBRICATION

(See Section 5, Commissioning, start-up, operation, and shut-down.)



START THE PUMP AT REDUCED SPEED OR WITH THE OUTLET VALVE PARTLY OPENED

(Unless otherwise instructed at a specific point in the user instructions.)

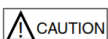
This is recommended to minimize the risk of overloading and damaging the pump motor at full or zero flow. Pumps may be started with the valve further open only on installations where a partly opened valve cannot occur. The pump outlet control valve may need to be adjusted to comply with the duty following the run-up process. (See Section 5, Commissioning, start-up, operation, and shut-down.)



NEVER RUN THE PUMP DRY



SUCTION VALVES TO BE FULLY OPEN WHEN PUMP IS RUNNING



DO NOT RUN THE PUMP CONTINUOUSLY OUTSIDE THE ALLOWABLE OPERATING REGION

Operating at a flow rate higher than normal or at a flow rate with no backpressure on the pump may overload the motor and cause cavitation. Running the pump at a flow rate below the manufacturer's recommended minimum flow rate will cause damage. Low flow rates may cause a reduction in pump/bearing life, overheating of the pump, instability, and cavitation/vibration.

1.2.4 Safety data sheets (SDSs)

Safety Data Sheets are not supplied with the pumping unit.

1.2.5 Personal Protective Equipment (PPE)

During the installation and maintenance of vertical turbine pumps a variety of personal protective equipment should be available and used by personnel performing the work. Personal protective equipment used should include all the items listed below but should include other items where applicable. This list is not a complete list of needed equipment but should serve as a minimum for equipment that should be used or available.



- Hearing Protection
 - Ear plugs
 - Noise reducing ear covers



- Eye Protection
 - Safety glasses
 - Full face protection when needed



- Hard Hat



- Foot Protection
 - Steel toe boots
 - Insulated electrician boots when needed



- Hand Protection
 - Work gloves
 - Insulated gloves for electrical work when needed

1.2.6 Noise level data

There are situations where a pumping unit can produce a substantial amount of noise during operation and certain controls may need to be used. It is important to comply with all federal, local, and OSHA regulations when it comes to noise control and noise exposure. Anytime the noise emitted from a pumping unit is in excess of 85 dBA, the pumping unit and its surroundings should be looked at closely. For pumping units with noise levels in excess of 85 dBA two approaches can be used: control exposure time to the noise or to enclose the pumping unit to reduce emitted sound.

1.2.7 Acceptable Temperature Range

Unless otherwise specified, product is designed for pumped fluid operating within a temperature range of 32F to 150F.

1.2.8 Rigging and lifting

See sections 2.2 and 4.4 for instructions on rigging and lifting equipment.

2 Transport and storage

2.1 Transport and handling requirements

The pump and additional equipment has been prepared for shipment at the factory in such a way to minimize potential damage from handling and transport. Equipment should be moved in a controlled and careful manner to avoid excessive g-forces during handling. Components should be unsecured and removed from shipping containers only when necessary for installation.

2.2 Rigging and lifting



ALL EQUIPMENT USED FOR LIFTING MUST BE MAINTAINED AND INSPECTED TO BE IN GOOD CONDITION AND APPROPRIATE FOR THE WEIGHT.

Care should be taken when lifting or moving the pump to ensure the safety of personnel around the pump and ensure the pump is not damaged. Heavy components of the pump should be lifted using a forklift or overhead crane whenever possible. Heavy parts can be carefully and slowly skidded from the shipping container to the ground if lifting equipment is not available. Be sure the pump is not dropped during unloading, this may result in loss of proper pump alignment during assembly. Use lifting lugs when available, as improper placement of slings or lifting equipment can deform the pump.

For pumps that will be installed in sections, the parts should be placed near where the pump will be installed and should be laid out in the order in which they will be installed. Arrange pallets or wood on the ground to support components and to avoid excess dirt or debris from entering the pump.

Lifting chains, cables, and other equipment should not have contact with machined surfaces.

Column, tubes, and shaft sections should be handled and lifted with care. These parts are critical to the alignment of the pump and deformations will result in loss of proper alignment which will cause pump malfunction to occur. If damage or deformation is suspected shaft runout should be checked before installation.

2.3 Receipt, inspection, and damage reporting

When shipment is received, extreme care should be exercised when unloading. Heavy parts should be carefully skidded to the ground if lifting equipment is not available. Do not drop the unit, or any parts, as damage may cause trouble in assembly and operation of the units.

Inspect unit for signs of transit damage before beginning to uncrate or put into storage. If damage is evident, the transporting company agent should be notified before uncrating and a claim filed with the agent.

2.4 Unpacking

If unit appears undamaged proceed to uncrate. In many cases, the pump is shipped as a unit from the factory and it is advisable to lift into the vertical position before uncrating. If this is not possible, the longer units must be supported at more than one place to avoid putting undue strain on the unit when raising to the vertical position.

Clean all parts of all dirt, packing materials and other foreign matter. Flush the pump inside and outside with clean water. Clean all machined surfaces. These are coated with a rust preventive before shipment which must be removed. Remove any rust spots found on the machined surfaces with a fine emery cloth or scotchbrite pad. Clean all threaded connections and any accessory equipment.

Note: Parts and accessories may be placed inside shipping containers or attached to skids in individual packages. Inspect all containers, crates and skids for attached parts before discarding.

2.5 Storage (short term and long term, inside and outside)

If the unit is to be stored prior to installation, carefully select a storage space so the unit will not be subjected to excess moisture, extreme weather conditions, corrosive fumes, or other harmful conditions. Carefully inspect the unit and clean any rust spots on machined surfaces with fine emery cloth or scotchbrite pad and coat with a rust preventive. If the unit is stored for a long period (over one month) it should be inspected periodically, cleaned, and shafting rotated as required (reference Long Term Storage Procedure PRO-M03).

2.6 Disposal of packaging materials

Dispose of all packing materials in accordance with local laws and ordinances.

2.7 Pre-Installation checklist

The following checks should be made before starting actual installation to assure proper installation and prevent delays:

1. Where more than one unit is received, check the pump serial number against the packing slip to be sure the correct unit is being installed.
2. With motor driven units be sure the voltage and frequency on the motor nameplate agree with the service available. Also make sure the horsepower and voltage rating of the control box or starter agree with the horsepower and voltage rating of the motor.
3. Check the depth of the sump against the pump length to be sure there will be no interference.
4. Check the proposed liquid level in the sump against the pump length. The bottom stage of the pump must be submerged by the minimum amount specified.
5. Clean the sump and piping system before installing the pump.
6. Check the installation equipment to be sure it will safely handle the equipment.
7. Check all pump connections (bolts, nuts, etc.) for tightness. These have been properly tightened before leaving the factory, however, some connections may have worked loose in transit.
8. On the hollow shaft drivers, check the clutch size and drive key against the shaft size which must go through the clutch. Sometimes the shaft size coming through the discharge head is different from the shaft size going through the driver. Be sure you check against the shaft which will go through the driver.
9. On solid shaft drivers, check the motor shaft size against the coupling bore size.

3 Product description

3.1 Configuration

The basic components of Vertical Turbine Pumps are the driver, discharge head assembly, column assembly (when used), and bowl assembly. The pumps are normally shipped assembled and ready for installation. The drivers, couplings and mechanical seals (when used) are shipped unassembled to prevent damage. A strainer (when used) may or may not be attached to the pump.

3.1.1 Pump, driver, baseplate or soleplate, coupling, etc.

3.1.1.1 Drivers

A variety of drivers may be used, however, electric motors are most common. For the purposes of this manual, all types of drivers can be grouped into two categories:

1. Hollow shaft drivers where the pump shaft extends through a tube in the center of the rotor and is connected to the driver by a clutch assembly at the top of the driver.
2. Solid shaft drivers where the rotor shaft is solid and projects below the driver mounting base. This type of driver requires an adjustable flanged coupling for connecting to the pump.

3.1.1.2 Discharge Head Assembly

The discharge head supports the driver and bowl assembly as well as supplying a discharge connection (except for the Type-U discharge connection which will be located on one of the column pipe sections below the discharge head).

A shaft sealing arrangement is located in the discharge head to seal the shaft where it leaves the liquid chamber.

The shaft seal will usually be a mechanical seal assembly, stuffing box, or tension assembly.

3.1.1.3 Column Assembly

Column assembly is of two basic types, either of which may be used:

1. Open line shaft construction utilizes the fluid being pumped to lubricate the line shaft bearings.
2. Enclosed line shaft construction has an enclosing tube around the line shaft and utilizes oil, grease or injected liquid (usually clean water) to lubricate the line shaft bearings.

Column assembly will consist of: 1) column pipe, which connects the bowl assembly to the discharge head, 2) shaft, connecting the bowl shaft to the driver and, 3) bearings, if required, for the particular unit. Column pipe may be either threaded or flanged.

Note: Some units will not require column assembly, having the bowl assembly connected directly to the discharge head instead.

3.1.1.4 Bowl Assembly

The bowl assembly consists of: 1) impellers rigidly mounted on the bowl shaft which rotate and impart energy to the fluid, 2) bowls to contain the increased pressure and direct the fluid, 3) suction bell or case which directs the fluid into the first impeller, and 4) bearings located in the suction bell (or case) and in each bowl.

3.2 Nomenclature

3.2.1 Nameplate information

All discharge heads and bowl assemblies supplied by National Pump Company will be affixed with a permanent nameplate. The name plate will have a variety of information stamped on it to provide information about the pump design condition as well as the component the nameplate is affixed to.

Information found on the discharge head nameplate will include:

- Serial Number
- Head Model
- Pump Model and Number of Stages
- Pump Design Condition (flow, discharge head, and power)

Additional Information found on discharge head nameplate for API pumps will include:

- Maximum Allowable Working Pressure (MAWP)
- Hydrostatic Test Pressure
- Rated Operating Speed
- Designed Temperature Range
- Customer Tag Number (if supplied)

Information found on the bowl assembly nameplate will include:

- Serial number
- Bowl model
- Number of stages
- Impeller model
- Impeller trim

3.2.2 Pump

Pump components have a naming style that allows for the pump model and impeller model to be known and easily identified. National Pump Company uses a combination of numbers and letters to identify a pump or impeller model. For example, the pump model J11MC-4 represents the bowl type, nominal bowl diameter, impeller model, and the number of stages. In this specific example the bowl type is “J”, the nominal bowl diameter is 11 inches, the impeller model is “MC”, and the number of stages is 4. The impeller model can be further interpreted: the “M” can be interpreted as a medium capacity impeller, and the “C” is an enclosed type impeller.

3.2.3 Parts

Part names and descriptions can be found in Section 8. Item numbers shown match those from ANSI/HI 2.1-2.2-2014. Figures provided are guides, application specific drawings should be referenced when available.

3.3 Auxiliaries

More information and detailed descriptions for auxiliary equipment including mechanical seals and drivers can be found in the documentation supplied by the manufacturer of that equipment.

3.4 Support systems

More information and detailed descriptions for support systems can be found in the documentation supplied by the manufacturer of those support systems.

4 Installation

This is a precision piece of equipment and should be treated as such. Proper installation is necessary to provide maximum service from the pump. To insure proper alignment three items are very important during installation:

1. All machined mating surfaces (such as the mating flanges of pump and driver) must be clean and free of burrs and nicks. These surfaces should be cleaned thoroughly with a scraper, wire brush or emery cloth if necessary and any nicks or burrs removed with a fine file.
2. Exterior strain must not be transmitted to the pump. The most common cause of trouble in this respect is forcing the piping to mate with the pump. It is recommended that flexible connectors be installed in the piping adjacent to the pump. This is especially critical on Type-U units where the discharge may be several feet below the supporting structure, and a relatively small strain can cause misalignment.
3. All threads should be checked for damage and repaired if necessary. If filing is necessary, remove the part from the pump if possible, or arrange a rag to catch all filings so they do not fall into other parts of the pump. Clean all threads with wire brush and cleaning solvent. Ends of shafts must be cleaned and any burrs removed since alignment depends on the shaft ends butting squarely. Lubricate all screwed connections with a thread lubricant – an anti-galling threading compound such as “Never- Seez” should be used on stainless and monel mating threads.



Apply thread lubricant sparingly to male shaft threads only when making up shaft connection. Excess lubricant should not be allowed to get between the ends of the shaft.

Below are general instructions for installing the pump.

1. Position lifting equipment so it will center over the foundation opening.



Sump and piping should be thoroughly cleaned of all loose debris before starting installation.

2. If a sole plate is used, level the mounting surface, grout and anchor in place. Reference 4.3 for additional details.
3. Clean pump discharge flange.



All machined surfaces are coated with rust preventive prior to shipment. This must be completely removed along with any paint overspray or rust which might be on the machined faces.

4. Lift pump, mount strainer if required and lower slowly into sump. Hand guide the pump as it is lowered and watch for any obstructions or binding of the pump which can be felt through the hands. Stop lowering unit when still a few inches above the foundation.



Be particularly careful not to damage any piping which may extend down along the column and/or bowl assembly. This piping (when used) must remain open. Should it be damaged, it should be removed and replaced.

5. Rotate pump until discharge flange faces proper direction for alignment with piping and align anchor bolt holes.
6. Slowly lower pump onto foundation.
7. Install anchor bolts or nuts, but do not tighten.
8. Shift the pump slightly on the foundation, if required, to facilitate alignment.

9. Check level of discharge head once sitting on grout plate.



Exterior stresses should not be transferred to the pump. All piping must be carefully aligned and supported to prevent this.

Note: It is strongly recommended that flexible connectors (Dresser couplings, or equal) be installed in the piping immediately adjacent to the pump

10. Tighten discharge flange bolting using proper torque sequence. Be sure the flanges mate without forcing.
11. Tighten anchor bolting.
12. Mechanical seal should be installed at this time if the pump is so equipped. See section 5.4.3.1 for further details.

4.1 Factory support requirements (field engineer, technician)

There are no support requirements from the factory on field installations.

4.2 Location

When onsite assembly of a pump is required, a clean, drained area should be provided near the point of installation. The space should be large enough in size to accommodate the pump components laid out in the order they will be installed as well as the driver. Protective covers should be placed over pump openings and all pump components to ensure that dirt or excess debris does not enter the pump or pumping fluid. Leave protective coatings or covers on all machined surfaces until ready for installation.

It is important that the pump be installed in an area accessible enough to perform regular maintenance and inspections on the pumping unit. To minimize frictional head loss, place and orient the pump in such a way that will require the least amount of fitting and elbows. Pumps and drivers should be protected against flooding.

4.3 Foundation

The foundation may consist of any material that will afford permanent, rigid support to the discharge head and will absorb expected stresses that may be encountered in service.

Concrete foundations should have anchor bolts installed in sleeves twice the diameter of the bolt to allow alignment with the holes in the mounting plate as illustrated in Figure 4-1.

4.3.1 Leveling

Provisions to properly fill and vent the sole (grout) plate must be made prior to installation. Discharge heads may be mounted on a sole plate or sub-base grouted to a concrete foundation.

Shims and metal wedges are not recommended for leveling because they are difficult to remove before or after grouting. On large units, small leveling screws made of cap screws and nuts under the sole plate may be used.

The leveling screw threads should be covered with a nonbinding material, such as grease, putty, or tape, before grouting, to facilitate their removal. Leveling screws shall contact a suitably sized and corrosion-resistant leveling plate. A gap of about 1 to 2 inches (25 to 50 mm) should be allowed between the sole plate and the foundation for grouting, reference Figure 4-1.

The preferred levelness is dead level, however, an acceptable tolerance is 0.002 inch per foot.

4.3.2 Grouting

When the sole plate or discharge head has been correctly leveled using the leveling screws, it will be supported on the leveling screws or shims. After the initial grout has cured, the forms and leveling screws or shims shall be removed and the void filled with a second application of grout.

The grout material that supports the sole plate or discharge head is a critical element of the pump support structure and should be carefully selected. If the grout cracks or fails, the structure will be compromised. It is not recommended to grout level shims or wedges in place because they introduce discontinuities and stress concentrations that may cause the grout to crack. Foundation bolts should not be fully tightened until the grout is hardened, usually about 48 to 72 hours after pouring.

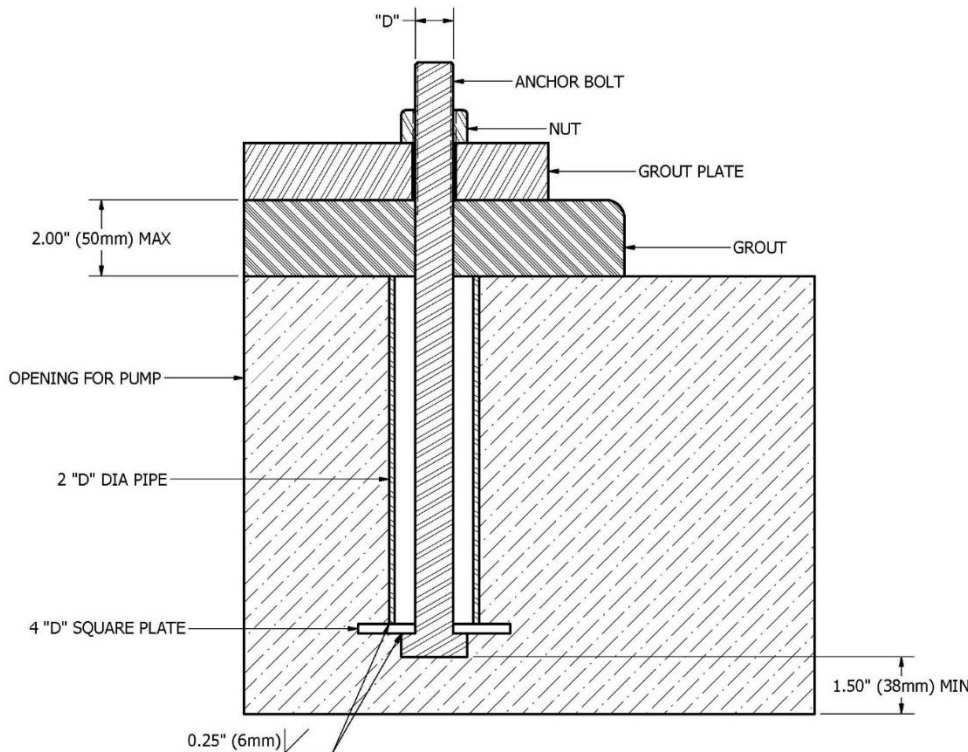


Figure 4-1 – Recommended Anchor Bolt Size and Grouting

Note: D = Anchor bolt diameter.

4.4 Rigging and lifting

For installation, overhead lifting equipment should be used and centered over the foundation opening. Lifting equipment must have an adequate capacity to lift the driver, pump assembly (without driver), or the heaviest subassembly of the pump. Ensure there is enough headroom provided by the overhead lifting equipment to accommodate the longest section of the pump to be handled at a time. I-beams for supporting pump subassemblies should be used when the pump is installed in sections.

On pump components with lifting lugs lift only at these points and nowhere else on that component. Driver lifting lugs are designed for lifting the driver only and should not be used to lift an attached pump assembly.

4.4.1 Lifting locations and procedures

For the various assemblies and sub-assemblies of a pump there are different lifting location and procedures that should be followed.

For suction barrels, two eye bolts (or an equivalent lifting device) should be installed in the threaded holes on the suction barrel. The eye bolts should be installed directly across from each other to ensure even and level lifting, which will help with installation. With the eye bolts installed, attach lifting rope, chains, or other device to the eye bolts. Lift the suction barrel until it is completely vertical and being supported only by the overhead crane. Slowly lower the suction barrel into the opening in the foundation, guiding it by hand to avoid damaging the suction barrel. Once the suction barrel is lowered into the opening secure it by either grouting and leveling it or securing it to a pre-installed grout plate (if equipped). Figure 4-2 shows the general arrangement for lifting a suction barrel.

For bowl assemblies, a clamp is needed to securely hold the bowl assembly during lifting. The clamp must be secured to the bowl assembly near or on the top bowl. Once the clamp is secured to the bowl assembly lifting ropes, chains, or cables can be attached to both sides of the clamp. Lift the bowl assembly until it is completely vertical and off the ground. The bowl assembly can then be installed into the pump opening and the first section of column built. Figure 4-3 shows the general arrangement for lifting a bowl assembly.

Lifting the column assembly is done in the same fashion as a bowl assembly. The clamp should be secured to the column pipe and lifted until it is vertical. The column should be installed and then the assembly lowered to install the next column section. The column should be built in this way until it is ready for discharge head assembly installation. Column with lifting lugs should be lifted by the lifting lugs only.

For discharge heads, the location for lifting will vary slightly between different models of discharges head. Cast discharge heads (N-260 and Hi-Pro) have locations for lifting pins located near the bottom of the discharge head, where fabricated discharge heads have lifting lugs near the top of the head. Though the location for lifting varies between the types of head the procedure is generally the same. A lifting pin, shackle, or similar device is recommended for lifting discharge heads. To begin, place the lifting pin or shackle through the hole provided on the discharge head. Attach lifting rope, chains, or other device to the pin or shackle and begin lifting the discharge head upwards until it is centered over the pump opening. Lower the discharge head until it is slightly above the mounting surface and align the head with all piping connections and bolt holes. Once the discharge head is lined up it can be lowered the rest of the way and secured to the foundation. Figure 4-4 shows a cast head being lifting using standard lifting pins and figure 4-5 shows a fabricated head being lifted with lifting shackles.

For pre-assembled pump assemblies, the lifting must occur from two locations. In most installations the primary lifting location will be the lifting lugs provided on the discharge head, but to prevent damaging the pump during lifting or potential swinging during pump movement the pump must be supported and lifted in another location as well. This location is most commonly the bowl assembly, which can be supported and lifted using the clamp secured to the bowl assembly.

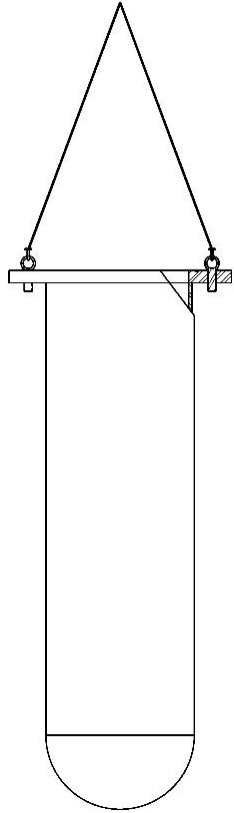


Figure 4-2 – Barrel Lifting

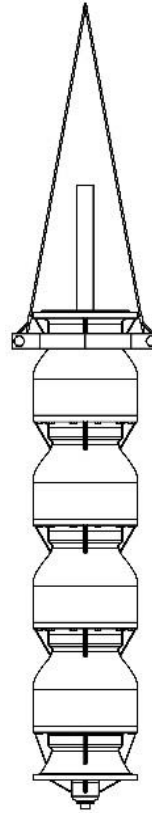


Figure 4-3 – Bowl Lifting

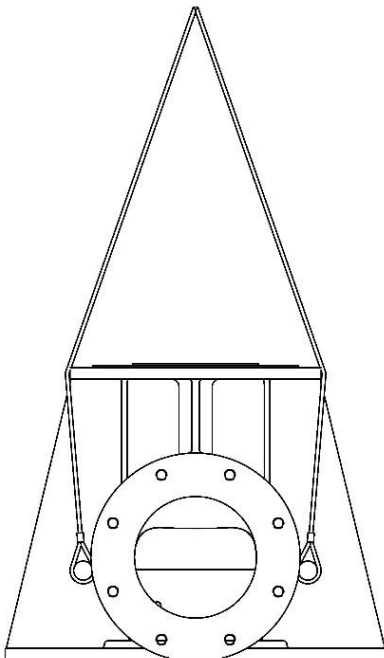


Figure 4-4 – Cast Head Lifting

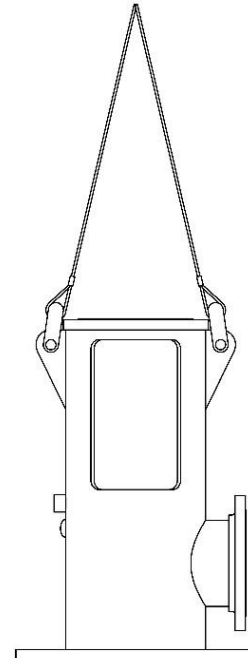


Figure 4-5 – Fabricated Head Lifting

4.5 Piping and connections

4.5.1 Piping, general guidelines

4.5.1.1 Pipe supports/anchors/joints

Suction and discharge piping should be anchored, supported, and restrained near the pump to avoid application of forces and moments to the pump in excess of those permitted by the factory.

In calculating forces and moments, the weights of the pipe, internal thrust, contained fluid and insulation, as well as thermal expansion and contraction, should be considered.

If an expansion joint is installed in the piping between the pump and the nearest anchor in the piping, a force equal to the area of the maximum inside diameter (ID) of the expansion joint, times the pressure in the pipe, will be transmitted to the pump. If reducers or increasers are used, the flexible connection should be placed in the smaller diameter pipe. Pipe couplings that are not axially rigid have the same effect. This force may be larger than can be safely absorbed by the pump or its support system.

Expansion joints or flexible connection provided at the pump suction and discharge may be restrained to prevent transmitting the load to the pump.

If it is necessary to use an expansion joint or non-rigid coupling, then it is recommended that a pipe anchor be located between it and the pump. Note that an anchor provides axial restraint, whereas a pipe support or guide does not.

If a pipe anchor cannot be used, acceptable installations can also be obtained using tie rods across the expansion joint or flexible pipe coupling, provided careful attention is given to the design of the tie rods. The total axial elongation of the tie rod and pipe assembly should not exceed the factory recommendation. The total axial rigidity of the tie rods, including their supporting brackets, should equal that of the pipe, or as an alternate, limit axial deflection to 0.250 mm (0.010 in) when subjected to the maximum working pressure in the system. Many standard tie rod designs are inadequate for use near pumps because they are based on maximum allowable stress only, and do not consider deflection. In fact, some standard tie rod designs result in very high deflection values due to the use of high-strength steel in the tie rods, which allow high stress values. Since deflection is proportional to stress, these high allowable stresses result in high deflections.

4.5.1.2 Suction piping requirements

A vertical pump in a suction barrel or a vertical multistage pump performs properly only if it is supplied with a steady flow of liquid with a uniform velocity profile and with sufficient pressure to provide adequate net positive suction head available (NPSHA).

Failure of the suction piping to deliver the liquid to the pump in this condition can lead to noisy operation, swirling of liquid around the suspended pump assembly, premature bearing failure, and cavitation damage to the impeller and inlet portions of the casing.

For pumps operating with suction pressure below atmospheric pressure, or handling fluids near their vapor pressure, the suction line should slope constantly upwards toward the pump to avoid trapping vapor using eccentric reducers where necessary.

In systems where the suction line is not always kept full of liquid, there is a possibility that a large slug of air or vapor may be swept into the pump during a restart, causing a partial or complete loss of pump prime. Any high point in a suction line will accumulate gas with similar results.

Entrained air reduces pump total head and rate of flow, with amounts as small as 1% by volume affecting radial flow pumps, and 3% to 5% affecting axial flow pumps. Cascading water causing air entrainment should therefore be avoided. For well pumps, the perforated casing should be located below the pump

suction. Return lines into sumps or tanks should terminate a minimum of two pipe diameters below the low liquid level. Undersized or partially blocked intake screens and trash racks result in similar problems, caused by excess pit velocity. Adequate provisions for cleaning rotating screens and trash racks should be made.

Reference ANSI/HI 9.8 Pump Intake Design for suction piping recommendations.

4.5.1.3 Pipe reducers

Reducers are installed just ahead of the pump suction when the pipe is larger than the pump nozzle. Reducers used at the pump suction should be of the conical type and sufficiently long to prevent liquid turbulence.

With the liquid source below the pump, the reducer should be eccentric and installed with the level side up. Eccentric or concentric reducers may be used when the liquid source is above the pump and the suction piping is sloping upward towards the source.

4.5.1.4 Suction valves and manifolds

Block valves should be installed to isolate the pump for safe maintenance.



SUCTION VALVES TO BE FULLY OPEN WHEN PUMP IS RUNNING

Foot valves are specially designed check valves sometimes used at the inlet-to-bowl assemblies for well pumps to keep the column water filled and to prevent backspin and well disturbance caused by rapidly draining water.

4.5.1.5 Elbow at pump suction

When a straight run of pipe at the pump suction cannot be provided, certain arrangements of fittings should be avoided for vertical pumps installed in suction barrels and for vertical multistage pumps. When liquid flows through an elbow or makes a turn through a tee, the exit velocity will be strongly nonuniform. Elbows positioned with their plane of curvature perpendicular to the pump shaft should therefore not be used since a strong vortex motion can be set up in the liquid in the pump barrel. This could lead to a swirling motion in the suspended pump and result in bearing failure, noisy operation, and cavitation damage in the first stage of the pump assembly. Splitters inside the suction barrel can be used to break up the liquid swirl.

Ninety-degree suction elbows should be designed to include guide vanes.

4.5.1.6 Suction tanks

In many process applications, a suction line may be taken off the side or bottom of a process or storage vessel.

When this is done, it is necessary to ensure that the submergence level over the inlet to the suction line is adequate to prevent vortices. If operating levels of liquid in the vessel cannot provide the required submergence, then the size of the inlet should be increased as necessary to reduce the velocity to the point where the submergence is adequate.

4.5.1.7 Discharge valves

A check valve and an isolation valve should be installed in the discharge line. The check valve serves to protect the pump from reverse flow and excessive backpressure. The isolation valve is used in priming, starting, and when shutting down the pump. Except on axial flow, mixed flow, and high energy pumps, it is advisable to close the isolation valve before stopping or starting the pump. Operating pumps of specific

speed over 100 (5000) at shutoff may cause a dangerous increase in pressure or power. If increasers are used on the discharge side of the pump to increase the size of piping, they should be placed between the check valve and the pump. If expansion joints are used, they should be placed between the pipe anchor and the check valve.



START THE PUMP AT REDUCED SPEED OR WITH THE OUTLET VALVE PARTLY OPENED



DO NOT RUN THE PUMP CONTINUOUSLY OUTSIDE THE ALLOWABLE OPERATING REGION

4.5.1.8 Air and vacuum release valves for wet-pit and well pumps

For medium- and large-size vertical wet-pit pumps discharging into a pressurized system, an automatic air and vacuum release valve is recommended. The valve should be located on the pump discharge nozzle or between the pump discharge nozzle and the discharge valve or check valve, whichever is closest.

The release valve prevents a large volume of air from being compressed, and then setting up a severe shock wave when suddenly released, with potential for serious equipment damage. The air release valve also prevents air from entering the pressurized system.

The valve also relieves the vacuum that might otherwise be generated in the discharge during shut-down when the liquid recedes in the column pipe to the sump or well standing level. Vacuum release valves may be critically important to prevent equipment damage on restarting flow into an evacuated column.

4.5.2 Nozzle loads

Piping attached to the discharge head should be properly aligned to prevent additional nozzle loads. Piping systems should be installed with proper anchors and expansion joints to minimize nozzle loads. Contact the factory for recommended allowable nozzle loads for a specific pump.



PREVENT EXCESSIVE EXTERNAL PIPE LOAD

4.5.3 Check valves

Check valves may be located in the discharge to prevent backflow but should not be used in the suction line. They are sometimes used in series-parallel connections to reduce the number of valves that should be operated when changing from one type of operation to the other. In some applications, check valves may be provided with dashpots to mitigate the slamming effect of the valve during closing.

Excessive backspin speed and hydraulic shock can cause severe damage to the pump and motor. Install at least one check valve to help prevent this. Install check valve in discharge pipe not more than 25 ft above pump.

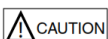
4.5.4 Strainers

Strainers may be attached at the point of suction on a pump in order to keep out unwanted solids or large debris. Clean strainers have a minimal pressure drop, but the pressure drop may increase as debris accumulates and block the strainer openings. Pressure taps can be installed to monitor the pressure drop caused by the strainer. Strainers attached to the suction of the pump usually clean themselves by backflow when the pump is stopped, however depending on the debris accumulated they may require manual cleaning.

4.6 Alignment

Alignment is maintained throughout the pump through registered fits between corresponding parts. Alignment of the top shaft that will connect to the driver should be checked before mounting and coupling the driver to the pump. For pumps with driver positioning jackscrews, reference section 4.6.1.3 for additional details.

The alignment should be checked again once the pump is secured to the foundation and is attached to any suction or discharge piping to be used in regular pump operation. Alignment should be checked by fixing a dial indicator to an available surface measuring shaft movement while rotating the shaft. Alignment should be checked multiple times throughout installation (before securing to foundation and after, before attaching suction or discharge piping and after). If the pump does not stay in alignment the problem could be in the foundation or excessive pipe strain distorting or shifting the pump or sub-assemblies.



PREVENT EXCESSIVE EXTERNAL PIPE LOAD

4.6.1 Auxiliary (driver, coupling, etc.)

4.6.1.1 Installing Hollow Shaft Drive

1. Clean the driver mounting flange on the discharge head and flange. Check for burrs or nicks on the register and mounting face.
2. Remove driver clutch.
3. Lift the driver and clean the mounting flange, checking for burrs and nicks.
4. Some electric motors will be supplied with a “lower guide bushing” (steady bushing) which is installed at the bottom of the motor to stabilize the shaft at this point. Some motor manufacturers mount this guide bushing before shipping while others will ship the guide bushing with instructions for field mounting. Check the packing slip to see if a guide bushing is required. If so, determine if the bushing is already mounted or not and proceed accordingly.
5. Raise and center driver over pump.
6. Lower carefully until about 1/4” above mounting flange. Rotate driver until junction box on electric driver or input shaft on gear drive is in correct position. Align bolt holes and insert bolts.
7. Lower carefully into place making certain that the female register on the driver mates over the male register on the pump.
8. Tighten mounting bolts.
9. Check driver manufacturer’s instruction manual for special instructions including lubrication instructions and follow all “startup” directions.



ENSURE CORRECT LUBRICATION

10. Electric drivers should be checked for rotation at this time. Make electrical connections and jog motor momentarily to check rotation. **DRIVER MUST ROTATE COUNTER-CLOCKWISE** when looking down at top end of motor. To change the direction of rotation on a three-phase motor, interchange any two line leads. To change direction of rotation on a single-phase motor, interchange the leads of either phase.



NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER.



Reverse rotation with the pump connected can cause extensive damage to the pump – ALWAYS check rotation before connecting driver to pump.

Note:

On units equipped with one-piece head shaft (no line shaft coupling between driver and pump) Steps 11, 12 and 13 will not be applicable.

Reference Figure 4-6 for steps 11 thru 17.

11. Clean all shaft threads (both ends of head shaft and on top shaft). Try the line shaft coupling and head shaft nut on their respective threads. These should thread on by hand. If not, clean up threads with a thread file or fine three cornered file. Check ends of shaft where they will butt inside line shaft coupling. Ends must be square and clean. Fit gib key so it slides smoothly.
12. Lubricate head shaft threads and thread (LEFT OR RIGHT HAND threads) head shaft nut half way onto head shaft.



Apply thread lubricant only to male shaft threads. Apply sparingly to avoid build-up between ends of shaft which could cause misalignment.

13. Lower head shaft carefully down through driver. Clean and lubricate threads and thread into line shaft coupling. Shafts must butt against each other.

Head shaft should stand centered (long shafts may lean slightly from own weight, however, they can be centered without effort) in the driver hollow shaft.

Note:

If not, check driver mounting flange for improper mounting and re-clean ends of shaft where coupled inside discharge head.

14. Remove head shaft nut and install clutch on driver being careful that it fits down properly.
15. Install gib key in clutch and shaft. Gib key should be a slip fit. Do not force.
16. Thread adjusting nut down (RIGHT OR LEFT HAND threads) on shaft until it bears against clutch.

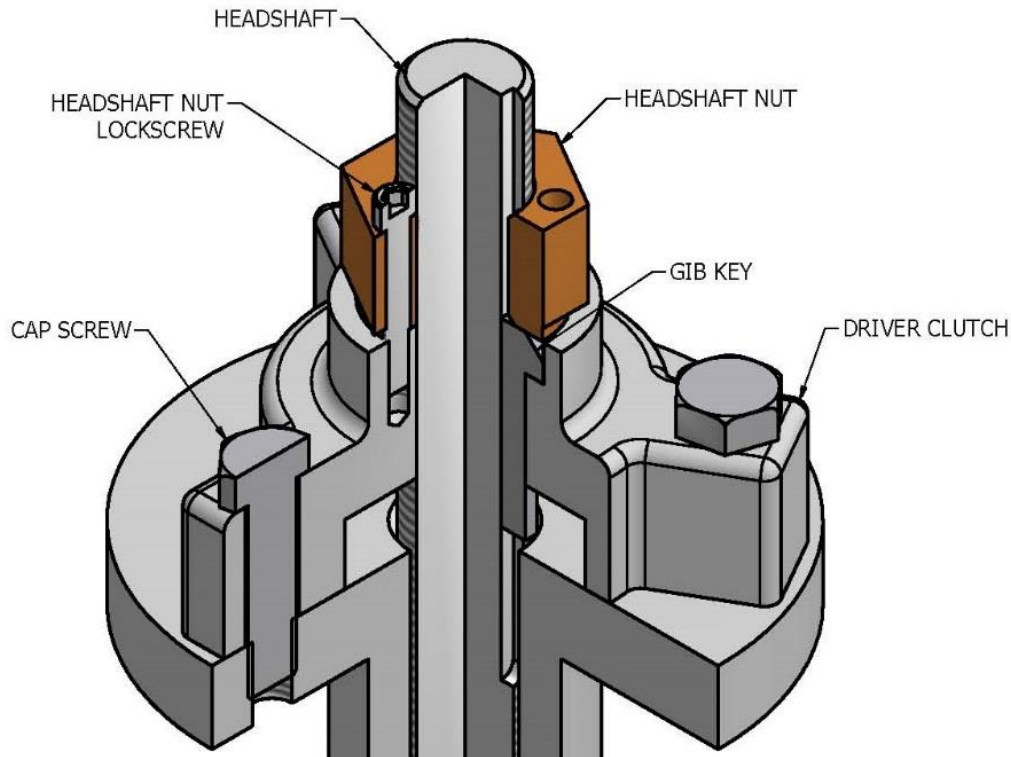


Figure 4-6 – Hollow Shaft Driver Coupling

17. See section 4.7 for impeller adjustment.
18. Adjust mechanical seal (if equipped) AFTER adjusting impellers.

4.6.1.2 Installing Solid Shaft Driver

1. Clean driver mounting flange on discharge head and check for burrs or nicks on the register and mounting face.
2. Clean pump half of AFS coupling, fit key to shaft, and install. Clean top shaft threads. Lubricate and try adjusting nut. The adjusting nut should run down on the threads by hand until flush with top of threads on top shaft.
3. Lift driver and clean mounting flange, checking for burrs and nicks.
4. Install driver half-coupling on driver shaft (see AFS coupling drawing in section 8):
 - a. Place straight key into keyway making sure the key is up far enough to clear the groove cut around the shaft near the end.
 - b. Slide driver half-coupling onto shaft far enough to insert the circular thrust rings into the shaft groove.
 - c. Install circular thrust ring in shaft groove. When properly positioned, the half coupling will slip down over the circular key and hold it in position (see AFS coupling drawing in section 8)
5. Mechanical seal should be installed at this time if the pump is so equipped. See section 5.4.3.1 for further details.

6. Install pump half-coupling on head shaft:
 - a. Slide pump half-coupling onto shaft.
 - b. Install key and push down to clear threads.
 - c. Thread adjusting nut (RIGHT OR LEFT HAND threads) onto shaft until end of shaft is even with top of adjusting nut.
7. Center motor over pump and rotate to align mounting holes. Rotate driver until junction box on electric driver or input shaft on gear drive is in correct position. Align bolt holes and insert bolts.
8. Lower driver carefully into place making certain that the female register on the driver mates over the male register on the discharge head.
9. Bolt driver to discharge head.
10. Check driver manufacturer's instructions for special instructions including lubrication instructions and follow all "startup" instructions.



ENSURE CORRECT LUBRICATION

11. Electric drivers should be checked for rotation at this time. Make electrical connections and jog motor momentarily to check rotation. **DRIVER MUST ROTATE COUNTER CLOCKWISE** when looking down at the top end of motor. To change the direction of rotation on a three-phase motor, interchange any two line leads. To change direction of rotation on a single-phase motor, interchange the leads of either phase.



NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER.



Before jogging the motor make sure the coupling halves are not touching and that the driver can rotate freely without rotating the pump. Driver half-coupling must be in proper position as shown in the AFS coupling drawing in section 8 so the circular thrust ring will not come out.



Reverse rotation with the pump connected can cause extensive damage to the pump. ALWAYS check rotation before connecting driver pump.

12. On pumps using the spacer-type coupling, bolt the spacer to the driver half-coupling.
13. On adjustable flanged couplings — thread the adjusting nut up the shaft until there is a proper gap between nut and spacer or driver half-coupling. (See section 4.7 for impeller adjustment.)

Note:

Adjusting Nuts on all sizes have drilled holes inside inserting handle of hex wrench or round bar to facilitate adjustment.

14. Adjust mechanical seal AFTER adjusting impellers.

4.6.1.3 Driver positioning jackscrews

For discharge heads equipped with motor positioning jackscrews the motor alignment must be dialed in to ensure that the driver shaft is concentric with the pump shaft. For these motors the concentricity of the shaft must be checked at several locations using a dial indicator.

1. Place the motor on top of the discharge head making sure that registered fit between the top of the discharge head and the motor is achieved
2. Thread in all motor positioning jackscrews so that they are near the motor but not yet touching the motor base
3. Place the dial indicator in position 1 shown on figure 4-7
4. Spin the motor shaft by hand while checking the dial for runout reading
5. If the dial indicator measures a difference of more than 0.002" (.05 mm) adjust the motor using the positioning screws
6. Repeat steps 3-5 until the maximum variation read by the dial indicator on a full revolution is less than 0.002" (0.05mm)
7. Place the dial indicator in position 2 shown on figure 4-7
8. Spin the motor shaft by hand while checking the dial for runout reading
9. If the dial indicator measures a difference of more than 0.002" (.05 mm) adjust the motor using the positioning screws
10. Repeat steps 7-9 until the maximum variation read by the dial indicator on a full revolution is less than 0.002" (0.05mm)
11. Now that the motor is dialed in to the correct location, the coupling between the top pump shaft and driver shaft can be installed
12. With the driver coupling installed and appropriately adjusted, place the dial indicator as shown in figure 4-8
13. Spin the coupled shafts while checking the dial for runout reading
14. If the dial indicator measures a difference of more than 0.002" (.05 mm) adjust the motor using the positioning screws
15. Repeat steps 12-14 until the maximum variation read by the dial indicator on a full revolution is less than 0.002" (0.05mm)

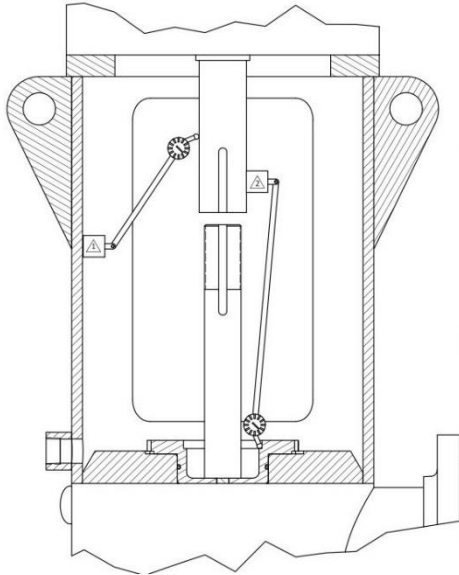


Figure 4-7 – Motor Shaft and Seal Housing Runout

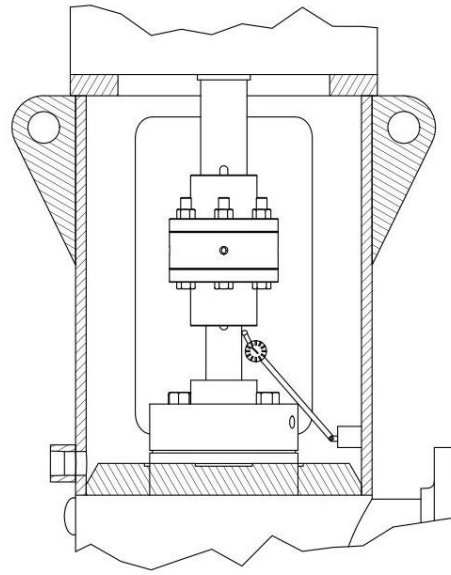


Figure 4-8 – Pump Shaft Runout

4.7 Impeller adjustment

Proper impeller adjustment positions the impeller inside the bowl assembly for maximum performance. The impellers must be raised slightly to prevent dragging on the bowls.

Impellers are of two basic types: “enclosed” and “semi-open” (sometimes called “semi-enclosed”). The type of impeller will determine proper adjustment. The type of impellers installed in the pump can be determined from the pump nameplate or packing slip. The second letter of the pump type indicated enclosed impellers by “C” and semi-open “O”, thus “MO” would indicate semi-open impellers while “MC” would indicate enclosed impellers.

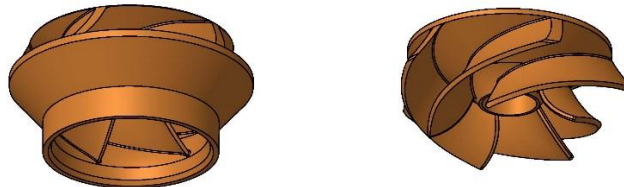


Figure 4-9 – Enclosed and Semi-Open Impellers

ENCLOSED IMPELLERS — enclosed impellers should be raised from the impeller seat the amount specified in the table below which varies based off the bowl size. The impeller running clearance in the table below is in addition to the lift needed to compensate for net shaft stretch due to the hydraulic thrust of the pump. If the net shaft stretch is unknown, contact the factory.

Bowl Size	Running Clearance
<6"	1/16"
6" to 12"	1/8"
12" to 20"	3/16"
>24"	1/4"

Table 4-1 – Impeller Running Clearance Setting

SEMI-OPEN IMPELLERS — the adjustment of semi-open impellers is more critical than for enclosed impellers.

The performance of the pump will vary considerably for a small change in the impeller setting. For maximum performance, the impeller must run within a few thousandths of the bowl seat — exact shaft adjustment will vary according to variables of each installation; however, for close-coupled units as covered by this manual a general rule of .015" plus .005" for each 100 feet of discharge head produced by the pump plus .005" for each 10 feet of column assembly will provide near ideal adjustment.

The highest discharge head the unit will be expected to operate against should be used for this adjustment. As an example — a pump designed to operate at 400' discharge head but will also be operated against a closed valve for short period at which time it will produce 500', therefore $5 \times .005" = .025"$. If the unit has 20' of column assembly — $2 \times .005" = .010"$. The initial adjustment would be $.025" + .010" + .015" = .050"$.



The impellers must be down against the bowl seat when starting impeller adjustment. All dimensions and instructions given above assume the impellers are initially seated. When pumps are subjected to suction pressure the pressure acting against the shaft ends, raise them. If the suction pressure is great enough it can raise the shaft. Make sure the shaft is down when starting to adjust the impellers.

If, after making the above adjustment, the pump does not deliver its rated capacity, the impellers can be lowered in small increments (approximately 1/4 turn of adjusting nut) at a time until the lowest possible adjustment is achieved without the impellers dragging. On the other hand, if the impellers appear to be dragging after the initial adjustment, the unit should be stopped and the impellers raised. Dragging impellers will increase the load significantly and can usually be heard and felt as increased vibration.

Note: If semi-open impellers are raised and then adjusted down, a slight increase in power required will be noted due to the increased delivery of the pump. Do not confuse this with the marked increase when the impellers are lowered enough to drag.

4.7.1 Hollow Shaft Driver

Impeller adjustment, when using a hollow shaft driver is accomplished at the top of the driver by the following procedure. The driver canopy will have to be removed before beginning.

1. Install head shaft as outlined in section 4.6.1.1 if not already in place.
2. Install driver clutch in accordance with the driver instruction manual and bolt into place.
3. Install gib key, making sure top of gib key slides easily down below top of clutch.
4. Check shaft position — raise shaft slightly and lower until there is a definite feel of metal contacting metal. This indicates the impellers are "on bottom" and is the correct starting position for impeller adjustment.
5. Thread head shaft nut down (RIGHT OR LEFT HAND threads) until impellers are just lifted off their seat and the shaft will rotate freely. When semi-open impellers are used the correct determination of the point where the impellers just barely clear their seat is very important for proper adjustment.
6. Adjust impellers as outlined in section 4.7.
7. Lock the head shaft nut with lock screws inserted down through holes in head shaft nut and threaded into driver clutch.



Always lock head shaft nut before starting driver. Failure to do so could result in damage to the pump and driver.

4.7.2 Solid Shaft Driver

Impeller adjustment when using solid shaft drivers is accomplished in the adjustable flanged coupling located below the driver.

4.7.2.1 Adjustable Flange Coupling

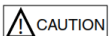
1. Assemble coupling on pump and driver as outlined in section 4.8.1.2.
2. Rotate adjusting nut up shaft (threads are RIGHT OR LEFT HAND) until the nut bears firmly against spacer or driver shaft and top shaft will not move down. This will insure that the impellers are all the way down against their seat and in proper position for adjustment.
3. Thread adjusting nut (66) down until the proper impeller adjustment as outlined in section 4.7 can be measured between the adjusting nut (66) and spacer (88) or driver half-coupling (42) as shown in section 8.
4. Slide pump half-coupling (44) up shaft and align adjusting nut (66) bolt holes with those in spacer (88) or driver half-coupling (42). Rotate driver shaft until bolts can be inserted and tightened.
5. Tighten all bolts which will raise impellers to correct for any operating position.

4.8 Lubrication, priming, and cooling systems

4.8.1 Line shaft lubrication

Open line shaft bearings are lubricated by the pumped fluid and on close coupled units (less than 50' long) will usually not require pre or post lubrication.

Enclosed line shaft bearings are lubricated by extraneous liquid (usually oil or clean water) which is fed to the tension bearing by either a gravity flow system or pressure injection system. The gravity flow system utilizing oil is the most common arrangement. The oil reservoir must be kept filled with a good quality light turbine oil (about 150 SSU at operating temperature) and adjusted to feed 10 to 12 drops per minute plus one (1) drop per 100' of setting.



ENSURE CORRECT LUBRICATION

Injection systems are designed for each installation — injection pressure and quantity of lubricating liquid will vary. Refer to packing slip or separate instruction sheet for requirements when unit is designed for injection lubrication.

4.8.1.1 Pre/Post-Lubrication

Open line shaft pumps less than 50' long will not require any pre/post-lubrication. Open line shaft pumps with a pumping level over 50' should be equipped with a pre/post-lubrication system to lubricate the bearings prior to starting and after shut-down of the pump unless otherwise specified by the factory. Pre-lubrication should be allowed to flow down the shaft for 45 minutes before the pump is started or until a 30-gallon tank is empty. Post-lubrication should be allowed until the pump stops rotating once shut-down.

Enclosed line shaft pumps should be pre-lubricated for 45 minutes by the lubrication fluid that is to be used (usually oil or clean water). This pre-lubrication can be gravity fed or pressure injected. Care should be taken to ensure that the flow of lubricant is available and consistent for subsequent startups.

The following oil can be recommended for Enclosed Line Shaft Bearing Lubrication under normal operating conditions.	
Manufacturer	Trade Name of Oil
Continental Oil Company	Conoco Turbine Oil, light
Exxon Company	Teresstic – 32
Mobil Oil Company	Mobile DTE – 797
Shell Oil Company	Tellus 32
Standard Oil Co. of Calif.	Chevron OC Turbine 9
Texaco, Inc.	Texaco Regal 32 R&O
If none of the above oils are available, an oil with the following specifications should be obtained. Turbine type oil with rust and oxidation inhibitors added. Viscosity 145-175 SUS at 100F with a 90 minimum viscosity index.	
It is recommended that detergent type oils not be used.	

Table 4-2 – Recommended Enclosing Tube Oil

4.8.2 Priming

Priming is not required on any National Pump Company pumping units, but the beginning of the suction for the pump must maintain a minimum submergence depth. The minimum submergence depth varies for different pump models, contact the factory for the required value for a specific pump model.



NEVER RUN THE PUMP DRY

4.8.3 Cooling system

Refer to literature provided by the motor or auxiliary equipment manufacturer to determine if cooling systems are necessary and the requirements of those cooling systems.

4.9 Electrical

Electrical boxes and conduit should be installed in accordance with industry standards, local ordinances, and in unison with specific factory recommendations for a certain pump (if any). Ensure that the guards installed on the discharge head can still be opened with electrical conduit and boxes installed so normal maintenance and inspections can be completed.



NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER.



GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL.

4.10 Control, monitoring, and alarm equipment (hardware)

All control, monitoring, and alarm equipment should be installed in accordance with the installation instruction provided by the manufacturer of that equipment. Ensure that all control equipment is functioning normally prior to running the pump the first time. Check with the factory before installing anti-reverse rotation devices as their application is not always desirable.

5 Commissioning, start-up, operation, and shut-down

5.1 Lubrication

Prior to turning on the pumping unit, lubrication flow must be started for pumps equipped with enclosed line shaft assemblies.



ENSURE CORRECT LUBRICATION

Other than the stuffing box lubrication outlined in section 6.11.2.1.1 and line shaft lubrication outlined in section 4.9.1, the pump will not require further periodic lubrication. The suction bearing on the bowl assembly should be repacked when repairs are made. However, no attempt should be made to repack until repairs to the bowl assembly are necessary.

Drivers will require periodic attention. Refer to the driver instruction manual for recommendations.

5.2 Rotation

When looking down from the top of the pumping unit, the **SHAFT MUST ROTATE COUNTER-CLOCKWISE**. This means that on a top-mounted electric motor the motor **MUST ROTATE COUNTER-CLOCKWISE** as well. The rotation of the motor should always be checked before connecting the driver to pump, as reverse rotation of the pump can cause extensive damage to the pumping unit.

An anti-reverse rotation device can protect the driver from damage during reverse rotation from backflow. This is most crucial on right angle gear drives, but can also be used on electric motors as well.

5.3 Guarding

All discharge heads or motor mounts feature finger guards to prevent accidental damage or injury due to the rotating pump shaft, driver shaft, or any coupling of the two. These guards should be closed and secured prior to start-up and should remain closed for duration of time the pump is running.



GUARDS MUST NOT BE REMOVED WHILE THE PUMP IS OPERATIONAL.

5.4 Checklist – start-up

Before starting the pump, the following checks should be made:

1. Rotate the pump shaft by hand to make sure the pump is free and the impellers are correctly positioned.
2. Is the head shaft adjusting nut properly locked into position?
3. Has the driver been properly lubricated in accordance with the instructions furnished with the driver?



ENSURE CORRECT LUBRICATION

4. Has the driver been checked for proper rotation?

Note:

If not, the pump must be disconnected from the driver before checking. The **DRIVER MUST ROTATE COUNTER-CLOCKWISE** when looking down at the top of the driver.

5. Check all connections to the driver and control equipment.

6. Check that all piping connections are secure.
7. Check that anchor bolt are properly torqued.
8. Check all bolting and tubing connections are properly torqued (driver mounting bolts, flanged coupling bolts, gland plate bolts, seal piping, etc.).
9. On pumps equipped with stuffing box, make sure the gland nuts are only finger tight — DO NOT TIGHTEN packing gland before starting.
10. On pumps equipped with mechanical seals, clean fluid should be put into the seal chamber.

With pumps under suction pressure this can be accomplished by bleeding all air and vapor out of the seal chamber and allowing the fluid to enter.

With pumps not under suction pressure, the seal chamber should be flushed liberally with clean fluid to provide initial lubrication. Make sure the mechanical seal is properly adjusted and locked into place.

Note: After initial start-up, pre-lubrication of the mechanical seal will usually not be required as enough liquid will remain in the seal chamber for subsequent start-up lubrication.

11. On pumps equipped with enclosed line shaft, lubricating liquid must be available and should be allowed to run into the enclosing tube in sufficient quantity to thoroughly lubricate all line shaft bearings.

5.4.1 System flushing

System flushing is not required before installing or running and pump, but it is recommended if it is known or suspected that dirt or debris exists in the piping systems. When flushing piping systems pumps and other sensitive equipment should be protected from contaminated fluid. This is most commonly done with start-up strainers which collect debris before it reaches the pump or other equipment exposed to the fluid. Once the system is flushed the start-up strainers should be removed and all collected debris should be removed.

Once system flushing is complete, ensure the pump has adequate submergence in the pumping fluid and all piping and connections are attached the pump can be started. Contact the factory for required submergence on a specific pump.

5.4.2 Priming

Priming is not required for vertical turbine pumps, however the suction must have a minimum submergence level when started and must maintain that minimum submergence level during operation. Depending on the type of set up the pumping unit is installed in the draw down will differ, but it is crucial to the performance and life of the pump that the suction of the pump always maintain the required minimum submergence level. If the water level falls below the minimum submergence level the pump may create surface vortices and begin to suck in air; which will affect pump performance and can cause damage to the pumping unit. The minimum submergence level varies for different pump models, contact the factory with questions on a specific pump model.



NEVER RUN THE PUMP DRY

5.4.3 Shaft sealing settings and adjustments (mechanical seals, packing, etc.)

5.4.3.1 Mechanical Seal

Because of the numerous mechanical seal arrangements available, separate instruction manuals are written covering installation and operation of these seals. There are, however, comments which apply to all seals.

1. The seal cavity must be clean before installing seal.
2. The faces and register of the seal housing and gland plate or cap must be clean and free of burrs.
3. The shaft seal is a precision product. Treat it with care. Take particular care not to scratch or chip the lapped faces of the runner or seat.
4. Circulation lines must remain in place and open. Do not remove.
5. Impeller adjustment must be made PRIOR to seal adjustment.

Note: Read the mechanical seal instruction manual furnished with this unit.

5.4.3.2 Packing Boxes

Packing boxes are pre-packed at the factory and will be factory installed. Do not tighten the packing gland. See section 6 for further information.

5.4.3.2.1 Packing Box Adjustment

On the initial starting it is very important that the packing gland not be tightened too much. New packing must be “run in” properly to prevent damage to the shaft and shortening of the packing life. See section 6.11.2.1.3 for further information. The stuffing box must be allowed to leak for proper operation. The proper amount of leakage can be determined by checking the temperature of the leakage, this should be cool or just lukewarm — NOT HOT.

When adjusting the packing gland bring both nuts down evenly and in small steps until the leakage is reduced as required. The nuts should only be tightened about ½ turn at a time at 20 to 30 minute intervals to allow the packing to “run in.”

Under proper operation, a set of packing will last a long time. Occasionally a new ring of packing will need to be added to keep the box full. After adding two or three rings of packing or when proper adjustment cannot be achieved, the stuffing box should be cleaned completely of all old packing and re-packed.

5.4.3.3 Enclosing Tube Tension Assembly

The enclosing tube (enclosed line shaft design) tension is pre-adjusted at the factory before shipping on short set pumps: additional adjustment will not be required.

See assembly instructions (section 6.11.3) if assembly or adjustment is required for any reason.

5.4.4 Initial Starting

1. If the discharge line has a valve in it, it should be partially open for initial starting — Min. 10%.



START THE PUMP AT REDUCED SPEED OR WITH THE OUTLET VALVE PARTLY OPENED

2. Start lubrication liquid flow on enclosed line shaft units.



ENSURE CORRECT LUBRICATION

3. Start the pump and observe the operation. If there is any difficulty, excess noise or vibration, stop the pump immediately and refer to section 7 for probable cause.
4. Open the discharge valve as desired.



DO NOT RUN THE PUMP CONTINUOUSLY OUTSIDE THE ALLOWABLE OPERATING REGION

5. Check complete pump and driver for leaks, loose connections or improper operation.
6. If possible, the pump should be left running for approximately ½ hour on the initial start-up. This will allow the bearings, packing or seals, and other parts to “run-in” and reduce the possibility of trouble on future starts.

Note:

If abrasives or debris are present upon startup, the pump should be allowed to run until the pumpage is clean. Stopping the pump when handling large amounts of abrasives (as sometimes present on initial starting) may lock the pump and cause more damage than if the pump is allowed to continue operation.



Every effort should be made to keep abrasives out of lines, sumps, etc. so that abrasives will not enter the pump.

5.5 Start-up, operation, and shut-down

5.5.1 Minimum continuous flow

Minimum continuous flow for a specific pump model can be found on the pump performance curve. Contact the factory to find out the minimum continuous flow for a specific pump model. A pump can be operated below the minimum continuous flow for short periods of time (less than 1 minute).

5.5.2 Lubrication system settings

Oil lubricated pumps equipped with line shaft enclosing tubes should have the flow of oil started prior to starting the pump. Ensure that the oil reservoir is filled to the appropriate level and all valves and controls are functioning properly. Product lubricated pumps do not require any pre-lubrication of bearings.



ENSURE CORRECT LUBRICATION

Check the startup check list or manual for any drivers or auxiliary equipment prior to start up and follow any instruction on lubricating those components, if necessary.

5.5.3 Drive system settings

Refer to literature provided by the driver manufacturer for any drive system setting requirements or recommendations.

5.5.4 Valve settings and operation (timing)

A pump should not be operated with the discharge valve closed for long periods of time (over 1 minute). Running the pump at complete shut off can cause damage to the pumping unit, motor, and auxiliary equipment. If there is any danger of the pump running against a closed discharge valve, install a pressure-relief or bypass valve in the discharge pipe to allow the specified minimum flow through the pump. Minimum liquid flow through the pump is needed for cooling and lubrication of the pump. Run the bypass/relief valve and discharge pipe to a floor drain or a tank for collection.



DO NOT RUN THE PUMP CONTINUOUSLY OUTSIDE THE ALLOWABLE OPERATING REGION

5.5.4.1 Operation at Shut-Off

In the usual application of vertical turbine pumps, no harm will result from operation under conditions of shut-off heads for a short period of time; however, not all installations are “usual” and for this reason, consideration should be given to any unit which may be subjected to this usage. The following points should therefore be checked and resolved before putting the equipment into operation at or near shut-off heads.

1. Thrust bearing capacity must be adequate.
2. If prolonged operation at no flow is contemplated, the problem of heat dissipation may become acute, since the entire shut-off horsepower is converted to heat in the available fluid.
3. For high pressure units, stresses at shut-off heads should be investigated. This information may be obtained from the factory upon request
4. Certain impeller designs may have critical horsepower characteristics at low flows. Shut-off power requirements should be examined for driver overloads.
5. It must be kept in mind that impeller shaft bearings depend on pumped fluid for lubrication. Fluid temperatures, if raised excessively due to lack of flow, may impair lubrication efficiency and may also damage the motor through excessive heat.

To summarize, designs will easily accommodate most of the considerations listed above. However, to obtain the best possible application, the factory should be notified at the time of order if operation at static flow heads will be a possibility and this precaution must be observed to validate any warranties.



ENSURE CORRECT LUBRICATION



DO NOT RUN THE PUMP CONTINUOUSLY OUTSIDE THE ALLOWABLE OPERATING REGION

5.5.5 Condition monitoring

There are a variety of conditions that can be monitored in a pumping unit, the frequency of monitoring these conditions depends on the users need to know the status of the conditions and the probability of failure of the pump and the severity of failure of the pump. If there is a low probability of failure and low severity if the pump were to fail, then the conditions of the pump should be monitored regularly, but constant or

frequent monitoring might not be needed. However, if there is a high probability of failure and the severity of failure is high, then monitoring should occur on a more frequently level or even constantly.

The probability of failure should be determined based off of factors such as the environment the pump was placed in, working fluid in the pump, historical data, or recent trends. The severity of failure should be determines based off the consequences of failure including safety consequences, environmental consequences, and economic consequences.

Based off the probability of failure and the severity of failure the frequency of condition monitoring can be determined. The conditions that can be monitored include but are not limited to:

- Power monitoring
- Temperature monitoring
- Corrosion monitoring
- Leakage monitoring
- Pressure monitoring
- Vibration monitoring
- Periodic lubrication analysis
- Shaft position monitoring
- Rate-of-flow monitoring
- Maintenance inspection
- Speed (RPM) monitoring

5.5.6 Vibration

5.5.6.1 Allowable Limits

The allowable pump vibration values vary between different standards. API 610, Hydraulic Institute, and ISO 13709 have different values for the allowable pump vibration for different style of pumps. This section includes the allowable values for the Hydraulic Institute and API 610 standards. The allowable limit is based on measurements at the top of the discharge head and depend on if the pump is operating within the Preferred Operating Region (POR) or Allowable Operating Region (AOR).



DO NOT RUN THE PUMP CONTINUOUSLY OUTSIDE THE ALLOWABLE OPERATING REGION

The table below shows the allowable pump vibration values as set by the Hydraulic Institute in ANSI/HI 9.6.4 for vertical turbine pumps in factory tests for pumps that run at over 600 RPM pumping clear fluids. The values for allowable pump vibration are given in overall vibration velocity RMS.

	Below 268 bhp	At and Above 268 bhp
POR	0.13 in/sec	0.17 in/sec
AOR	0.27 in/sec	0.21 in/sec

Table 5-1 – Allowable Vibration Limits per HI 9.6.4

The table below shows the allowable pump vibration values as set by the API 610 standard in section 6.9.3 for vertical turbine pumps in factory tests. The values for allowable pump vibration are given in overall vibration velocity RMS.

	Below 268 bhp	At and Above 268 bhp
POR	0.20 in/sec	0.20 in/sec
AOR	0.26 in/sec	0.26 in/sec

Table 5-2 – Allowable Vibration Limits per API 610

These values of allowable vibration must be adjusted for pumps with non-standard operating conditions including but not limited to pumps that operate under 600 RPM or pump solids-bearing liquids. Contact the factory for the allowable pump vibration value for pumps with non-standard operating conditions.

5.5.6.2 Alarm and Trip Settings

Alarm and trip setting are best set based on baseline data when available. ANSI/HI 9.6.5 Condition Monitoring recommends the alarm be set at 30% above baseline and trip be set at 50% above baseline. A time delay for transient conditions and start-up and shut-down maybe required.

If baseline data is not available, ANSI/HI 9.6.4 Vibration Measurements and Allowable Values recommends that the alarm be set at 1.5 times above the allowable limit and trip be set at 2.0 times the allowable limit.

5.5.7 Performance testing/verification

Once the unit is running, check operating speed, rate of flow, suction and discharge pressure, and power input. The values measured in the field may differ from the values from a quoted performance curve or a factory performance test slightly, but the field values give a baseline for checking performance in the future. This baseline can be used to determine possible wear and the need for maintenance.

5.5.8 Bearing temperature

Refer to literature provided by the drive of bearing manufacture for allowable limits and recommended alarm and trip settings.

6 Maintenance

It must be borne in mind that eventually repairs have to be made, either to the pump or to the motor. When regular maintenance checks indicate that an overhaul is required, it should not be delayed.

Repairs will consist of removal of the unit and disassembly to the point necessary for replacement of worn parts.

Disassembly should be performed in a clean area with sufficient space to lay out the parts in order of disassembly. Cleanliness throughout repairs is important. Remember this is a close tolerance, high speed machine and should be handled as such.



Protect machined surfaces from burrs and scrapes which will cause misalignment on reassembly.

A periodic inspection is recommended as the best means of preventing breakdown and keeping maintenance costs to a minimum. Maintenance personnel should look over the whole installation with a critical eye at each inspection — a change in noise level, amplitude or vibration, or performance can be an indication of impending trouble.

Any deviation in performance or operation from what is expected can be traced to some specific cause. Determination of the cause of any misperformance or improper operation is essential to the correction of

the trouble — whether the correction is done by the user, the dealer or reported back to the factory. Variances from initial performance will indicate changing system conditions or wear or impending breakdown of unit.

6.1 Schedule

Recommended maintenance intervals will vary based off of usage conditions of the pump including excessive heat, moisture, or dust in the area of operation. It is recommended that a log of inspections and maintenance be kept by the pump operator. A suggested schedule of preventative maintenance for normal applications is provided below, this should be adjusted as necessary for any specific operation conditions.

Item	Action Required	Frequency
Packing, Packing Box (IF EQUIPPED)	Inspect for excessive leakage	Monthly
	Grease packing box	Monthly
	Adjust gland and replace packing	As needed
Pump/Motor Alignment	Check for change in alignment	Annually
Bearings	Check that lubrication system is operating (if equipped)	Monthly
	Lubricate (grease) bearings	As needed
Bolting	Check for loose bolting	Annually

Table 6-1 – Recommended Maintenance Intervals

6.1.1 Cold weather maintenance

When the pumping fluid has a freezing temperature that may be experienced in the area of operation precautions must be taken, this is most common when the pumping fluid is water. When the pump is not in operation it may be necessary to drain the pump casing and suction line if the pump may experience temperatures at or below the freezing temperature for the pumping fluid. For pumps in a well or pit it may be necessary to remove the pumping unit if the fluid level cannot be drained below the pump.

6.2 Recommended spare parts

When ordering spare or replacement parts the pump serial number and size and type of pump must be given. This can be found on the nameplate furnished with the unit. Give the complete name and reference number of each part as indicated on the applicable sectional drawing (section 8) and the quantity required.

Spare parts to be kept in inventory will vary according to service, field maintenance anticipated, allowable down time and number of units. A minimum inventory of one complete set of bearings, gaskets, o-rings, and packing (or mechanical seal) and one spare of each moving part is suggested.

6.3 Consumables

During pump maintenance and pumping equipment maintenance the following items are normally used and should be on hand to use.

- Replacement packing, if equipped
- Lubricant (grease or oil)
- Anti-Locking Thread Grease
- Cleaning materials
- Touch-up coating, if needed

6.4 Required tools and fixtures

No installation should be attempted without equipment adequate for the job. The following list covers the principal items required for an installation.

1. Mobile crane capable of hoisting and lowering the weight of the pump or motor.
2. Cable sling for attaching to the pump and motor lifting eyes.



ALL EQUIPMENT USED FOR LIFTING MUST BE MAINTAINED AND INSPECTED TO BE IN GOOD CONDITION OF AND APPROPRIATE FOR THE WEIGHT.

3. Ordinary hand tools—end wrenches, socket set, screw drivers, allen wrenches, collet hammer, etc.
4. Wire brush, scraper and fine emery cloth or scotchbrite pad.
5. Thread compound and light machinery oil.

6.5 Fastener torques, rotation direction, and sequence

The standard torque values shown are for standard fasteners without lubricant. On a standard construction assembly fasteners will have right hand threads, but different thread types may be available upon request. When assembling a pump unit, it is important to follow the tightening sequence: start by tightening the bolt nearest to the top of the bolt circle, then tighten the bolt most opposite the first on the circle, and then continue in a crisscross pattern until all bolts have been properly torqued. For square bolt patterns tighten bolts by tightening bolts that are across from each other and working through a cross pattern until all bolts are torqued to spec. Table 6-2 indicates recommended torque values for standard fasteners.

Fastener Size	Torque (ft-lb)		Fastener Size	Torque (ft-lb)	
	Grade 5 Steel	Stainless Steel		Grade 5 Steel	Stainless Steel
1/4	8-11	6-7	3/4	266-333	128-132
5/16	17-22	11-12	7/8	429-537	194-203
3/8	31-39	20-21	1	644-805	287-300
7/16	49-62	31-33	1-1/8	794-992	413-432
1/2	75-94	43-45	1-1/4	1120-1400	523-546
9/16	109-136	57-59	1-3/8	1470-1835	706-738
5/8	150-188	93-97	1-1/2	1950-2438	888-930

Torque values shown are for dry fasteners with no added lubricant or anti-seize.

Table 6-2 – Recommended Fastener Torque Values



Cleanliness and proper lubrication are very important since one small chip, burr or one dry bearing can be a cause for re-doing the whole job.

6.6 Pump decontamination

Before disassembling a pump, it is important to ensure that entire unit is cleaned completely and there is no residual fluids that could cause injury or illness. This is most important for pumps used to pump chemicals or sewage. A pumping unit can be cleaned in different ways, but the basic steps should be included in any cleaning procedure: draining the pump of working fluid, flushing the pump with clean water or other solvent, removal of contamination on the pumping unit. For any pumps used to pump chemicals all cleaning materials and runoff fluids must be handled and disposed of in accordance with all federal, local, and OSHA regulations. Throughout decontamination and disassembly, workers should wear protective clothing as warranted by the chemical or fluid in the pumping unit.

During decontamination it is important that the chemicals and cleaners used will no damage, corrode, or otherwise affect pump components. The materials of the pump are suitable for the working fluid the pump will usually handle, but may not be suitable for all type of cleaners or chemicals. Keep contact time between cleaners and pump components to minimum if possible and flush all pump components with water or other pumpage fluids when done decontaminating or cleaning. Contact the factory if there are questions about potential damage caused by cleaners.

6.7 Disassembly

Note: Refer to section 8 for parts drawings and identification. These drawings are general, reference project specific drawings if provided.

1. Disconnect electrical leads from motor.



NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER.

2. Loosen mechanical seal from shaft.
3. Disconnect pump shaft from driver:
 - a. Hollow Shaft—Remove head shaft nut lock screw, head shaft nut (66), gib key and driver clutch. Unscrew head shaft (10) from shaft coupling (70) inside discharge head and remove.
 - b. Solid Shaft—Lower shaft and unbolt driver half coupling.
4. Remove bolts which attach driver to discharge head.
5. Lift driver off pump and set on wooden supports.
 - a. With solid shaft drivers be sure supports are high enough to clear shaft and coupling half.
6. Seal
 - a. Stuffing box construction — remove slinger (40) and packing gland (17).
 - b. Mechanical seal construction — loosen seal cover cap screws and remove gland plate.

Note: With sleeve mounted mechanical seals the seal and sleeve assembly should be removed with the gland plate. See Seal Instruction Manual for further details.

- c. Enclosed line shaft construction – remove lock screw and lubrication line and unscrew lock and tension nuts (185). Threads could be left or right hand.

7. Disconnect discharge piping from pump.
8. Remove anchor bolts (or nuts).
9. Lift pump vertically until pump suction clears foundation or sole plate (129).
10. Cover opening in foundation.
11. Lower pump into a horizontal position on suitable support and in a suitable area for disassembly.

Note: If more than minor repairs are anticipated it is recommended that the unit be taken to a shop or other clear area with a smooth floor and overhead lifting equipment.

12. Remove cap screws which attach the stuffing (packing) box (83), tension bearing (183) or seal housing (87) to discharge head (187).
13. Remove stuffing (packing) box (83), tension bearing (183) or seal housing (87).

Note: If non-sleeve mounted mechanical seal is used the set screws which lock the seal assembly to the shaft must be loosened before removing seal housing.

Note: Before proceeding further, make sure the discharge head and bowl assembly are supported independently of each other.

14. Disconnect bowl assembly or top column from discharge head. This connection may be flanged or the column pipe or bowl assembly may be threaded into the discharge head. If threaded, the threads will be **RIGHT HAND**.
15. Remove discharge head (187) being careful not to damage or bend shaft.
16. Disconnect column pipe (101) (if present) at first joint below top and remove from shaft.
17. Line shaft

- a. Open line shaft construction — Each time a line shaft coupling (70) is exposed by removing length of column pipe the line shaft (12) and coupling should be removed by holding the lower line shaft and turning the coupling in a **RIGHT HAND** direction (line shaft threads are **LEFT HAND**). Bearing retainers (193) should be removed after the line shaft coupling. Before lifting the bearing retainer out of the pipe coupling or register in flanged column — any nicks or burrs on the shaft should be removed.



When using wrenches on shafting always place the wrenches on the same side of the shaft to avoid excess side strain on the shafting. Care should always be taken so that exposed lengths of shafting are not damaged or bent.

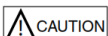
- b. Enclosed line shaft construction — each time a length of column pipe is removed the enclosing tube (85) and line shaft (70) must also be disassembled. Locate the joint and unscrew (RIGHT OR LEFT HAND threads) the enclosing tube (85) from the line shaft bearing (39) (which acts as a bearing for the shaft and also as an enclosing tube coupling). Leave the line shaft bearing threaded into the enclosing tube not being removed (to support the line shaft). Slide the enclosing tube up to expose the line shaft coupling and uncouple as outlined in step 17(a) above.
18. Disconnect each section of column pipe one at a time and remove along with shaft and enclosing tube as applicable until all are removed.
19. Remove bowl assembly to clear area and continue disassembly.

6.8 Inspection

When the pumping unit is disassembled all components should be inspected for wear, damage, or other deformations. Any pump components that are worn such that they do not maintain the acceptance criteria or dimensions of the original part should be replaced with new parts or re-conditioned to a useable state.

6.8.1 Acceptance criteria

Parts showing signs of damage, cracks or excessive wear should be replaced.



When repairing a pump that has been in service for several years, the physical condition or strength of all parts such as cap screws, bowls, threads, etc., must be carefully checked to be sure that these parts can continue to perform their function without failure.

6.8.2 Shaft straightening

Anytime the pump is disassembled caution should be taken to make sure the protruding shaft is support to maintain straightness throughout the shaft. If a shaft becomes bent or deformed outside of the acceptable limit it requires straightening or replacement. Shaft straightness shall be within 0.0005-inch total indicated runout (TIR) per foot of shaft length.

6.9 Assembly

Assembly of the unit is basically the reverse of disassembly.

Before proceeding with assembly, clean thoroughly and check all threads, registers and mating faces for burrs. Clean up with file where required. Lubricate as outlined above. Oil all shafts lightly.

Proceed with assembly in reverse order of disassembly as outlined in section 6.7 above.

6.9.1 Clearances

Check all bearings for total clearance over the shaft diameter. It is recommended that all bearings indicating wear be replaced. The following indicates the maximum allowable diametrical clearance over existing shaft diameter:

1.00" through 1.75" shaft — .020" clearance.

1.94" through 2.44" shaft — .025" clearance.

2.69" through 3.94" shaft — .030" clearance.

All bearings are pressed into their respective bores and can be either pressed out or machined on the inside diameter until the wall is thin enough to collapse.

If equipped, the running clearance between wear rings should be checked to be within the acceptable range. The acceptable range for wear rings varies based off the size of the impeller. The table below shows the minimum clearance required for various pump models; replacement is recommended when the clearance has increased by 50% over the minimum.

Rotating Ring Size (in)	Standard (in)	Galling (in)	Rotating Ring Size (in)	Standard (in)	Galling (in)
<2.000	0.010	0.015	12.000 to 12.999	0.024	0.029
2.000 to 2.499	0.011	0.016	13.000 to 13.999	0.025	0.030
2.500 to 2.999	0.012	0.017	14.000 to 14.999	0.026	0.031
3.000 to 3.499	0.013	0.018	15.000 to 15.999	0.027	0.032
3.500 to 3.999	0.014	0.019	16.000 to 16.999	0.028	0.033
4.000 to 4.499	0.015	0.02	17.000 to 17.999	0.029	0.034
4.500 to 4.999	0.016	0.021	18.000 to 18.999	0.030	0.035
5.000 to 5.999	0.017	0.022	19.000 to 19.999	0.031	0.036
6.000 to 6.999	0.018	0.023	20.000 to 20.999	0.032	0.037
7.000 to 7.999	0.019	0.024	21.000 to 21.999	0.033	0.038
8.000 to 8.999	0.020	0.025	22.000 to 22.999	0.034	0.039
9.000 to 9.999	0.021	0.026	23.000 to 23.999	0.035	0.040
10.000 to 10.999	0.022	0.027	24.000 to 24.999	0.036	0.041
11.000 to 11.999	0.023	0.028	25.000 to 25.999	0.037	0.042

Table 6-3 – Wear Ring Minimum Clearance

6.10 Impeller re-adjustment

Ordinarily, impellers will not require readjustment if properly set at initial installation. Almost no change in performance can be obtained by minor adjustment of enclosed impellers. However, the positioning of semi-open impellers has a definite effect on the performance of the pump. This fact is sometimes used to adjust the output of the pump without valving. This method does allow the performance to be easily adjusted, but this greatly affects the efficiency of the pump as a result. Figure 6-1 illustrates the general effect of raising semi-open impellers.

After extended operation under abrasive conditions the sealing faces between semi-open impellers and the bowl will wear, causing a reduction in performance. The pump performance can be brought back up to almost “as new” by proper readjustment of the impellers. See section 4.7 for proper adjustment procedure.

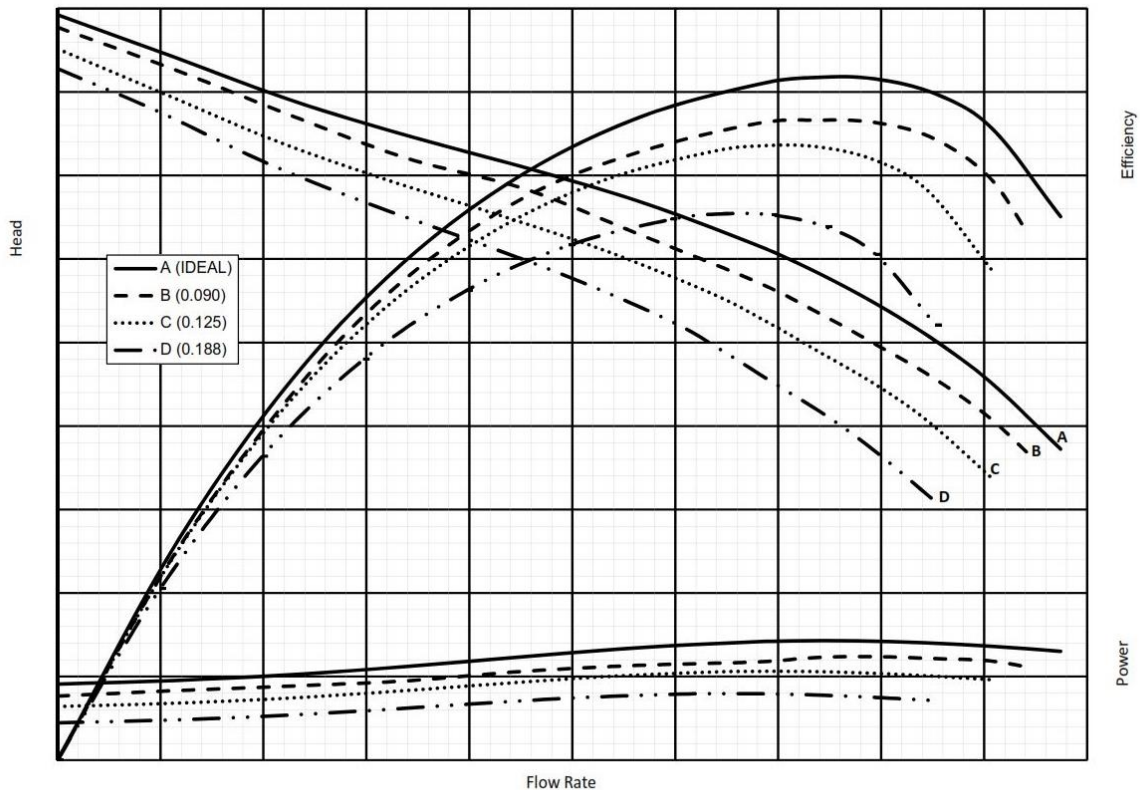


Figure 6-1 – Semi-Open Impeller Performance Versus Running Clearance

Note: All adjustments of the impellers will change the mechanical seal setting. Unless the adjustment is to be very minor, it is recommended that the seal be loosened from the shaft until the adjustment is complete and then reset.

6.11 Seal maintenance and assembly

6.11.1 Mechanical seal

6.11.1.1 Mechanical seal maintenance

Cartridge mechanical seals do not require any adjustment. This seal type is set to the shaft after the pump lateral is set and must be un-set prior to any adjustment. Refer to the Mechanical Seal Instruction Manual for further information.

Component mechanical seals should not be readjusted unless there is a reason. Best results will be obtained if the seal is properly set on start-up and left that way. If the seal starts to leak after an extended operating period, some extra service may be obtained by readjusting. However, it is usually best to plan on replacing the seal at the next maintenance period.

After impeller readjustment, seal leakage may occur due to improper seal adjustment or improper seating of the seal parts. If readjustment of the seal will not correct the problem, refer to the Mechanical Seal Instruction Manual for further information.

6.11.1.2 Mechanical seal repairs

Mechanical seal repairs can be affected without removing the complete unit. The mechanical seal assembly can be replaced by removing the spacer and lowering half coupling on solid shaft units. On hollow shaft units, the driver shaft and shaft coupling inside the discharge head must be removed or lifted out of the way. Replacement of the bearing located at the bottom of the seal housing will usually require removal of the driver in order to obtain sufficient headroom.

6.11.2 Packing box

6.11.2.1 Packing box maintenance

Maintenance of the packing box will consist of greasing the box when required, tightening the packing gland occasionally as the leakage becomes excessive, and installing new packing rings or sets as required.

6.11.2.1.1 Greasing the packing box

Under ordinary operation, once-a-month greasing of the packing box will be adequate. A good grade of grease such as Standard of California No. TB-medium or Texaco Multi-fax No. 2-medium should be used.

6.11.2.1.2 Replacing packing

Remove gland and all old packing. If the box contains a lantern ring remove this and all packing below it. Inspect shaft or sleeve for score marks or rough spot. Be sure bypass holes (if required) are not plugged. Repair or replace badly worn shaft or sleeve. If wear is minor, dress down until smooth and concentric. Clean box bore.

Oil inside and outside of replacement rings lightly and install box, staggering joints 90 degrees. Be sure to replace lantern ring in proper position when used.

Replace gland and tighten nuts, making sure gland enters box squarely. Keep the packing under moderate pressure for one minute to allow it to cold flow and adjust itself. Back off on the gland until loose before starting the pump.

6.11.2.1.3 Start up with new packing

Check that the bypass line (if used) is connected and packing gland nuts are finger tight only. Start pump and allow to run for 20 to 30 minutes. Do not tighten the gland during this "run-in" period even if leakage is excessive.

If the leakage continues to be more than normal, adjust as outlined in section 5.4.3.2.1. Should the new packing cause excess heating during "run-in," flush the shaft and packing box area with cold water or shut the pump down and allow to cool if necessary.

6.11.2.1.4 Auxiliary packing box maintenance

Pumps equipped with mechanical seals may also be provided with an auxiliary stuffing box to restrict leakage should the mechanical seal fail. This packing gland must be left loose since, under normal operation, the packing will not be cooled and lubricated by the pumpage. This stuffing box arrangement is designed to help contain leakage past the mechanical seal. It is not designed as a primary seal and should not be used as such.

6.11.2.2 Packing box repairs

Packing box repairs can be affected without removing the complete unit. Packing replacement, as outlined in section 6.11.2, can be accomplished without disturbing the pump driver. The stuffing box bearing can be replaced if necessary by removing the driver and sliding the stuffing box off the shaft.

6.11.3 Tension assembly

6.11.3.1 Tension nut assembly and adjustment

Enclosed line shaft (oil lubricated) units use a tube tension assembly which must be properly tightened for proper operation. General construction is shown in section 8.

1. Clean all machined surfaces thoroughly before assembly.
2. Assemble tube tension bearing into top tube and tighten properly before placing discharge head on top column nipple.
3. Thread discharge head with top column flange on to top column nipple.
4. Place o-ring on tension nut and thread tension nut on to tube tension bearing until nut is snug against discharge head. Continue to tighten tension nut until the minimum amount of tension is achieved for the pumps setting length per figure 6-2 below. Install four (4) tension nut cap screws.



It is necessary that the enclosing tube have tension on it which is accomplished by tightening the tension nut. However, excess tightening will distort or break the tube tension bearing.

5. Place o-ring over tube tension bearing and proceed to thread lock nut onto the tube tension bearing. Tighten as required.
6. Install lock nut set, screw, and tighten.
7. Install lubrication line and fittings
8. Proceed with remainder of installation.

6.11.3.1 Mid-Stretch assembly

For oil lubricated, deep set pumps a mid-stretch assembly may be required. Figure 6-2 shows the ranges of pump setting where mid-stretch assemblies are recommended and required. A mid-stretch assembly is used to pull some tube tension in an application where the tube tension required for the total setting depth would be difficult or impossible to achieve at the tension assembly seal in the discharge head.

For example, a pump set at 1000 feet would require between 1.1"-1.2" of tension (per Figure 6-2), which could be difficult to achieve at the tension assembly alone so a mid-stretch assembly is used. The pump is built up as normal for the first 500' of column and at 500' a mid-stretch assembly is installed in the column. Since there are 500' of enclosing tube with no tension, figure 6-3 is used to determine that .35"-.75" of tension is needed (depending on the tube size) for the 500' of setting so far. The .35"-.75" of tension for the first 500' is pulled at the mid-stretch assembly and then the remaining 500' of column is built up as normal. Figure 6-2 is used to determine that .35"-.75" of tension is needed (depending on the tube size) for the 500' of setting since the last mid-stretch assembly. The .35"-.75" of tension needed for the column since the last mid-stretch assembly is pulled at the tension assembly seal in the discharge head.

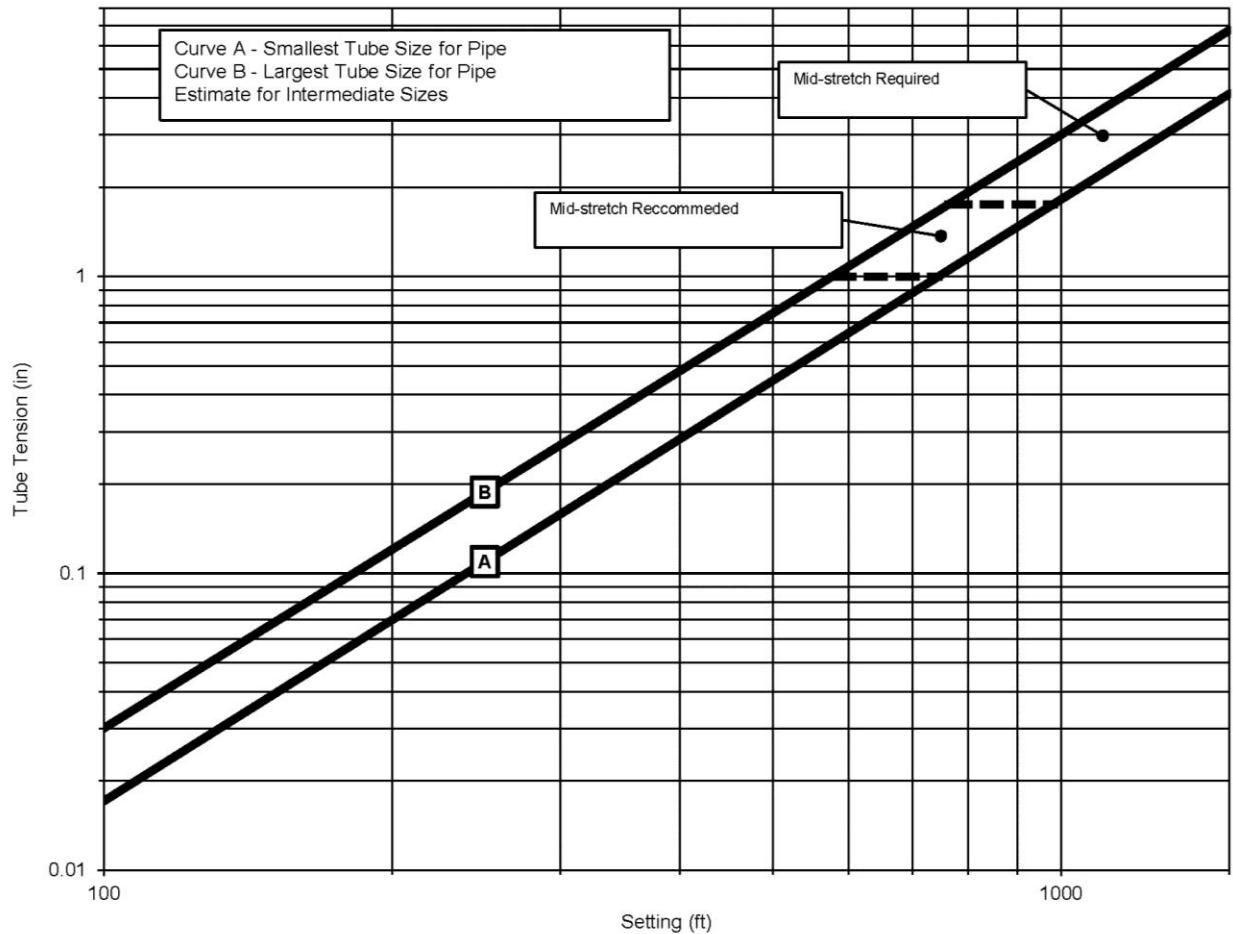


Figure 6-2 – Tube Size & Setting Depth Verse Required Tube Tension

6.12 Auxiliary equipment

For more detailed information on installation, operation, or maintenance of any auxiliary equipment including mechanical seals, flush plans, and drivers, see the manual provided by the manufacturer of that equipment.

7 Troubleshooting guide

7.1 Hydraulic performance

7.1.1 Pressure and flow

CONDITION	Probable Cause	Remedy
Pump Will Not Run	<ol style="list-style-type: none"> 1. Motor overload protection contacts open <ol style="list-style-type: none"> a. Incorrect control box b. Incorrect connections c. Faulty Overloads d. Low Voltage e. Ambient temperature of control box or starter too high 2. Blown fuse, broken or loose electric connections 3. Defective motor 4. Faulty control equipment 5. Faulty Switch 6. Pump binding 	<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> a. Check nameplate for HP and voltage b. Check wiring diagram furnished with starter c. Replace d. Check voltage at pump side of control box e. Use ambient compensated relays 2. Check fuses, relays or heater elements for correct size and all electrical connections 3. Repair or replace 4. Check all circuits and repair 5. Repair or replace 6. Pull master switch, rotate pump by hand to check. Check impeller adjustment or disassemble unit to determine cause
Pump Runs but No Fluid Delivered	<ol style="list-style-type: none"> 1. Line check valve backward 2. Line check valve stuck 3. Unit running backward 4. Lift too high for pump 5. Pump not submerged 6. Excessive amounts of air or gas 7. Intake strainer or impeller plugged, or pump in mud or sand 8. Impeller loose on shaft 	<ol style="list-style-type: none"> 1. Reverse check valve 2. Free the valve 3. See section 5.2 4. Check with performance curve 5. Lower pump if possible or add fluid to system 6. Correct conditions 7. Start and stop pump several times or use the line pressure if available to back flush. Pull pump and clean 8. Pull unit and repair
Reduced Capacity	<ol style="list-style-type: none"> 1. Bypass open 2. Lift too high for pump 3. Motor not coming up to speed 4. Strainer or impellers partly plugged 5. Scaled or corroded discharge pipe or leaks anywhere in system 6. Excessive amounts of air or gas 7. Excessive wear due to abrasives 8. Impellers not properly adjusted 9. Impeller loose on shaft 	<ol style="list-style-type: none"> 1. Check bypass valving 2. Check performance curve 3. Check voltage while unit is running 4. Start and stop pump several times or use line pressure if available to back flush. Pull pump and clean 5. Replace pipe or repair leaks 6. Correct conditions 7. Replace worn parts 8. See section 4.7 9. Pull unit and repair

7.2 Mechanical

7.2.1 Vibration and noise

CONDITION	Probable Cause	Remedy
Pump Noisy and Vibrating Excessively	<ol style="list-style-type: none">1. Unit running backward2. Pump breaking suction and pumping air3. Loose fasteners4. Badly worn motor or pump bearings5. Impeller loose on shaft6. Pump and motor shafts misaligned7. Stress due to piping misalignment	<ol style="list-style-type: none">1. See "Initial Starting of Unit"2. Lower pump or reduce capacity3. Check all bolts, nuts, etc.4. Pull unit and repair5. Pull unit and repair6. Pull unit and repair7. Correct

7.2.2 Wear and corrosion

CONDITION	Probable Cause	Remedy
Excess Wear	<ol style="list-style-type: none">1. Abrasives2. Pump in bind3. Vibration	<ol style="list-style-type: none">1. Clean system2. Pull master switch, rotate pump by hand to check. Disassemble unit to determine cause.3. Determine cause and correct
Corrosion	<ol style="list-style-type: none">1. Impurities2. Corrosive liquid	<ol style="list-style-type: none">1. Analyze fluid2. Change to corrosion resistant materials

7.2.2 Bearing temperature

Refer to literature provided by the motor manufacturer or thrust bearing manufacturer for information on measuring bearing temperature and acceptable operating temperatures.

7.3 Electrical, instrumentation, and controls

CONDITION	Probable Cause	Remedy
Motor Over-loaded	<ol style="list-style-type: none">1. Line voltage not correct2. Faulty equipment used to check3. Specific gravity higher than design4. Operation at point on pump curve other than design5. Motor speed too high6. Impellers dragging7. Pump in bind	<ol style="list-style-type: none">1. Check and correct2. Check equipment3. Correct specific gravity or re-evaluate system4. Check performance curve5. Line voltage too high or incorrect frequency6. Re-adjust7. Pull master switch, rotate pump by hand to check. Disassemble pump to determine cause.

Refer to the installation, operation, and maintenance manual provided by the sub vendor for additional troubleshooting information for electrical, instrumentation, and controls

8 Parts listing and sectional drawings

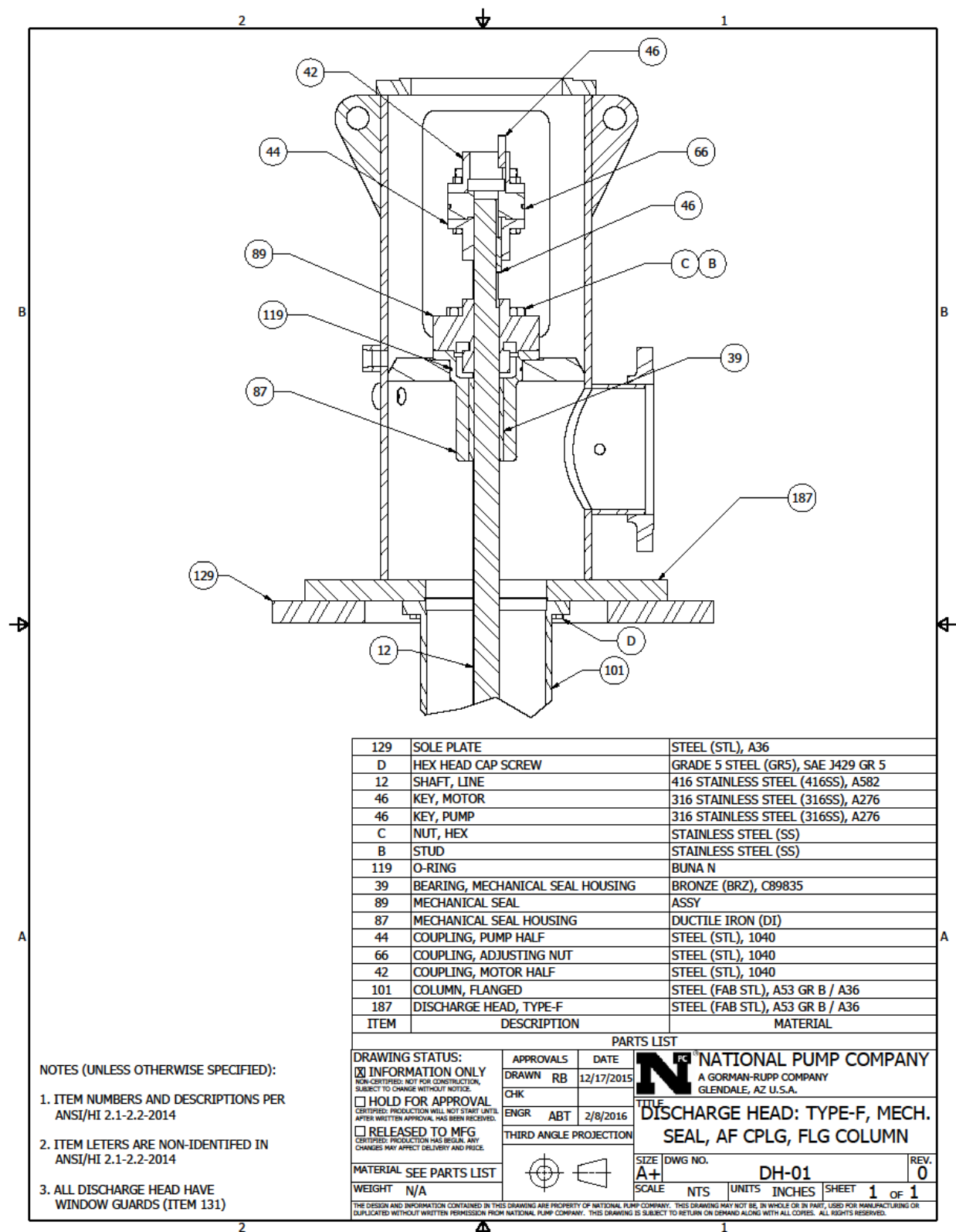


Figure DH-01 – Discharge Head Assy: Type-F, Mechanical Seal, AF Coupling, Flanged Column

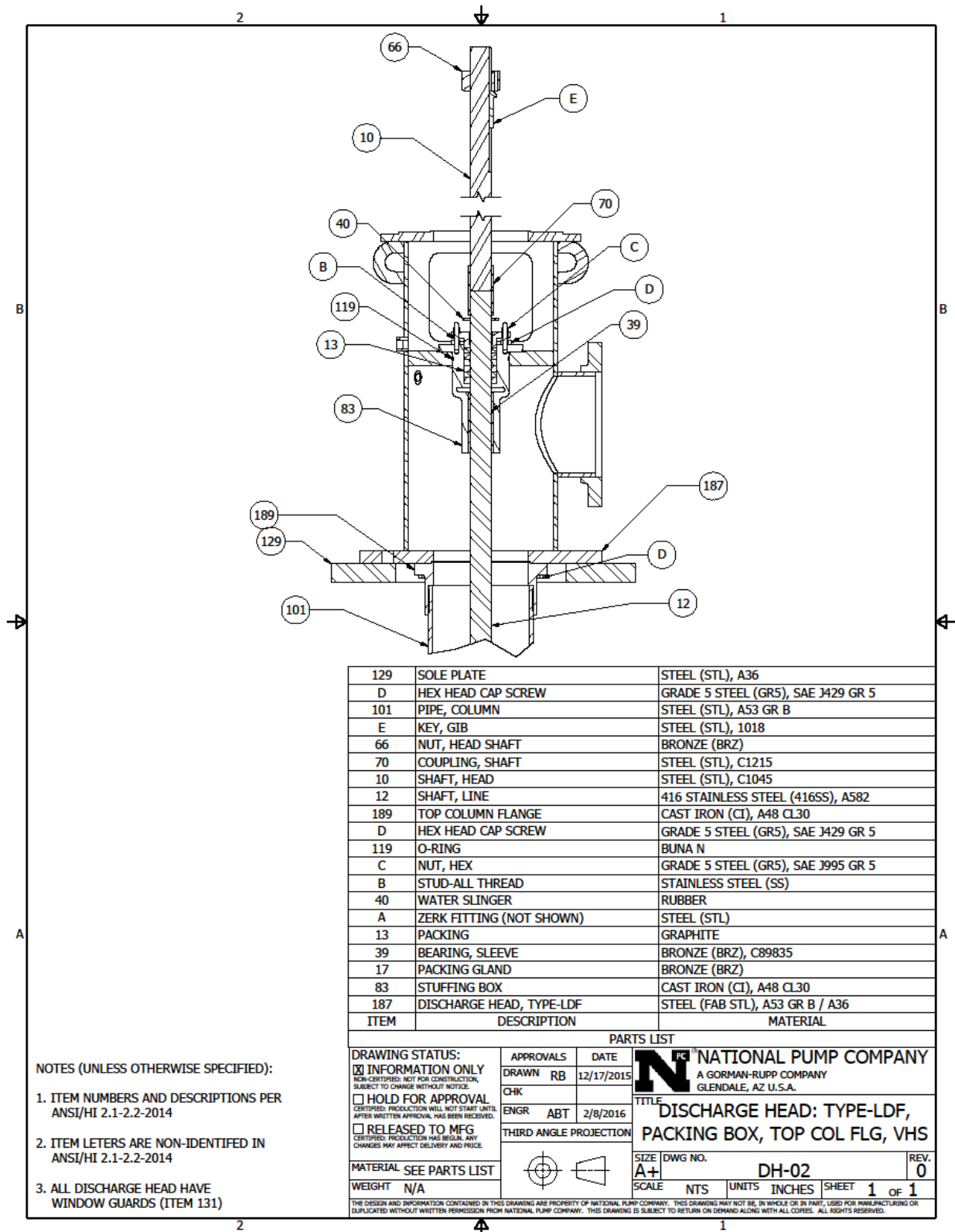


Figure DH-02 – Discharge Head Assy: Type-LDF, Packing Box, Top Column Flange, VHS Driver

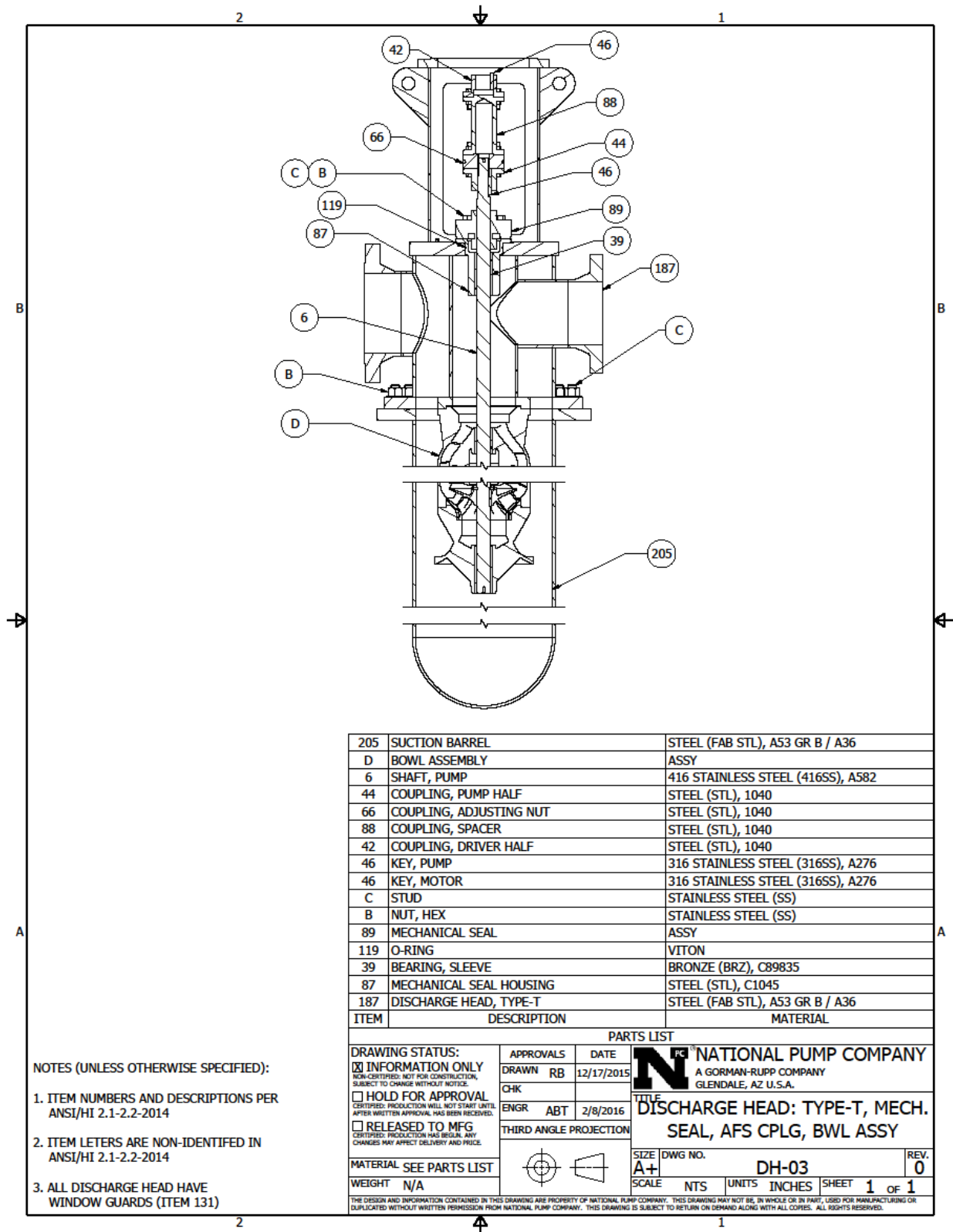


Figure DH-03 – Discharge Head Assy: Type-T, Mechanical Seal, AFS Coupling, Bowl Assembly

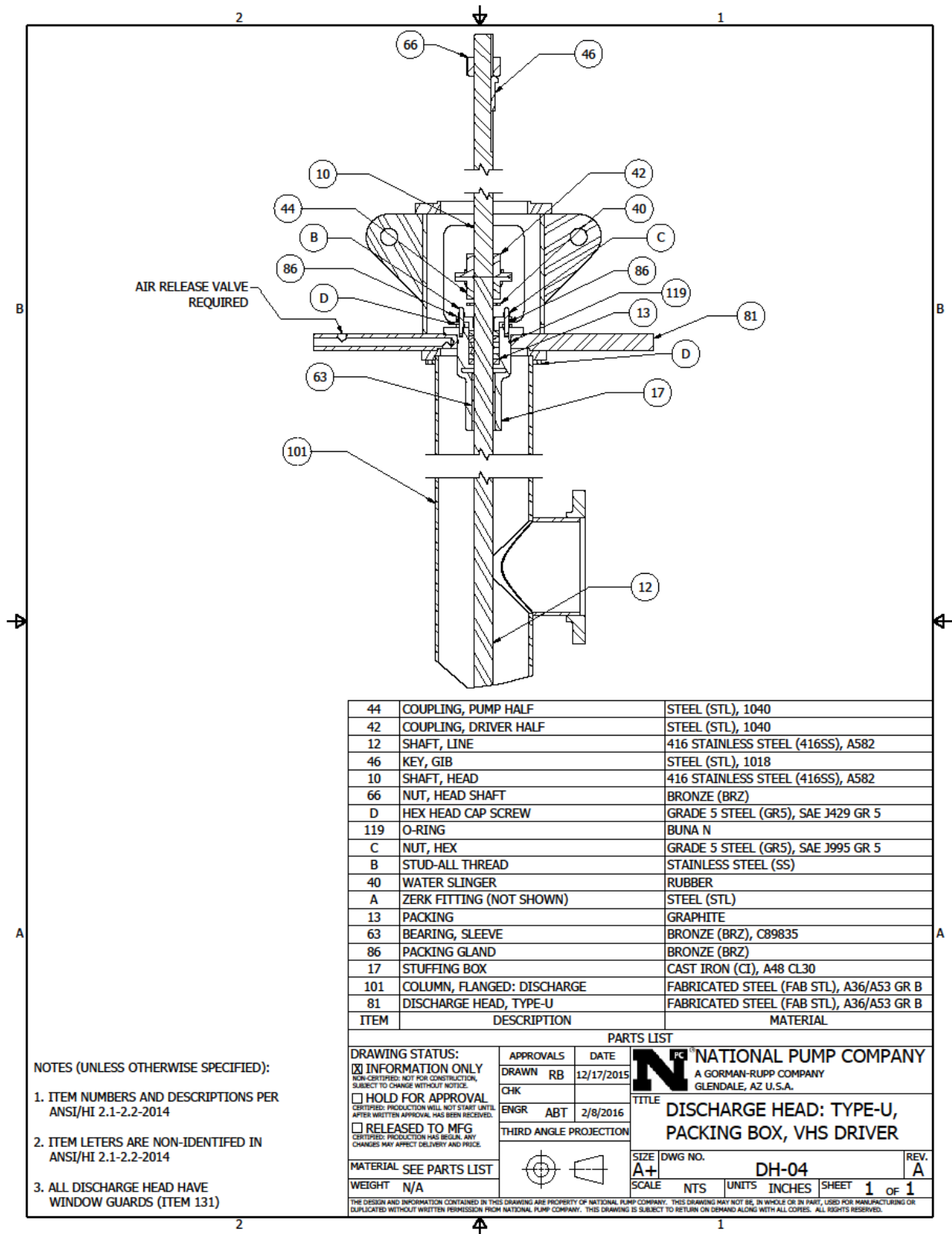


Figure DH-04 – Discharge Head Assy: Type-U, Packing Box, VHS Driver

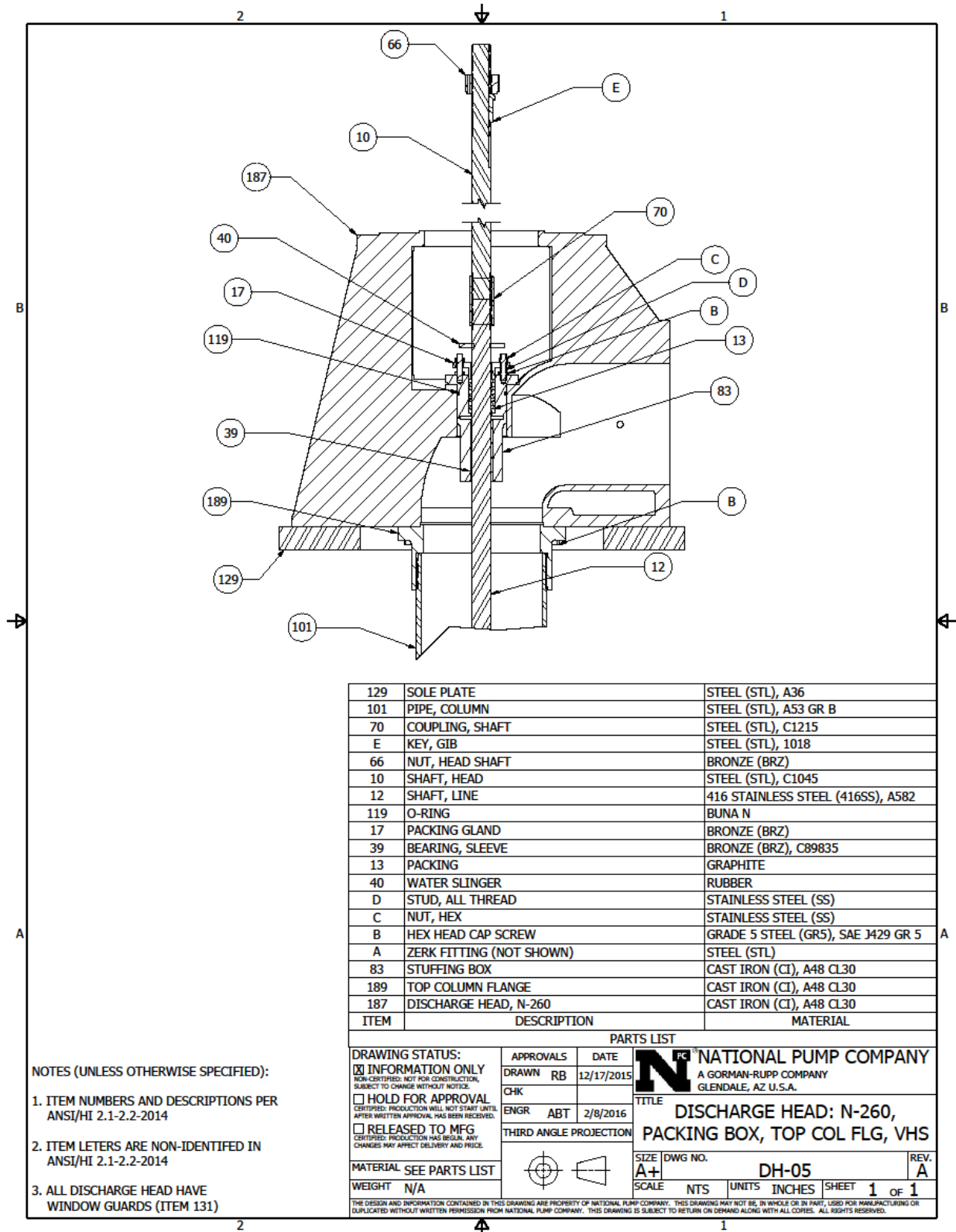


Figure DH-05 – Discharge Head Assy: N-260, Packing Box, Top Column Flange, VHS Driver

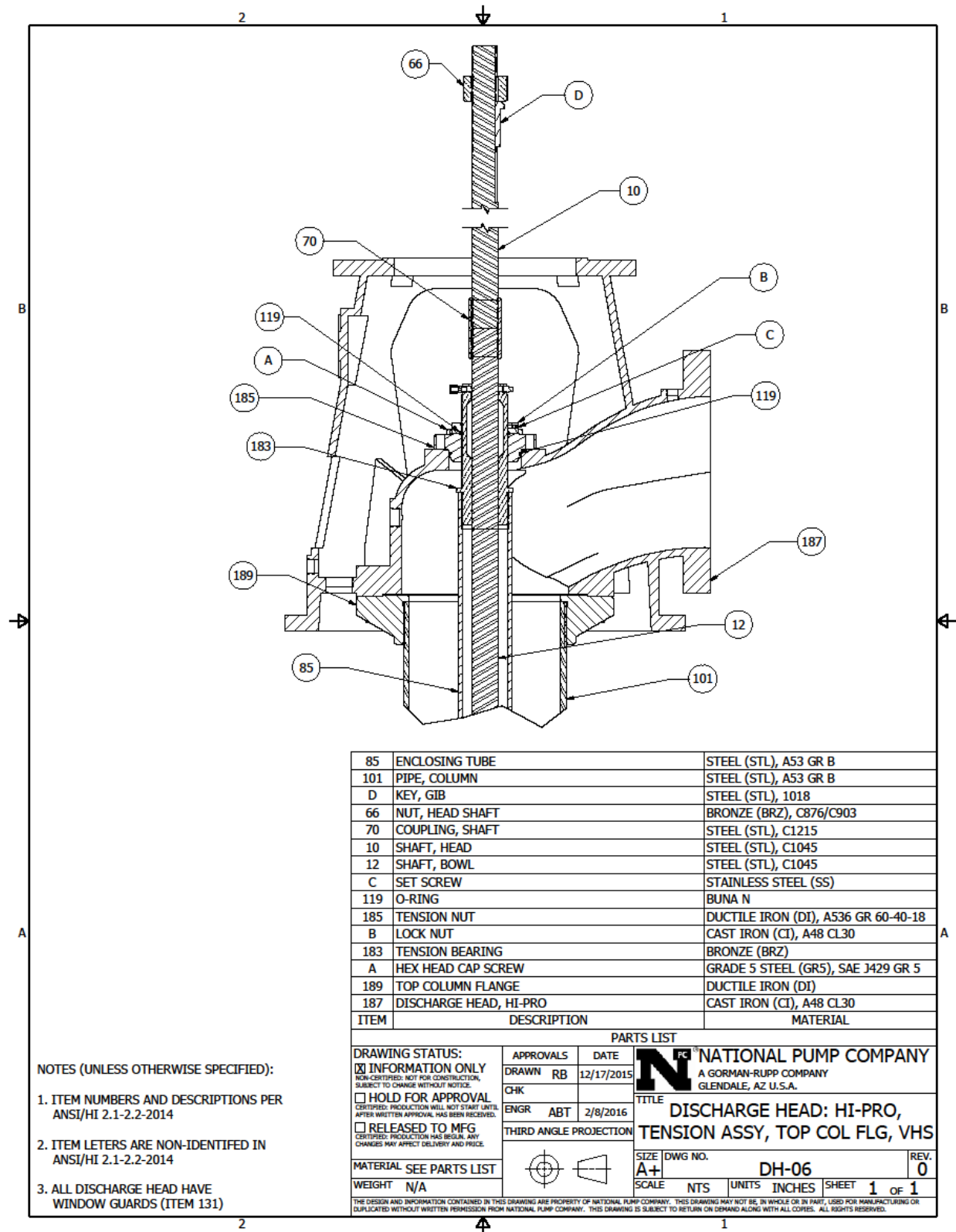


Figure DH-06 – Discharge Head Assy: Hi-Pro, Tension Assembly, Top Column Flange, VHS Driver

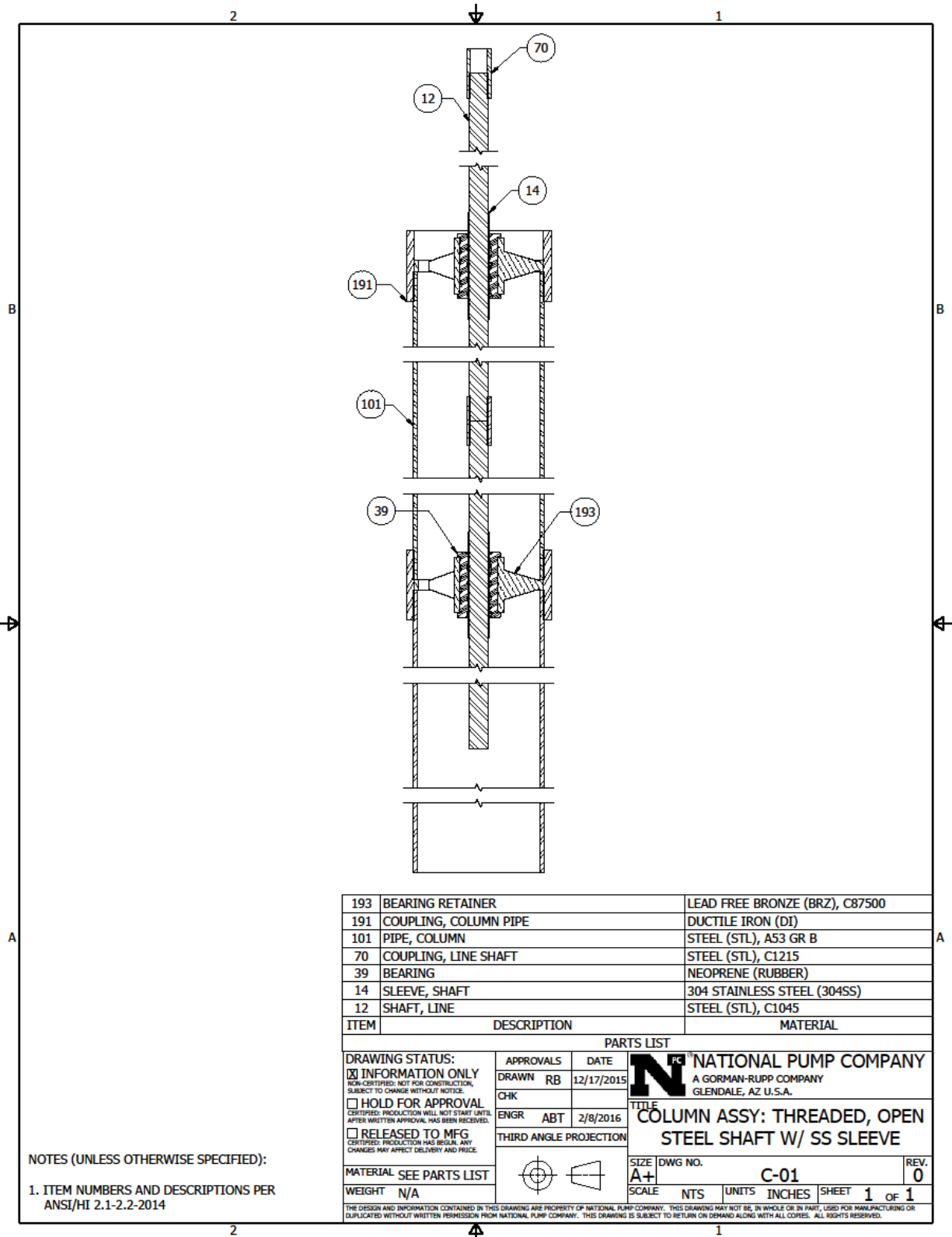


Figure C-01 – Column Assy: Threaded, Open Line Shaft with Stainless Steel Sleeve

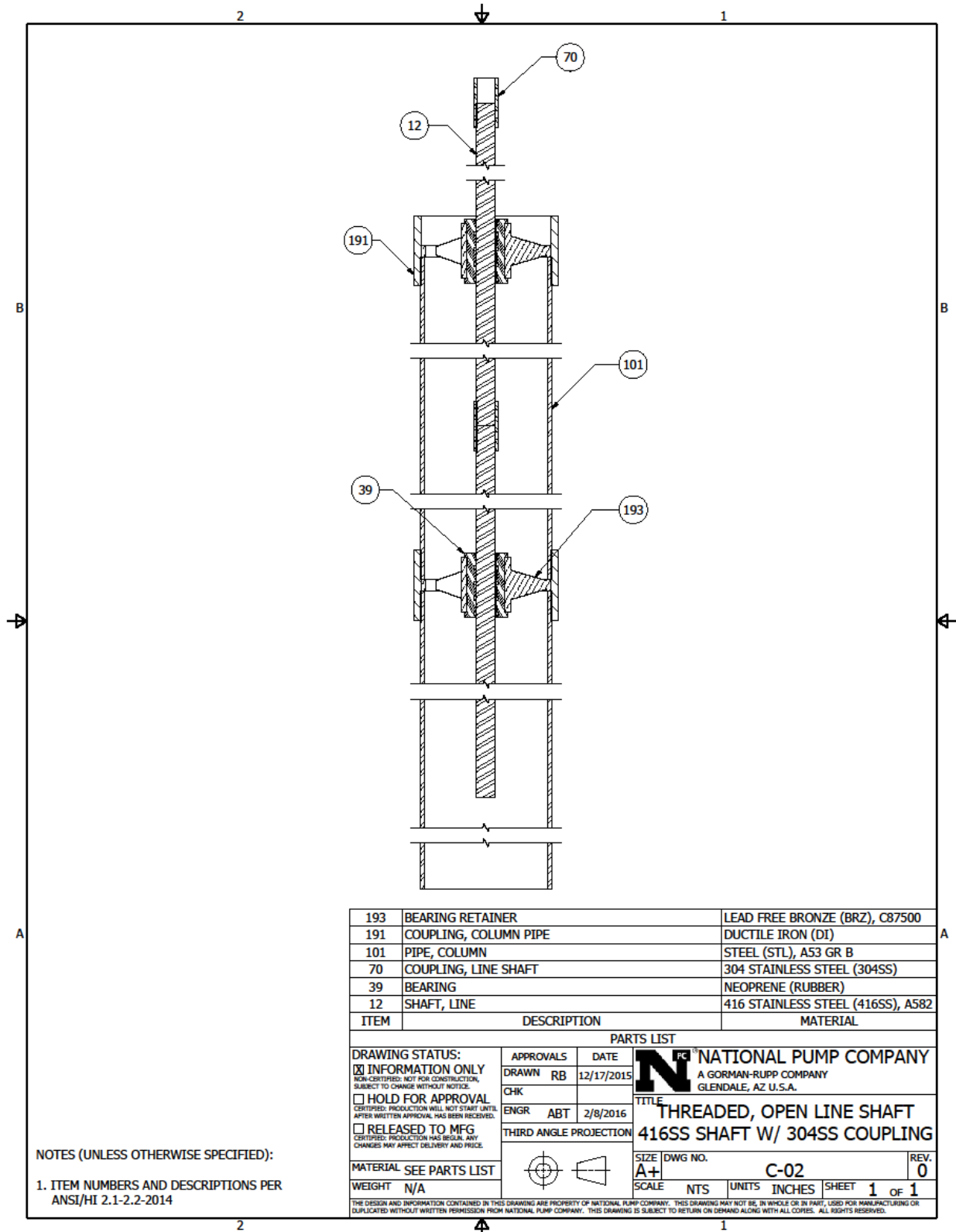


Figure C-02 – Column Assy: Threaded, Open Line Shaft, 416SS Shaft with 304SS Shaft Coupling

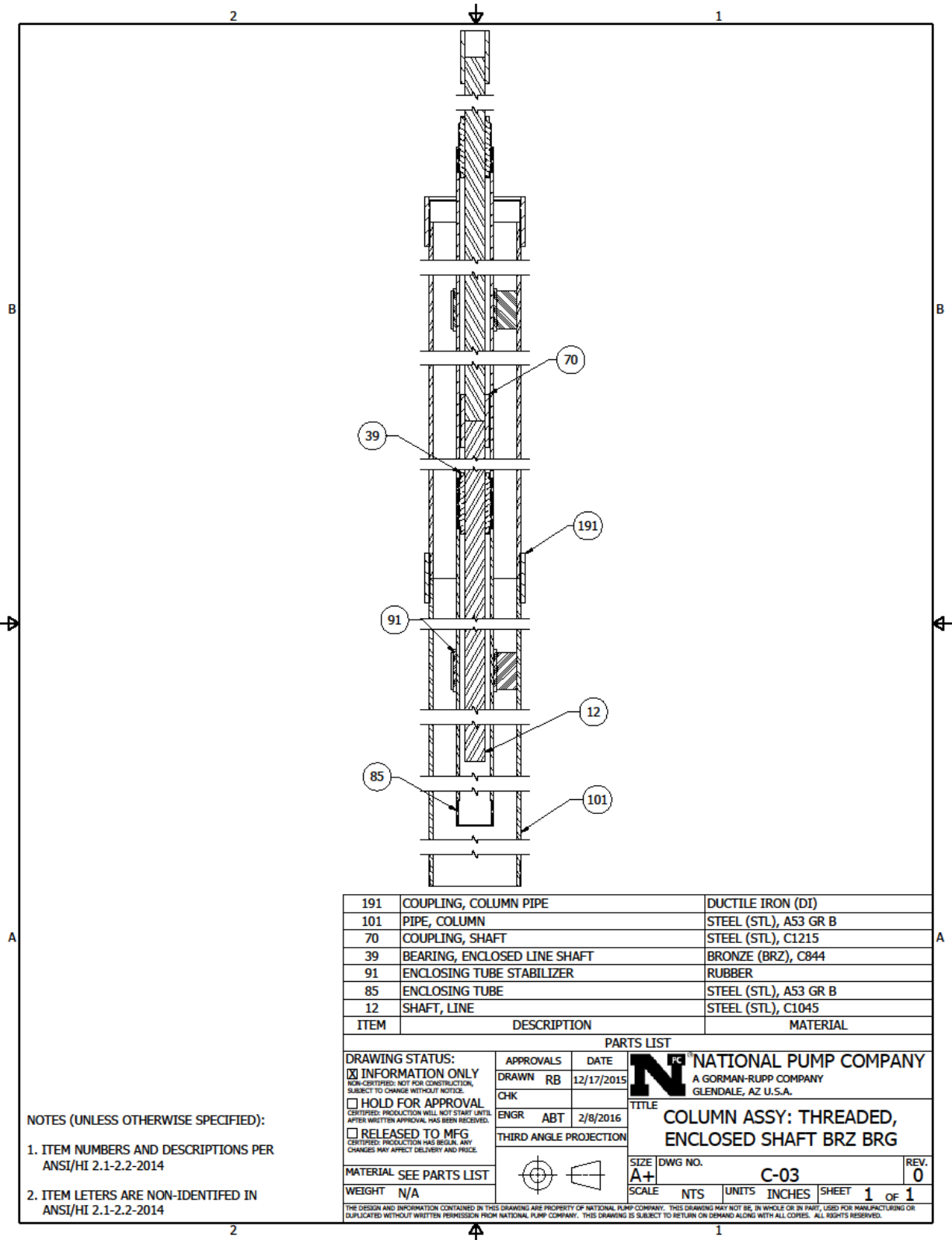


Figure C-03 – Column Assy: Threaded, Enclosed Line Shaft, Bronze Lined

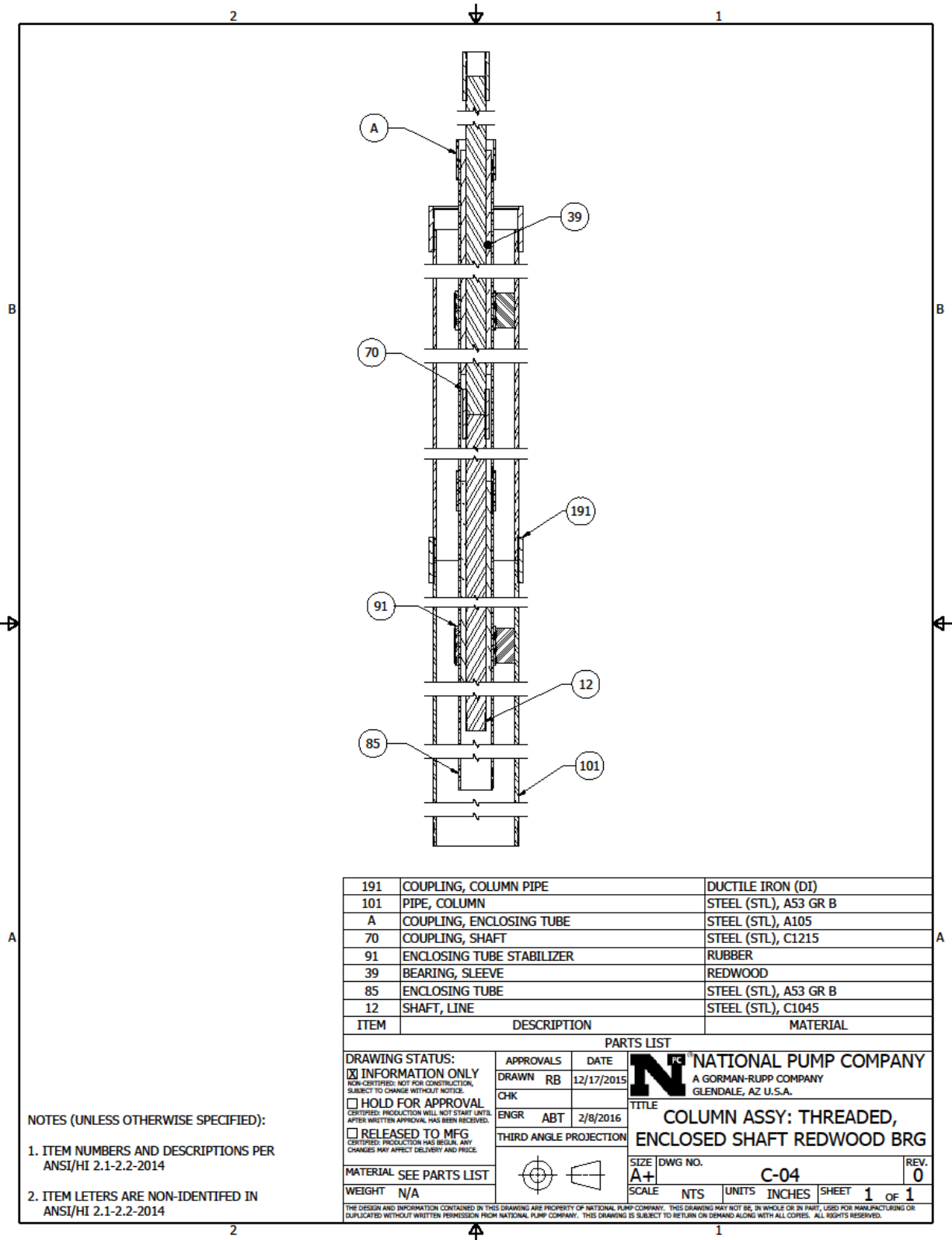


Figure C-04 – Column Assy: Threaded, Enclosed Line Shaft, Redwood Lined

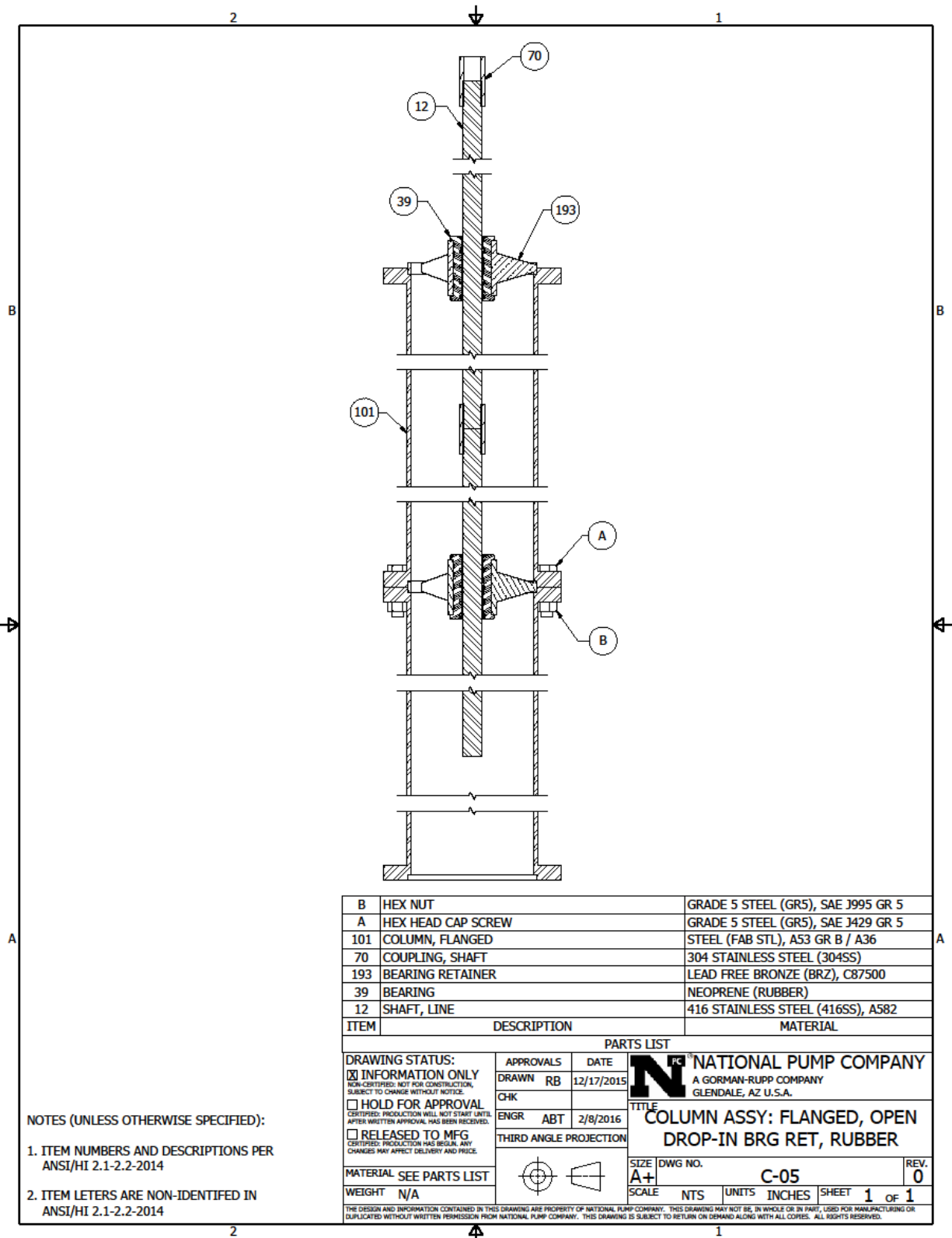


Figure C-05 – Column Assy: Flanged, Open Line Shaft, Drop-In Bearing Retainer

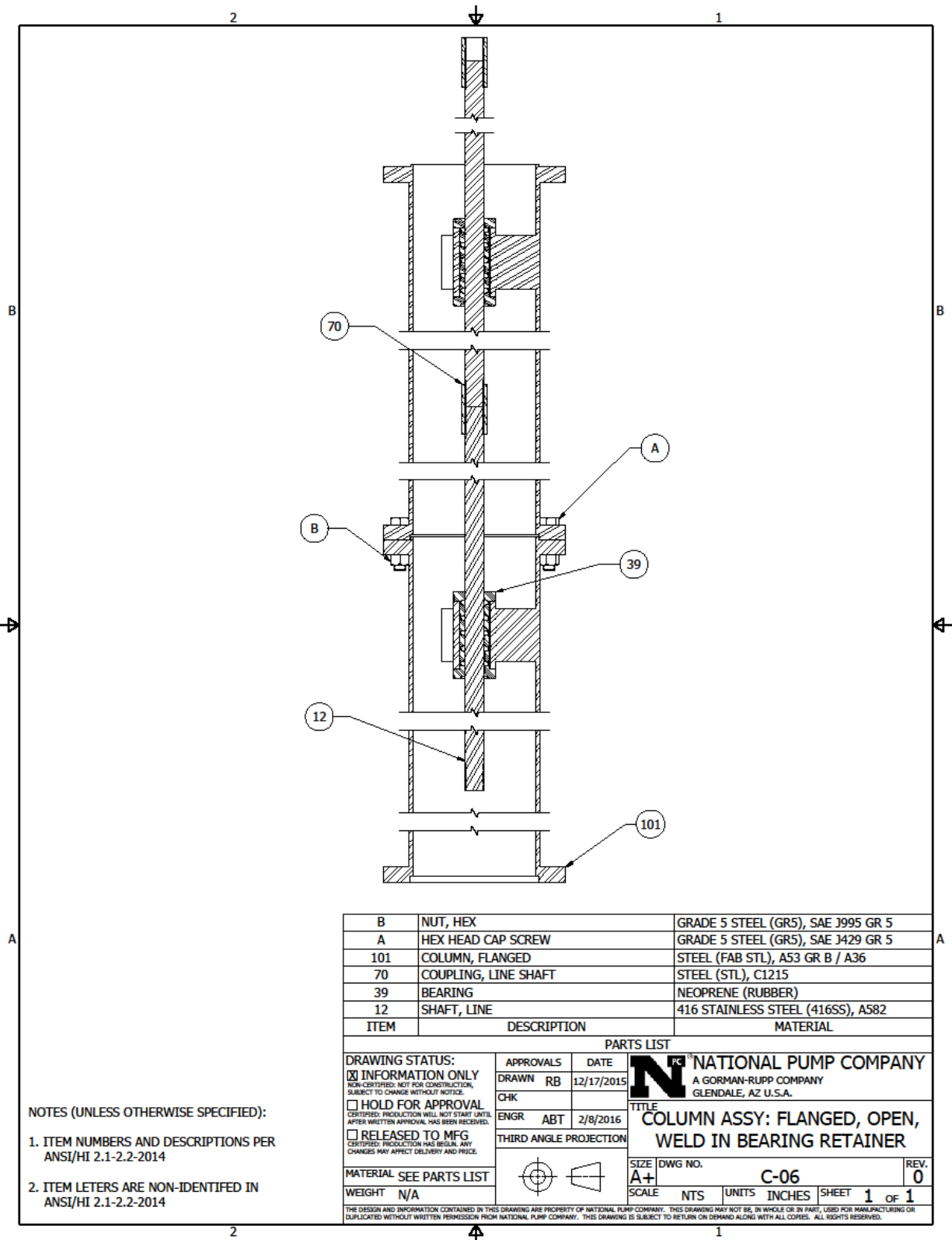


Figure C-06 – Column Assy: Flanged, Open Line Shaft, Weld-In Bearing Retainer

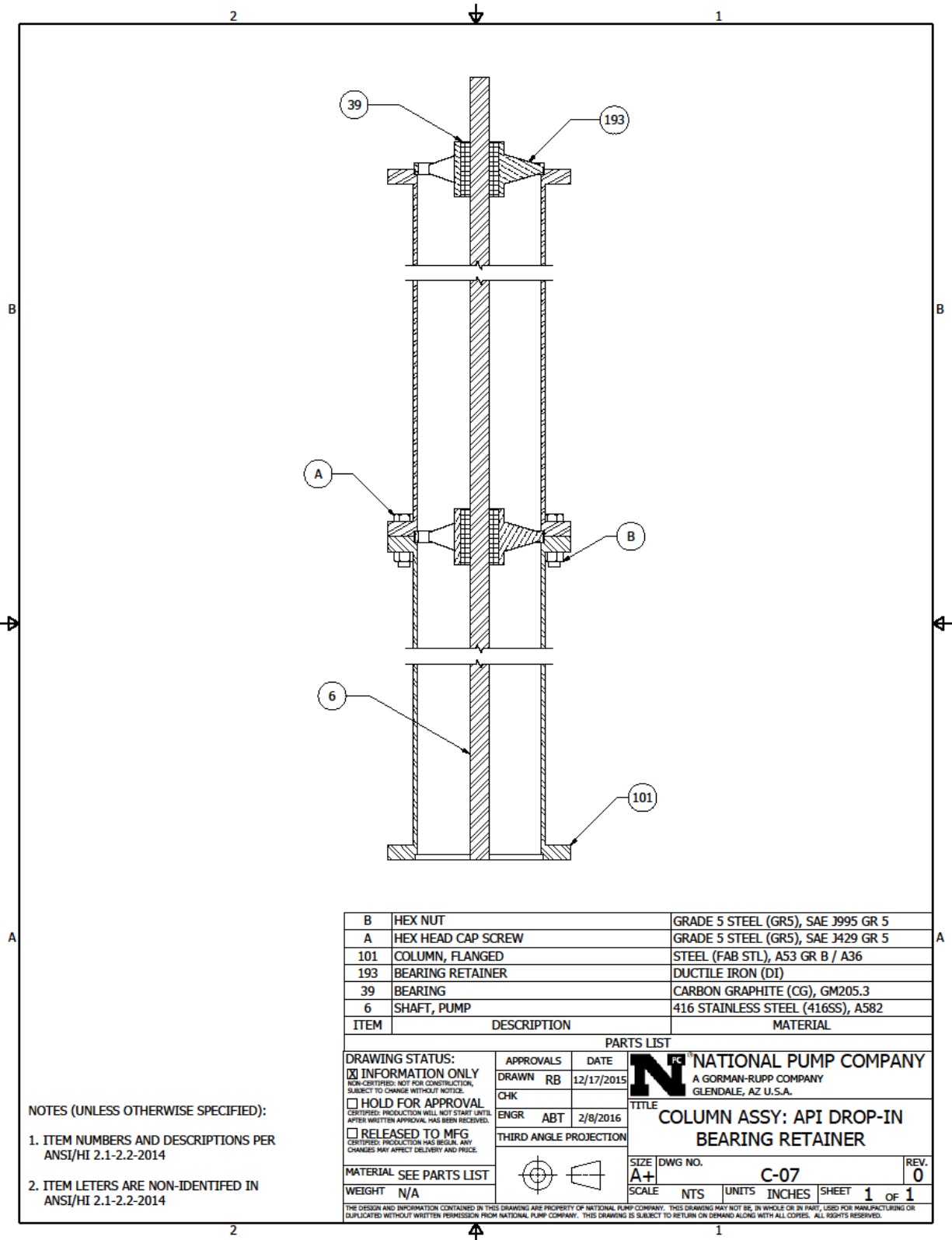


Figure C-07 – Column Assy: API Drop-In Bearing Retainer

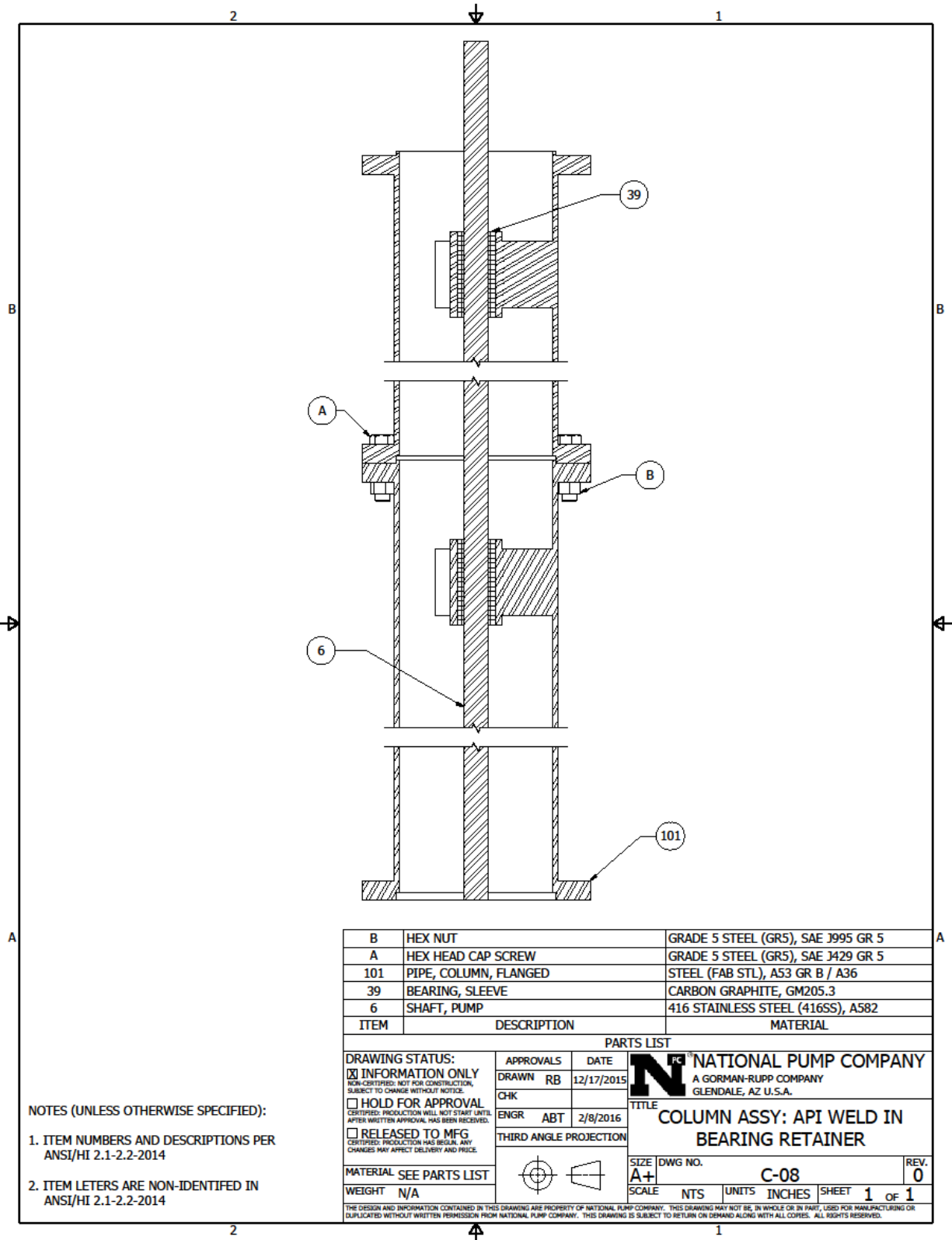


Figure C-08 – Column Assy: API Weld-In Bearing Retainer

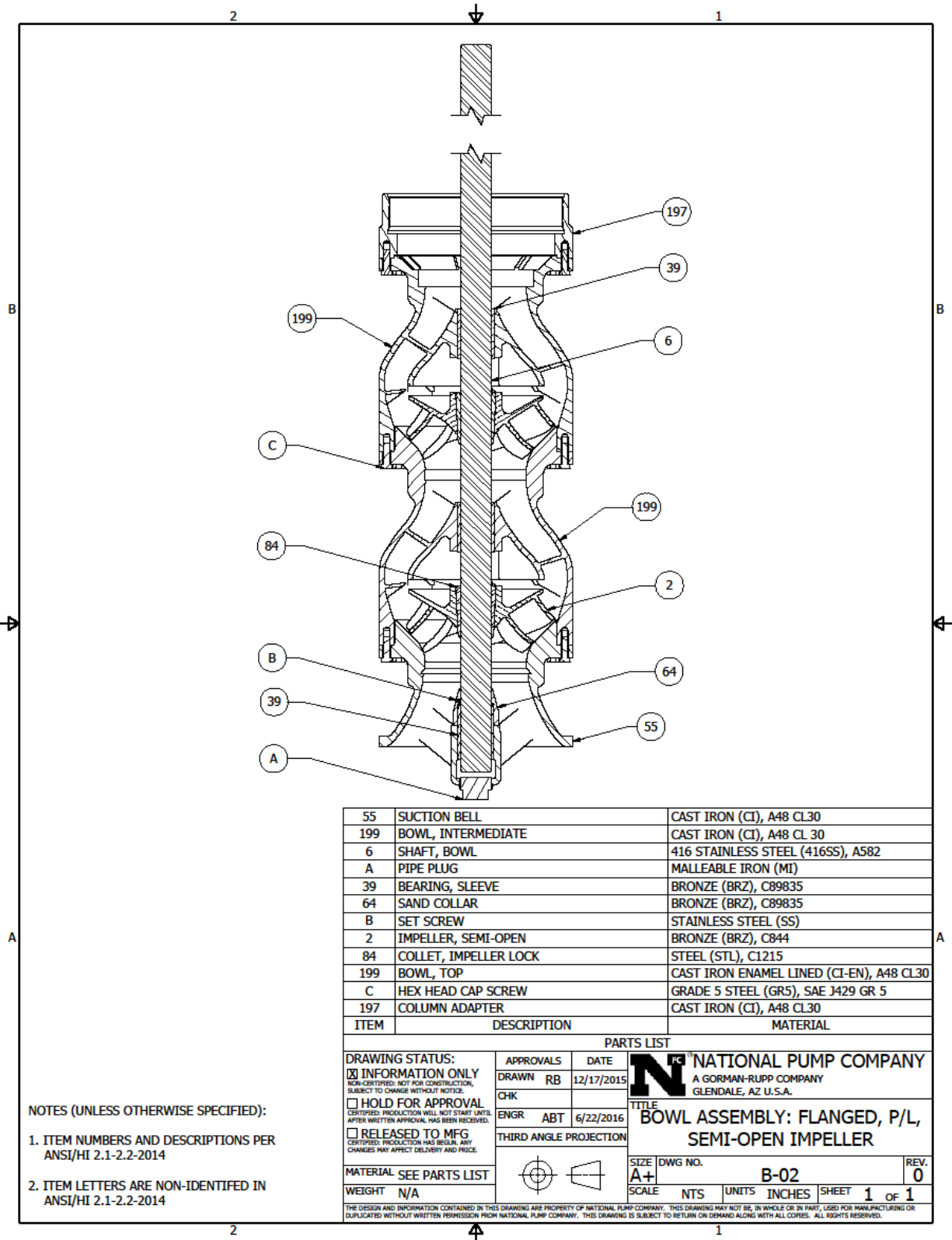


Figure B-02 – Bowl Assy: Flanged, Product Lubricated, Semi-Open Impellers

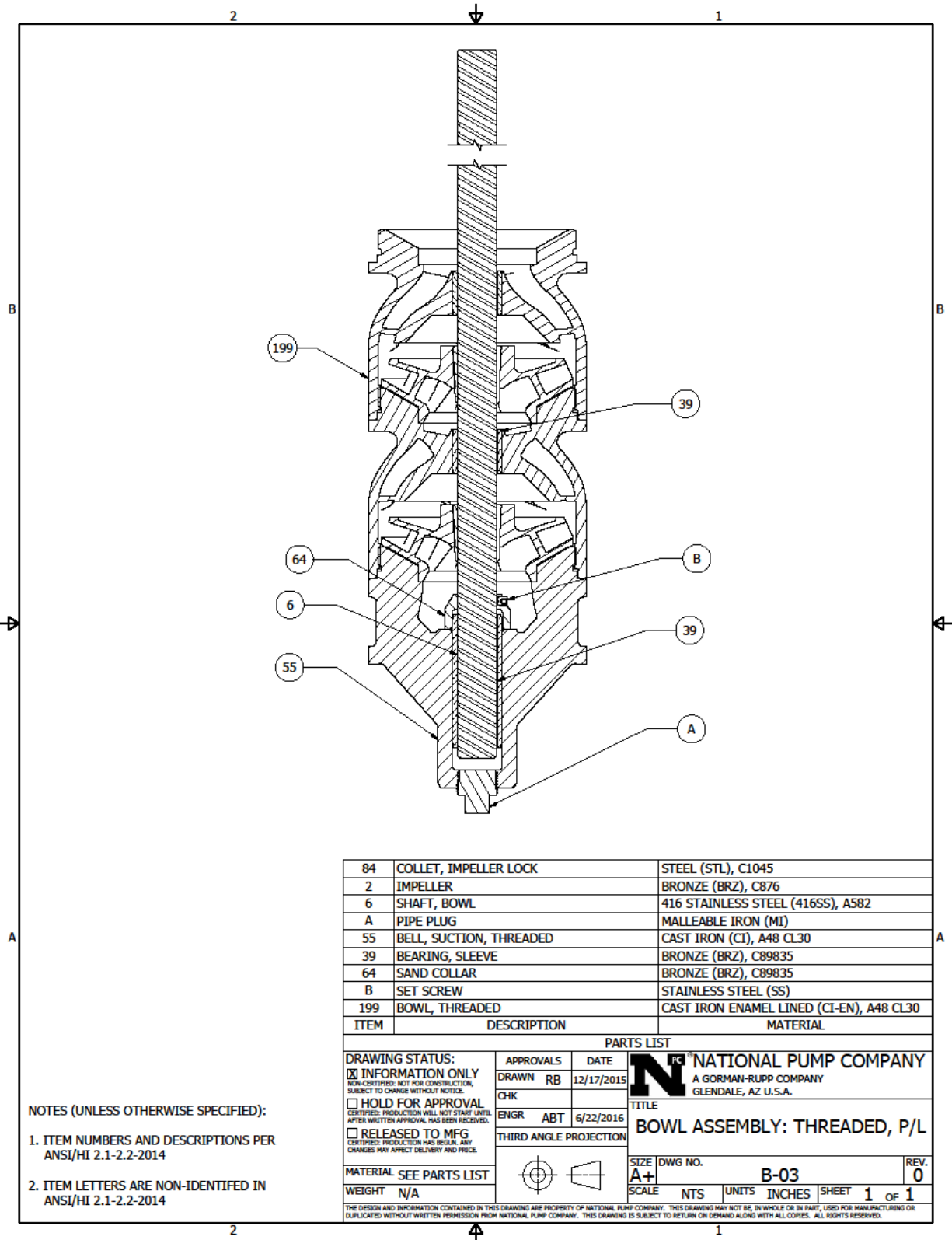


Figure B-03 – Bowl Assy: Threaded, Product Lubricated

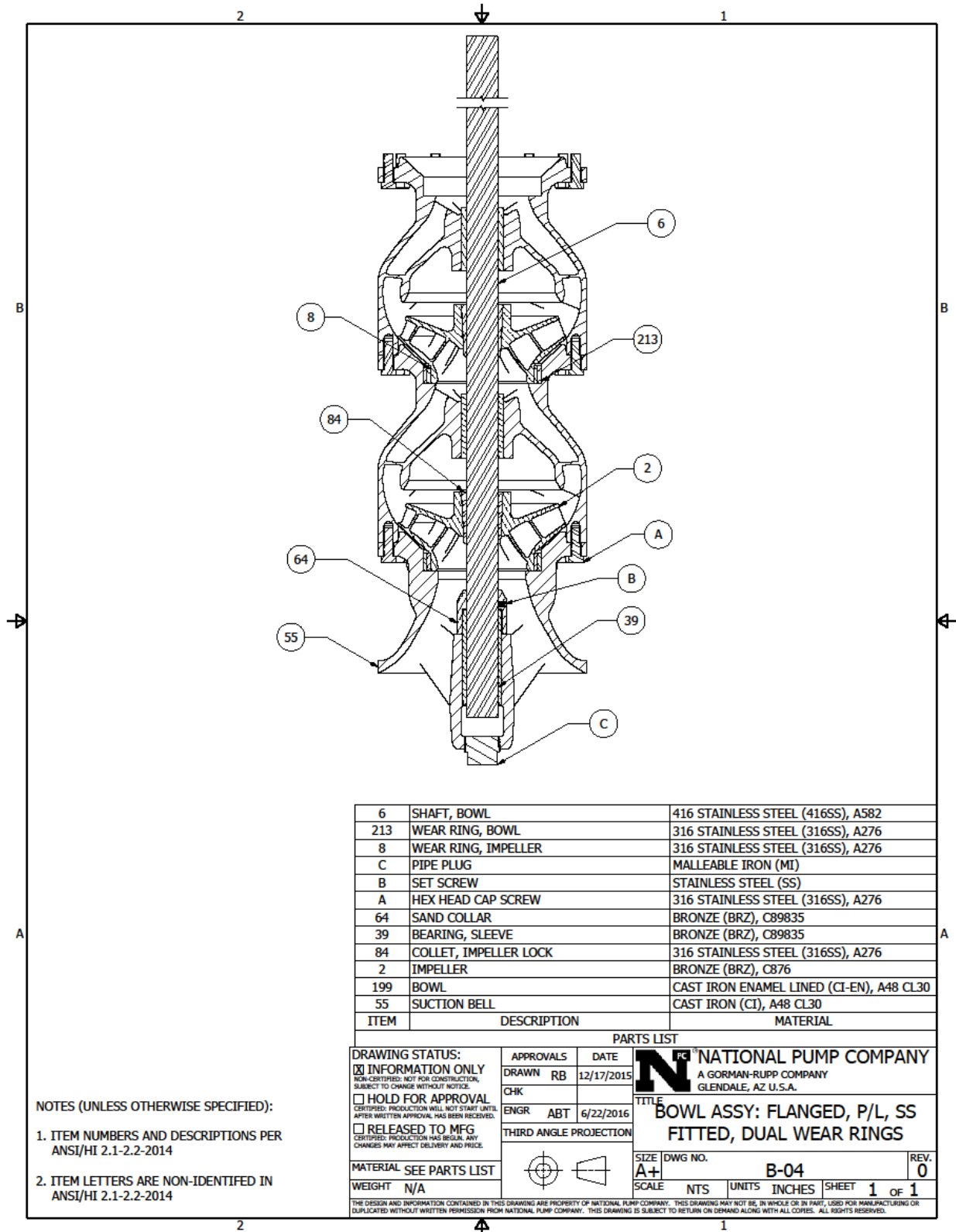


Figure B-04 – Bowl Assy: Flanged, Product Lubricated, SS Fitted, Dual Wear Rings

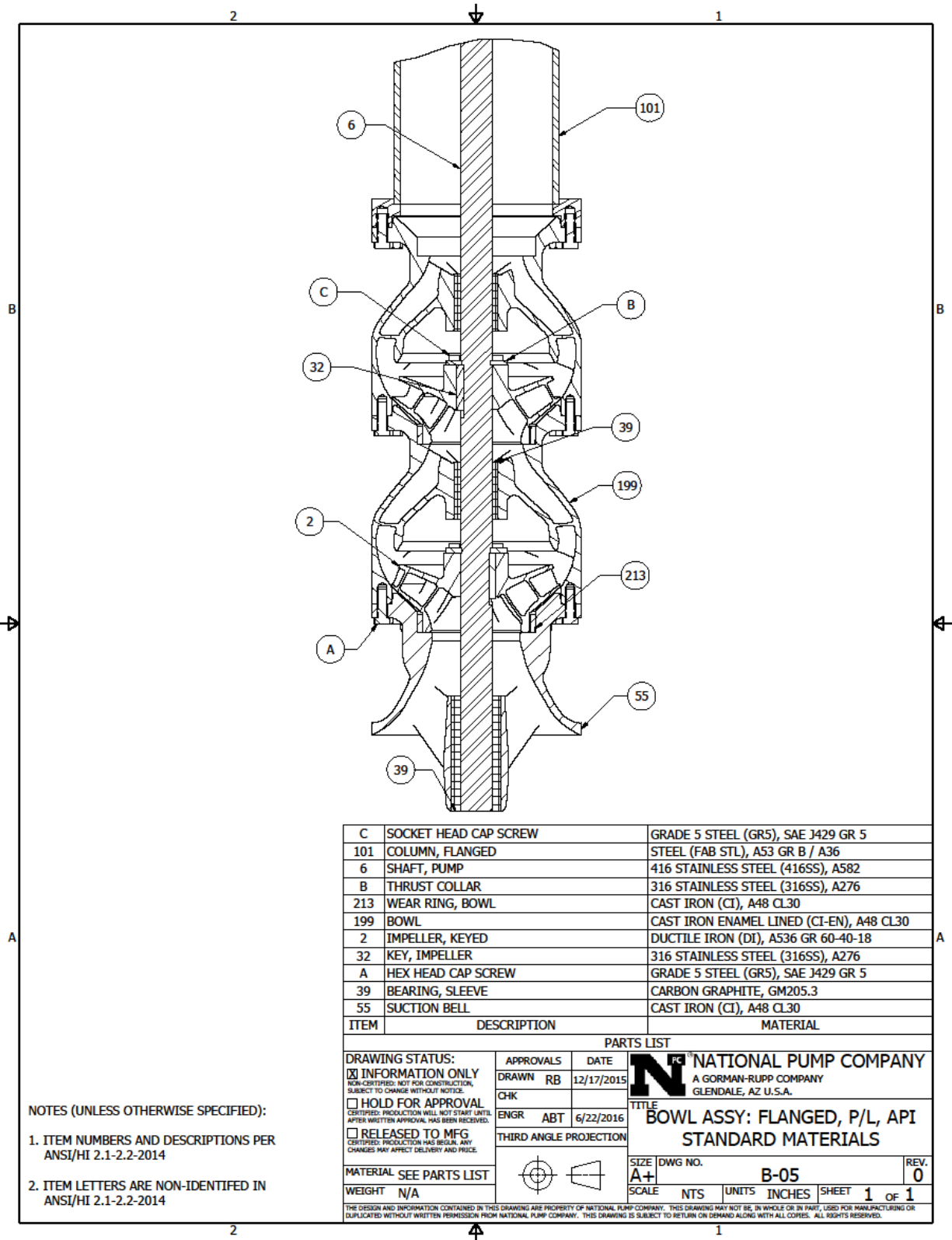


Figure B-05 – Bowl Assy: Flanged, Product Lubricated, API Standard Materials

9 Certification

National Pump Company does not mark the pumping unit in any way other than nameplate tags located on the bowl assembly and discharge head. These tags show the National Pump Company logo and information about that pump (see section 3.2.1 for more information on nameplate tags). This nametag certifies that the pump was manufactured and provided by National Pump Company and is backed by applicable manufacturer warranties and claims.

Testing and material certificates (if applicable) will be supplied to the customer in the final data book for that pumping unit, but no additional marks or certification will be placed on the pumping unit.

If any third party testing or other certification was done on the pumping unit there may be additional marking, tagging, or certification on the physical pumping unit. Contact the third party with question on certification or related marking.

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