1-800-297-3550

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EXPERT IN ENGINEERED

VACUUM SYSTEMS SINCE 1993

Performance. Reliability. Efficiency.

333 Rt 46 W

Building A,

Fairfield, NJ 07004

Operation & Maintenance Manual for NBE Series Vacuum Pumps & Compressors

WARNING

Do not operate PUMP before primed and connected to the constant supply of clean compressant Liquid. **IF RUN DRY, PUMP WILL BE DAMAGED**; always use a strainer to prevent sand and scale from entering the pump with liquid sealant.

Specific operating conditions combined with water hardness may result in excessive lime deposits inside the pump, causing it to bind. Should this condition be evident, flush the pump with a solvent at regular intervals.

This pump has been drained and flushed with water-soluble preservative oil before shipment. After the pump has been in service, do not store without draining as specified in this manual. The freezing of the preservative oil can damage the pump.

USE CAUTION when removing inlet screens. Any foreign material on the screen may fall into the pump and cause extensive damage at start-up.

The base must be mounted to a leveled foundation, and final coupling alignment is done during installation. (Refer to manual No.XXX, Installation Instructions, N.E.S. Company Vacuum Pumps and Compressors.)

NOTICE

SERVICE AND PARTS

SERVICE AND PARTS FOR NES VACUUM PUMPS ARE ASSURED THROUGH A WORLDWIDE NETWORK OF SALES AND SERVICE OFFICES LISTED ON THE BACK COVER OF THIS MANUAL. ANY REQUEST FOR INFORMATION, SERVICE, AND PARTS SHOULD BE DIRECTED TO THE NEAREST NES SITE / FIELD OFFICE.

WHEN ORDERING REPLACEMENT AND SPARE PARTS, SERIAL NUMBERS AND PUMP SIZES

MUST BE PROVIDED.
Serial number and pump size are located on nameplates riveted/fastened to the pump's casing/body. Parts must be identified by index number and name. Refer to pump exploded view and legend found in this manual.

If the location of the nearest office is unknown, information may be secured directly from N.E.S. Company Inc. New Jersey Head Quarters: 333 RT 46 W, BLDG: A, FAIRFIELD NJ 07004. Telephone number is 1-800-297-3550, Fax No. 973-933-6322

WARRANTY

NES Company warrants that (1) the goods will be of the kind described on its acceptance of Buyer's order as modified by any subsequent mutual agreement of the parties, (2) it will convey to Buyer good title to such goods, (3) such goods will be delivered free of any lawful security interest or lien or encumbrances unknown to Buyer, and (4) such goods will be of merchantable quality and free from defects in material or workmanship defects under normal use and prescribed maintenance for a period of two (2) years from the date of shipment. The warranties specified shall also extend to goods manufactured by others and supplied by N.E.S., unless such goods have been separately stated and quoted by N.E.S., in which case only the warranties in clauses (1), (2) and (3) shall apply. NES MAKES NO WARRANTY, EXPRESS OR IMPLIED, AS TO THE MERCHANTABILITY OF GOODS MANUFACTURED BY ITS SUPPLIERS AND SEPARATELY STATED AND QUOTED HEREIN. N.E.S.'s warranty in clause (4) above shall not apply to goods of standard construction when handling corrosive gases of using corrosive liquid compressant nor will clause (4) apply to goods which have been damaged, altered, or negligently maintained after delivery. Buyer's exclusive remedy for N.E.S.'s breach of the warranties outlined in clauses (1), (2) and (3) above shall be the replacement by N.E.S. of non-conforming goods with conforming goods, without extra cost to Buyer, F.O.B. point of manufacture, with transportation prepaid to U.S. destination or domestic port, and Buyer's exclusive remedy for N.E.S.'s breach of the warranty contained in clause (4) above shall be the repair by N.E.S. without charge, or the furnishing by N.E.S. F.O.B. point of manufacture, with transportation prepaid to U.S. destination or domestic port of a part or item of equipment to replace any part or item of equipment which is proved to have been defective; provided that (1) Buyer shall have notified N.E.S. of any such breach not later than ten days after the expiration of two (2) years from the date of shipment of the goods, and that (2) N.E.S. shall have the option of requiring the return of any defective material transportation prepaid to establish a claim. N.E.S. shall in no event be liable for the Buyer’s manufacturing costs, lost profits, goodwill, expenses, or any other consequential or incidental damages resulting from a breach by N.E.S. of any warranty. THERE ARE NO OTHER WARRANTIES, EXPRESS OR IMPLIED, WHICH EXTENDED BEYOND THE WARRANTIES SET FORTH HEREIN

Manual Index

List of Sections

Section 1. Safety Precautions

1.1 Safety Precautions:

1. Wear appropriate personal protective equipment, including safety glasses, lab coats, long pants, closed-toe shoes, and gloves, when working with vacuum pumps.
2. Store vacuum pumps on spill trays to prevent oil spills and ensure proper containment.
3. Insulate running areas of the vacuum pump for noise reduction, if necessary.
4. Dispose of used vacuum pump oils according to prevailing EH&S (Environmental Health and Safety) procedures.

Safety During Operation:

During continuous Operation of the pump, observe the following safety precautions:

1. Ensure electrical cables/cords and power switches are in good condition and free from defects or loose connections.
2. Keep belt guards in place to prevent hands or loose clothing from getting caught in the belt pulley.
3. Avoid operating pumps near containers of flammable chemicals, flammable chemical wastes, or combustible materials such as paper or cardboard.
4. Use appropriate vacuum tubing with thick walls, avoiding thin Tygon-type hoses.
5. Avoid placing pumps in enclosed, unventilated cabinets to prevent heat buildup and exhaust accumulation.
6. Replace old tubing that has become crumbly to maintain optimal performance.
7. Use the shortest length of tubing necessary to reach the desired location.
8. Avoid using solvents that may damage the pump.
9. Always close the valve between the vacuum vessel and the pump before shutting off the pump to prevent vacuum oil from being drawn into the system.
10. Place a pan under the pumps to catch and collect oil drips.
11. Regularly check oil levels and change the oil as needed. Properly dispose of vacuum pump oil contaminated with condensate following EH&S procedures.
12. For oil-filled pumps with total recirculation service, be aware that many vapors can condense in the pump oil. Use cold traps or other appropriate methods to trap evaporated materials and ensure proper venting of the pump exhaust.

Safety During Service:

Before performing maintenance or service on a vacuum pump or compressor, adhere to the following safety precautions:

1. Stop the pump. Ensure all power switches and circuit breakers are turned off. Use proper tagging to indicate "Do Not Switch On."
2. Equalize the pump pressure with atmospheric pressure by passing air into or out of the piping.
3. Empty or clear the service liquid from the pump before opening it.
4. If the pump has operated with harmful liquids or media, wash it thoroughly with an appropriate liquid as specified in the Material Safety Data Sheet (MSDS) of the operating fluid.
5. Maintain a record for each pump, documenting oil change dates, bearing greasing dates, shaft rotation dates, and maintenance schedules.

Please note that these rephrased instructions are provided for clarity and understanding. It is important to follow the specific safety guidelines and procedures recommended by your organization and NES Company Inc.

Section 2: About the Manual

The following document provides set-up instructions, Operation, and maintenance information for your NES NBE series of vacuum pumps. Please read the complete document carefully before operating your pump. If you need further assistance in understanding the details in this document or the pumps, please call

NES Company Inc. at 1-800-297-3550 or email at info@nescompany.com

When contacting NES Company Inc., please be ready with the following information:

1. A reference number to locate your pump in NES Company Inc.'s system.
2. The nature of the process in which the pump is used.
3. The steps taken so far in the installation and set-up of the vacuum pump.
4. Please ensure that the manual has been completely read by all the people involved in operating the pump.

Section 3: How the N.E.S. NBE pump works

3.1 Principle of Operation

The NES NBE series pumps are single-stage liquid ring vacuum pumps which rely on the rotation of an impeller to create a liquid ring seal within the pump chamber, which enables the pumps to create a vacuum. Initially, the pump is filled with a sealing fluid, typically water or another compatible liquid, which acts as both a sealant and a compressing medium. The impeller is mounted on a rotating shaft driven by an external motor, starts to rotate within the pump chamber generating a centrifugal force which impeller pushes the sealing fluid towards the outer periphery of the pump chamber forming a concentric liquid ring. As the impeller continues to rotate towards the discharge port, the space between the impeller blades gradually decreases due to the presence of the sealing fluid. This compression action causes the gas to be compressed against the sealing fluid, and the resulting gas-fluid mixture is discharged through the discharge port. The sealing fluid plays a crucial role in the Operation of the NES NBE Series pumps, ensuring effective sealing, gas compression, heat dissipation, and contaminant removal. The fig. 1 shows a typical NBE series liquid ring vacuum pump.

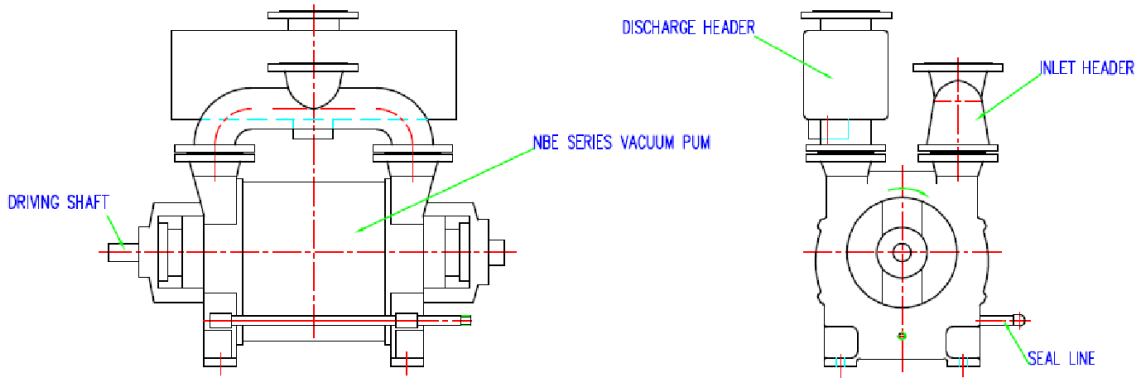


Fig. 1. NBE Series Liquid Ring Vacuum Pump

3.2 Operational parameters

The NES NBE series of liquid ring vacuum pumps comprise of the sizes ranging from NBE1-152 to NBE4-7000. The increasing number indicates increasing suction capacity. The single stage NBE series vacuum pumps are designed to operate with dry and moist gases with inlet temperature min. 32 °F and max. 176 °F, inlet pressure up to 28" Hg. Some pumps in this series operate to 23" Hg. For more details, please refer to the NES NBE Series Data Sheet, pump drawings, and performance curves.

Section 4: Installation

4.1 Uncrating, lifting, and moving instructions:

After the pump is received, it is important to ensure compliance with the listed items on the packing slip. If there is any visible damage, such as dents or scratches, immediate notification should be made to the freight carrier and NES Company Inc. It is important to note that NES does not take responsibility for damage that occurs during transit and such damage will not be covered under warranty.

Follow the instructions below when uncrating the pump.

1. Gently remove the crate lid and packaging material.

2. Dispose of the packaging material properly to avoid any personnel injuries caused by sharp nails or pointed objects.

3. Obtain information on the total weight, maximum outside dimensions, and location of lifting points. If this information is not available, contact NES Company Inc.

4. When lifting and moving the pump or pump assembly, ensure it remains horizontal to the ground.

5. Avoid exerting pressure on the seal water piping, valves, and other delicate components in the system with the lifting ropes.

4.2 Piping requirements:

Please confirm that the piping matches the system drawings provided by NES Company Inc. Also, check that the pipe sizes and configuration match the connection sizes on the pump/system. At the discharge, ensure that there is no back pressure on the pump by piping it horizontally into a separator/silencer. NES Company Inc. suggests incorporating valves and gauges on the sealing fluid piping and inlet piping. If possible, link the pump drain connection to the main discharge drain line and install a gate valve. Ensure the valve remains closed during Operation and open it when the pump is turned off to facilitate the flow of seal water out of the pump.

4.3 Electrical requirements:

Always refer to the motor nameplate to confirm the motor horsepower and voltage, ensuring it matches the electrical power source. Consult the relevant data sheet for the wiring specifications of process valves and actuators installed in the system.

Section 5: Operations

5.1 Preparation for Initial Start-Up

When commissioning the machine, especially after a drain or when it is dry, the following steps should be followed:

5.1.1 Initial Technical Status:

1. Please ensure all lines for pumped gases/vapors are correctly connected.

2. Close all shut-off fittings and avoid installing shut-off or non-return fittings on the discharge side.

3. It is necessary to drain the preservative liquid from the machine and its disposal according to applicable regulations.

5.1.2 Operating liquid:

Appropriate volume of the operating liquid must be poured and adjusted as specified in Section 5.3. This is followed by opening the shut-off valve for the operating Liquid. Depending on the size of the machine, this can be done approximately 5 to 15 minutes before the start-up. The machine's working area should be filled up to the point of overflow on the

discharge connection or the welding neck flange (if available for partial draining) on the discharge side. It is essential to ensure that the operating liquid level in the machine's working space does not exceed the shaft center during start-up.

WARNING!

Improper usage of the machine can lead to severe or even fatal injuries!

It is essential to carefully read and adhere to the safety precautions outlined in section 1. Failure to do so will prohibit any work with or on the machine.

Risk of injury from rotating parts (impeller, shaft):

There is a danger of limb amputation, entanglement of hair and clothing. Exercise caution!

Risk from gauge pressure and vacuum:

There is a risk of sudden fluid escape causing skin and eye injuries and entanglement of hair and clothing. Be cautious!

Risk from escaping fluid:

There is a risk of burns, scalding, slipping, and falling. Take precautions!

Commissioning and Operation should only be conducted under the following conditions: • All lines and fittings must be properly mounted on the connections in the end shield. Keep unused connections sealed with provided sealing devices (plugs, covers). • Ensure the machine is fully assembled. • Verify the motor rotation direction. • The operating liquid level should be up to the middle of the shaft, with the operating liquid supply connected and checked. • The housing should not be overfilled. • Check the fill level in the pump housing before starting. • Verify the condition of armatures and regulating devices on the suction and discharge sides. • Ensure suitable environmental conditions. • Check and align the drive elements (coupling, belt drives). • Align and ground the machine. • Close unused connections with blind flanges. • Keep inspection covers on the end shields closed.

WARNING!

Danger from gauge pressure and vacuum: The machine poses a significant risk of bursting parts, sudden fluid escape (resulting in skin and eye injuries), and entanglement of hair and clothing when subjected to excessively high pressures. Extreme caution is required!

The machine must not be operated with a blocked inlet or discharge side!

Before initiating Operation, ensure the following precautions: • Remove any closures from the inlet and discharge connections. • Ensure all pipes are properly connected. • Ensure that shut-off devices (e.g., valves, gate valves, etc.) in the lines are open. • Prevent the connections and lines from clogging with deposits or solid materials. • When handling fluids containing solid materials, connect suitable screens or filters upstream of the machine. • Be aware that air saturated with water vapor, containing droplets, emerging from the pressure side can cause icing and create a slip hazard during winter. • Take into consideration that air saturated with water vapor, containing droplets, emerging through the roof can cause icing, leading to additional roof loads and associated risks.

5.1.3 Shaft Seal:

For commissioning new machines with stuffing boxes having internal liquid supply, the stuffing boxes are usually adjusted during the factory test run. However, during commissioning, tightening of stuffing box packing by tightening each stuffing box gland by one screw rotation may be required. For restarting machines that were previously operated, the stuffing boxes should be readjusted. For stuffing boxes with external liquid supply, open the shut-off valve for the sealing liquid to moisten the stuffing box packing. These steps ensure a proper commissioning process for the machine. Please refer to Table 1 for types of mechanical shaft seals required for different NBE pump models.

For different types of mechanical seals and their respective sealant supplies, the following steps should be taken during commissioning:

1. Single-Acting Mechanical Seal with Internal Sealant Supply:

Before starting the pump confirm that the interior of the machine is filled with operating Liquid approximately up to the shaft center. This prohibits the mechanical seal from running dry.

2. Single-Acting Mechanical Seal with External Sealant Supply:

Shortly before starting the machine opens the shut-off fitting for the sealing liquid. This prevents drying of mechanical seal and maintains the liquid level in the machine at an appropriate level.

3. Double-Acting Mechanical Seal:

Just before starting the machine, open the shut-off valve for the sealing liquid. This will stop the mechanical seal from running dry.

4. Adjustment of Volumetric Flow or Feed Pressure of Flushing/Sealing Liquid:

Use a volume flow meter or a pressure gauge to check and adjust the values of the flushing or sealing liquid. This ensures that the desired volumetric flow or feed pressure is maintained.

It is important to carefully follow the specific instructions provided by the manufacturer for the mechanical seal and sealant supply configuration of your machine. These steps help prevent the mechanical seal from running dry, ensuring its proper functioning and longevity.

Type	Shaft Seals
NBE3/4... - ... 3	Stuffing box with external liquid feed (external sealant supply)
NBE3/4... - ... 4	Stuffing box with external liquid wetting (standard)
NBE3/4... - ... 5...9	Mechanical seals

Table 1: Types of mechanical shaft seals

5.2 Liquid Compressant (Seal Water)

The operating Liquid, often referred to as the sealing Liquid or liquid compressant, plays a crucial role in the operation of liquid ring machines like vacuum pumps and compressors. It helps create a liquid ring within the housing, which acts as a seal between the impeller and the housing, preventing direct contact between the gas being handled and the impeller. The sealing fluid is typically fresh water at a temperature of 60F. Refer to table 2. below for seal water flow rate information. Alternatively, other fluids such as diesel, mineral oil, and methanol can be used as sealing fluid depending on the process requirements and availability. When using a discharge separator, it is important to ensure that the seal fluid level always remains below the centerline of the pump during Operation. This prevents any back pressure caused by the discharged seal fluid.

WARNING!

When working with hazardous gases or operating liquids, it is imperative to prevent any unintended escape of gases or operating fluids in the event of an unforeseen reduction in seal function. This can be achieved by employing appropriate shaft sealing methods, such as mechanical seals with external supply, to ensure the integrity of the system.

CAUTION!

Risk of machine damage from escaping liquid spray!

When the feed pressure exceeds 4.35 psi above the discharge pressure, there is a high possibility of liquid spray escaping. It is crucial to ensure that the feed pressure of the sealing liquid does not exceed 0.3 bar [4.35 psi] above the discharge pressure!

Failure to properly operate the machine with sealing liquid can result in the rapid destruction of the mechanical seal!

DO NOT start the machine if the seal area is not filled with sealing Liquid, not even for a moment (e.g., to check the rotating direction)!

If necessary, ensure the sealing space is properly bled!

Incorrect feed pressure of the flushing/sealing liquid can cause faults and damage!

Due to low feed pressure:

The seal area may not receive an adequate amount of sealing liquid.

The mechanical seal may be damaged.

If the feed pressure is too high, then excessive wear on the mechanical seal will occur.

Always ensure that the feed pressure of the flushing/sealing liquid is properly adjusted to avoid these issues!

Vacuum pump:
Volumetric flow of operating Liquid in GPM dependent on inlet pressure in PSIA (in HgA) (tolerance approx. ± 10 %)

Type NBE3/4 ...	30.	32.	40.	42.	50.	52.	60.	62.	67.	72.
2.9 (5.9)	23	30	41	56	77	93	106	130	152	182
3.63 (7.4)	24	31	43	58	78	95	109	133	156	186
4.35 (8.9)	25	31	44	60	81	98	112	136	160	192
5.8 (11.8)	23	29	40	54	73	89	101	123	145	174
7.25 (14.8)	19	25	35	47	63	78	89	108	126	151
8.7 (17.7)	16	21	29	40	53	65	75	90	106	127
10.15 (20.7)	13	17	23	32	44	53	60	74	87	104
11.6 (23.6)	11	13	19	26	34	42	48	58	68	82

Compressor:
Volumetric flow of operating Liquid in GPM dependent on compression pressure in PSIG (tolerance approx. ± 10 %)

Type 2 NBE3/4 ...	30.	32.	40.	42.	50.	52.	60.	62.	67.	72.
2.7 PSIG	24	26	26	26	26	26	26	26	26	26
5.6 PSIG	31	35	44	52	55	63	66	77	88	97
8.5 PSIG	40	47	59	74	85	99	110	128	145	172
11.4 PSIG	50	57	75	99	114	134	150	126	211	247
14.3 PSIG	62	69	92	121	143	170	194	229	269	317
17.2 PSIG	71	79	108	145	171	204	233	273	326	392
20.1 PSIG	82	90	125	--	200	--	277	--	--	--
23.0 PSIG	--	--	141	--	229	--	319	--	--	--

Table 2: Operating Liquid Flow rate

5.2.1 Function of Liquid Compressant

The liquid compressant in a liquid ring machine, such as vacuum pumps, performs several important tasks. Here are the key functions of the operating Liquid:

1. Formation of the liquid ring: The primary function of the operating liquid is to form a liquid ring within the housing of the machine. This liquid ring is crucial to the principle of Operation of the machine. It serves as a rotating seal, creating a barrier between the impeller and the housing, and facilitating the compression of gases or the creation of a vacuum.

2. Sealing off the gap: The operating liquid acts as a sealing agent between the impeller and the port plate or housing. It fills the gap between these components, preventing direct contact between the gas being handled and the impeller. This sealing action helps maintain the efficiency and performance of the machine by minimizing gas leakage and optimizing compression or vacuum generation.

3. Cooling: Another important task of the operating liquid is to provide cooling for the machine. During Operation, the compression of gases or the creation of a vacuum can generate heat. The operating Liquid helps absorb and dissipate this heat, preventing overheating of the machine. Efficient cooling ensures the longevity of the components and contributes to the overall performance and reliability of the system.

4. Shaft seal: The operating liquid also acts as a seal for the shaft of the machine. It helps prevent any gas leakage along the shaft, ensuring that the gases being handled are contained within the system. By providing an effective shaft seal, the operating Liquid helps maintain the desired pressure differentials and prevents the loss of gases or vapors.

These tasks collectively contribute to the efficient and reliable Operation of the liquid ring machine. The operating liquid plays a critical role in maintaining proper sealing, cooling the system, and ensuring the effective functioning of the shaft seal, all of which are vital for optimal performance and longevity of the machine.

5.2.2 Characteristics of Liquid Compressant

The properties of the operating liquid in a liquid ring machine are important for ensuring its safe and efficient Operation. Here are some key properties and considerations:

1. Non-flammable, non-explosive, non-aggressive, and non-toxic: The operating liquid should be chosen to avoid any risks of fire, explosion, or harm to personnel. It should not have aggressive or corrosive properties that could damage the machine or pose safety hazards. Additionally, the operating liquid should be non-toxic to prevent any health risks.

2. Water as a common choice: Water is commonly used as an operating liquid due to its availability, low cost, and suitable properties for many applications. It is non-flammable, non-toxic, and generally non-aggressive. However, water quality and impurities should be considered.

3. Filtration to remove impurities: To maintain the proper functioning of the liquid ring machine, suitable filters or sieves should be installed upstream of the machine to remove impurities. This helps prevent the entry of abrasive or erosive substances into the machine, which could damage the components or reduce efficiency.

4. Maximum permissible dissolved solid quantity: It is recommended to limit the amount of dissolved solids in the operating Liquid. A maximum permissible dissolved solid quantity of 200 parts per million (ppm) is often used as a guideline. Excessive dissolved solids can lead to scaling, fouling, and reduced performance.

5. Managing calcium content and lime deposits: If the operating liquid has a high calcium content, there is a

risk of lime deposits forming within the machine, affecting its performance. In such cases, appropriate measures should be taken, such as the addition of water softeners or the installation of an ionic accelerator. These measures help mitigate the risk of lime deposits and ensure smooth Operation.

It is essential to select an operating liquid that meets the specific requirements of the liquid ring machine and the application. Considering the properties of the operating liquid and taking necessary precautions helps maintain the machine's performance, longevity, and safety.

CAUTION!

Risk of Damage Due to Calcification

Over time, hard lime layers can develop and eventually break open, leading to potential erosion damage to components. It is crucial to implement preventive measures to continuously prevent the formation of lime deposits or perform regular removal procedures.

WARNING!

Risk of Environmental Damage

If the operating liquid used is harmful to the environment, it is crucial not to drain it off into the open. Instead, it must be circulated in a closed circuit with forced circulation to prevent any potential environmental damage.

5.2.3 Types of Liquid Compressant

There are two variants of the operating Liquid in liquid ring machines depending on the internal routing and cooling requirements:

1. Normal Cooling (Economy Circulation): This is the standard design for the machine. In normal cooling, a portion of the operating liquid that is discharged from the machine is recirculated back into the system. This recirculation helps maintain the desired operating liquid flow and temperature. The volumetric flow rate of the operating liquid corresponds to the values specified in the machine's specifications.

2. Increased Cooling (Refrigeration Circulation): This design is specific to certain vacuum pump models and is the standard design for compressors. Increased cooling is used when operating conditions are unusual, such as handling gases at high temperatures or when higher suction capabilities are required. In this case, the operating liquid is completely removed from the machine and replaced with new, cooler Liquid. The internal partial circuit is closed, and the necessary adjustments, such as mounting plugs, are made for permanent use. The volumetric flow rate of the operating liquid is doubled compared to the specifications for vacuum pumps mentioned in the specifications.

The choice between normal cooling and increased cooling depends on the specific requirements and operating conditions of the liquid ring machine. Consulting with the manufacturer or a qualified service provider can help determine the most suitable variant for a given application.

5.3 Draining and Flushing

Draining: For draining and flushing the machine, open the shut-off valve.

• Locate the shut-off valve on the drainpipe connected to the draining and flushing connection.

• Place a suitably large catch container beneath the end shields of the machine.

• Unscrew the plug to completely drain the liquid from the end shields.

After fully draining the machine:

• Close the shut-off valve for draining and flushing.

• Reinstall the plug in its original position.

• If the pump has a mechanical seal, follow the instructions provided in the mechanical seals manual to completely drain the liquid from all seal housings.
Prior to initiating the pump after installation and alignment, commence with a preliminary inspection. Remove the drain plugs from the pump and allow the seal water line to be opened, enabling water to enter the pump. It should be noted that prior to shipping, the pump undergoes flushing with a water-soluble preservative to prevent any seizing during transportation. Allow the water to flush out all traces of preservative through the drains. Subsequently, cease the supply of seal water and securely close the drains using pipe thread compounds.

CAUTION!

There is a risk of slipping and falling due to escaping Liquid. When draining the machine, it is essential to use appropriate catch containers to prevent liquid from spilling onto the floor or work area.

Flushing: Regular cleaning is recommended to remove any foreign bodies that may have accumulated in the liquid ring. This can be done by temporarily opening the valves in the drain linear unscrewing the plugs for total draining during storage periods. Refill the system with clean water for the flushing process.

Flush out dirt during running operation: If the operating liquid becomes contaminated and there is a possibility of erosive wear, it is important to pipe and connect the end shield holes, closed by plug, to an external discharge. It is recommended to use piping with adjustable valves. The amount of drained fluid in the lobe should be adjusted to ensure it does not affect performance. The drained Liquid should be compensated through the seal water supply.

Removal of lime deposits: If deposits of lime are present, the machine needs to be treated with a decalcifier as part of maintenance. The necessary intervals for decalcification depend on the lime content of the operating Liquid. It is recommended that the intervals are not less than half a year to avoid material damaged calcification occurring at a high rate, it is advisable to implement continuous treatment for the machine.

Type: Recommended options include phosphoric acid (in a solution of 15 parts acid to 17 parts water) or ethanoic acid (in a solution of 20 parts acid to 100 parts water).

Filling Amount: The filling amount should correspond to the volume of the entire machine. The specific employed method should be selected based on the resistance of the materials in the machine. Follow the safety data sheets of the chemicals used and adhere to local disposal ordinances. It is recommended to have authorized personnel from NES Service conduct the decalcification process. NES also recommends contacting Dynamic Descaler to conduct the descaling process.

WARNING!

When using compressed air for cleansing, ensure that you take appropriate protective measures such as wearing protective glasses and a protective breathing mask to safeguard against potential hazards.
When utilizing chemical cleansers, it is crucial to adhere to the warning and application instructions outlined in the corresponding safety data sheets. Additionally, ensure that the chemical agents employed are compatible with the materials and components involved.

5.4 Preliminary Inspection

Conduct the following preliminary inspections prior to initiating the pump:

WARNING!

Ensure all the following steps are performed in the specified order to ensure personal safety and equipment protection.

1. Disconnect all power sources from the driver unit to prevent accidental starting.
2. Verify that all drain plugs on the pump are properly installed.
3. Prime the pump manually with the liquid compressant until there is a flow from the overflow.
4. Examine the separator, receiver, and heat exchanger (if applicable) to confirm that all shipping plug protectors have been removed and all open connections have been properly plugged or piped.
5. Look carefully at all piping to ensure correct connections to the pump and its basic system, following the installation drawings provided by N.E.S. Ensure that all piping is of the accurate size, securely connected, and sufficiently supported.
6. Inspect the vacuum pump and drive hold-down bolts, as well as the base or soleplate foundation bolts, to ensure they are tight. Shim the base if required.
7. Check all other significant operational component connections related to the pump, following the recommendations of respective equipment manufacturers.
8. Examine all pump control components (control valves, gauges, etc.) to verify their locations according to the N.E.S. installation drawings. Ensure that these components are correctly positioned in the piping scheme to achieve proper flow and functional Operation.
9. Check the pump inlet to confirm that the inlet screen and clean-out connections are properly installed and free from tools, equipment fragments, and debris.
10. Confirm that the liquid discharge connection is clear of any obstructions.
11. Disconnect the coupling or V-belt guard and manually rotate the pump shaft in the specified direction indicated on the drive end casing of the pump. The direction of rotation is marked by an arrow on the pump body and is illustrated in the installation drawing.

Ensure the pump shaft rotates freely. If the pump shaft is stuck and cannot be freed by manual rotation, contact your N.E.S. representative for assistance.

CAUTION!

do not try to free a binding or bound pump shaft by applying power to the drive motor. Such action can result in severe damage.

never operate the pump without sufficient priming and liquid seal flow. high liquid seal supply pressures do not guarantee sufficient flow. Please verify flow rates by consulting an N.E.S. representative and ensure flow from the vacuum pump discharge (or water trap silencer).

1. By keeping the main supply valves open and the pump primed, gently bump the drive motor for the pump to verify the correct direction of shaft rotation.

WARNING!

Ensure that the coupling or V-belt drive is protected with a guard before starting the drive motor. 2-5 Start-up and operating checks.

Once the preliminary inspection and pre-operational checks have been completed, start the pump, and perform the following pump operation checks:

WARNING!

If the pump is supposed to be checked a system, it is important to inform the relevant plant personnel before putting the pump into Operation, particularly if it is the first time. starting a system without prior notice can pose a risk of personal injury.

Note: Refer to the Troubleshooting section (Section 6) if any operational difficulties arise during the following steps.

i) Verify that the pump and system have adequate priming, and then activate all main water supply sources to the pump or heat exchanger.

ii) Once the water supply sources are activated and all personnel and equipment are safely away from the pump system, turn on the drive motor.

Note: If pump operation becomes unstable, resulting in increased vibration levels and decreased pumping volume, shut down the system immediately and determine the cause.

iii) While the pump is stabilizing at the required inlet vacuum, inspect the flow of the liquid seal (water) to the pump. Ensure that the liquid seal is flowing out of the water trap silencer drain.

iv) Continuously monitor the temperature of the pump casing during the start-up procedure. If the temperature rises quickly or reaches 25°F (14°C) or more above the liquid compressant temperature, shut down the unit immediately and determine the cause.

v) After starting the pump, monitor the temperature of the bearing bracket until the temperature stabilizes for a minimum of 30 minutes.

CAUTION!

If the temperature of a bearing bracket is more than 30°f (17°c) higher than the pump casing temperature, shut down the pump immediately and identify the cause.

Caution: if there is abnormal bearing noise, vibration, odor, or smoke, shut down the pump immediately and determine the cause.

vi) Inspect the pump for vibration and noise. Excessive vibration and noise indicate an abnormal condition for an N.E.S. pump. Shut down the pump immediately to avoid further damage and identify the cause.

vii) Verify the speed (R.P.M.) of the pump shaft rotation by removing the nameplate cap from the fixed bearing outer cap and using a tachometer with a shaft extension, if required. Evaluate the measured speed with the rated speed specified for the pump. The rated operating speed and capacity can be found in the purchase specifications or obtained by consulting your N.E.S. Representative.

5.5 Start-up and Operating Checks

5.5.1 Start-up

To proceed with the commissioning process, please follow these steps:

1. The shut-off valve in the inlet pipe should be opened first.
2. If your machine is equipped with a mechanical seal with an external sealant supply, open the shut-off valve for the sealing liquid.
3. Switch on the drive motor to start the machine.
4. Adjust the shut-off valve for the seal water as follows:

If you are using a method with volume flow measurement, open the shut-off valve for the operating Liquid wide enough for the volume flow meter to show the required volumetric flow.

Once the final inlet pressure is reached, adjust the volumetric flow of the operating liquid to the correct value.

Monitoring the volume flow using a flow meter and adjusting the operating liquid flow rate accordingly helps maintain the proper functioning and performance of the machine during commissioning.

If you encounter any difficulties or require further assistance during the commissioning process, it is advisable to contact the NES support or service department for guidance.

Method for pressure measurement during start-up: Perform this step when the pressures on the inlet connection and discharge connection are equal in the start-up state.

1. Adjust the shut-off valve for the liquid compressant so that the pressure gauge indicates approximately 14.5 psia (0 psi gauge pressure) in the start-up state.
2. As the final inlet pressure is reached during Operation, the pressure gauge may indicate a different value, ranging from approximately -2.9 to +1.45 psi

gauge pressure. This variation depends on the internal operating liquid connection.

Shaft seal:

For internal liquid supply packing, no special measures are required. For stuffing boxes with internal liquid wetting, little to no leakage can occur.

For stuffing boxes with external liquid supply, adjust the stuffing boxes and the volumetric flow and feed pressure of the sealing Liquid. Leakage can occur at the stuffing boxes, and it is important to ensure that the leakage is within acceptable limits (a few drops per second).

CAUTION!

Risk of shaft damage:

If there is excessive Liquid in the machine interior, the pressure on the shaft can become too high and lead to damage during start-up.

The operating liquid level in the working space of the machine must not exceed the shaft center during start-up.

Take the following measures:

1. Ensure that the operating liquid level in the working space is properly adjusted immediately before start-up.
2. Avoid any significant additional accumulation of liquid (operating liquid or sealing Liquid) in the working space of the machine between the preparation for commissioning and start-up.

5.5.2 Operational Checks

During pump start-up, it is crucial to perform the following checks to ensure optimal Operation, prevent pump wear, and avoid breakdowns:

1. If the pump exhibits excessive vibration levels or fails to generate vacuum and loses volume during start-up, promptly shut down the pump to prevent further damage.
2. Investigate and identify the root cause of the problem before running the pump again. Potential issues may include a loose foundation, improper alignment, insufficient sealing fluid, and malfunctioning valves or switches, among others. For detailed troubleshooting guidance, see section 6.
3. Once the pump stabilizes, regularly monitor the temperature of the pump body, bearings, motor, and cooling water to ensure they remain within acceptable limits.

4. If any of the components experiences a sudden temperature rise, immediately shut down the system and inspect the temperature of the inlet seal water and heat exchanger cooling water. Verify that the motor is properly wired and not overloaded.

5. When the pump is running smoothly, adjust the gland nuts to achieve a drip rate of 1-2 drops per second. This controlled drip rate helps to keep the packing cool, reducing wear and prolonging the pump's lifespan.

6. Continuously monitor the operating vacuum and corresponding air capacity, and ensure the pump is safeguarded against sudden load spikes by employing a properly calibrated vacuum relief valve. Additionally, take precautions to prevent liquid carryover into the pump, as even though the pumps are resilient, minimizing carryover is advisable for optimal performance.

WARNING!

Rotating Parts and Pressure/Vacuum Hazards:

Be aware of the dangers associated with rotating parts, such as the impeller and shaft, which can cause severe injuries, including cuts, amputations, and entanglement of hair and clothing.

Understand the risks related to gauge pressure and vacuum, which can result in sudden fluid escaping, leading to skin and eye injuries, as well as the potential for hair and clothing to be forcefully pulled in.

Recognize the dangers of escaping fluids, which can cause burns or scalding, as well as slippery surfaces that may result in slips and falls.

Preparatory Measures:

1. Shut down the machine and ensure it is secured to prevent accidental restart.
2. Place warning signs on the system controller and control elements, informing others that maintenance work is in progress and that the machine should not be switched on.
3. Allow the machine to come to a complete stop and take note of any run-on time.
4. Shut off lines, perform pressure relief, and drain excess liquid to eliminate gauge pressure or vacuum in the system before proceeding with any further work.

B. Components Removal:

1. Do not remove the following components until after the machine has come to a complete stop, the lines have been shut off, and the pressure has been released:
2. Lines and blind flanges on the inlet and discharge connections.
3. Inspection covers on the end shields.
4. Lines, fittings, and closures (plugs, covers) on the connections in the end shield.
5. It is crucial to strictly adhere to these safety measures and follow the specific instructions provided by the manufacturer to ensure the safety of individuals working with or on the machine. Failure to do so can result in severe injuries or accidents.

5.5.3 Shut down.

To shut down the machine, follow these steps:

1. Close the shut-off valve for the liquid compressant, and instantly switch off the drive motor.
2. For different types of shaft seals, follow the corresponding steps:

- For stuffing boxes with internal liquid supply, no special measures are needed.
- For stuffing boxes with external liquid supply, close the shut-off valve for the sealing liquid.
- For single-acting mechanical seals with external sealant supply, close the shut-off valve for the flushing/sealing Liquid shortly after the machine is switched off.
- For double-acting mechanical seals with external sealant supply, close the shut-off fitting for the sealing liquid after the machine is switched off.
- Close the shut-off valve in the inlet pipe.
- Wait until the machine and drive elements (drive motor, gear unit, coupling) have come to a complete stop before proceeding with further measures.

If there is a risk of frost, additional steps should be taken to drain the liquid from the machine, liquid separators, and pipes. The lines may need to be disassembled to ensure complete draining. For machines with mechanical seals, the liquid should be completely drained from all seal housings.

WARNING!

•Shutdown the machine and ensure it is secured to prevent accidental power-on.
•Display a warning sign on the system controller and control elements, stating "DANGER! Maintenance work on vacuum pump/compressor! Do not switch on!"
•Wait for the machine to come to a complete stop, considering the run-on time.
•Shut off all lines, ensuring pressure relief and drainage of excess Liquid.
•Confirm that there is no gauge pressure or vacuum present in the lines, tanks, etc., that are to be opened.
•Particularly, do not remove the following components until after the machine has completely stopped, the lines have been shut off, and the pressure has been released:
•Lines and blind flanges on the inlet and discharge connections.
•Inspection covers on the end shields. Lines, fittings, and closures (plugs, covers) on the connections in the end shield.

Section 6: Troubleshooting

6.1 Detecting Troubles

Pump does not start, although motor is switched on	
Possible causes:	**Solutions:**
Electric connections are interrupted	Inspect the electrical fuses, terminals, and cables
The pump motor does not start but produces a noisy vibration	
Possible causes:	**Solutions:**
One or several electrical connections could be interrupted	Inspect the electrical fuses, terminals, and cables.
The impeller might be obstructed	Disassemble the machine to drain, decalcify, and clean the machine. Reassemble the machine again. Verify the clearance between the impeller, rotor, and housing to ensure proper adjustment
The main circuit breaker trips immediately after the machine is started	
Possible causes:	**Solutions:**
There is a short-circuit in the motor winding	Inspect the motor winding
The motor is experiencing an overload	Decrease the flow rate of the seal liquid
The counter-pressure at the discharge connection is excessively high	Reduce the counter-pressure
The liquid flowrate is adjusted or set too high	Decrease the quantity of Liquid
The main circuit breaker trips immediately after the machine is started	
Possible causes:	**Solutions:**
There is a short-circuit in the motor winding	Inspect the motor winding
The motor is experiencing an overload	Decrease the flow rate of the seal liquid
The counter-pressure at the discharge connection is excessively high	Reduce the counter-pressure
The liquid flowrate is adjusted or set too high	Decrease the quantity of Liquid
Making abnormal noise or squealing	
Possible causes:	**Solutions:**
The machine experiences cavitation	Introduce air into the feed, install a valve on the inlet connection, or use an anti-cavitation valve
The flow rate of the seal liquid is excessive	Verify and adjust the flow rate of the sealing Liquid to ensure proper sealing. Reduce the flow rate if it is too high
Might be bearing making noises	Need to change the bearings
There is leakage of Liquid between the housings	
Possible causes:	**Solutions:**
The sealant may be damaged	Replace the sealant

Screws may be loose	Verify if the screws are tightened using the appropriate tightening torques
There is leakage of Liquid between the housings	
Possible causes:	**Solutions:**
The sealant may be damaged	Replace the sealant
Screws may be loose	Verify if the screws are tightened using the appropriate tightening torques
Machine damaged due to rough running	
Possible causes:	**Solutions:**
The base frame experiences vibrations	Add base concrete into the base frame and, if required, the gear unit base
The machine experiences vibrations	Verify the alignment and mounting of the machine
The pipes experiences vibrations	Inspect the mounting of the pipes
There is a pulsing gas flow	Ensure proper installation of the piping on the suction side and monitor for water slugs through the inlet piping. Also, examine the non-return fittings
Excessive Liquid on the inlet side, in the end shield, and around the rotor	Excessive operating liquid: Adjust the throttle to reduce the flow of operating Liquid. Inlet seal flow rate is too high: Install a pre-separator in the inlet pipe to separate excess Liquid
The separator is positioned at an elevated height	Position a pre-separator at a lower level in the inlet pipe to regulate the flow of Liquid. Operating liquid quantities are too high: Reduce the amount of operating Liquid used in the system
High power consumption leading to machine overload	
Possible causes:	**Solutions:**
Calcification or deposits are present	Remove calcification or deposits from the machine through decalcification. If necessary, disassemble and clean the machine Soften the seal liquid to prevent calcification or deposits
Measuring devices display incorrect readings	Inspect the measuring devices and calibrate them if needed
Discharge pressure is too high	Examine the system.
Pulsating power consumption	Check the operating liquid quantity. Inspect the non-return fittings. Reduce the inlet seal flow rate by installing a pre-separator in the inlet pipe
Separator placed too high	If the separator is placed too high, reposition it to a lower level. Operating liquid quantities may be too high: Adjust the operating liquid quantities to an appropriate level

Impeller frictions	Rectify the impeller gap by opening the inspection cover (if present) and checking the impeller gap
Packing is tightened too securely	Readjust the packing gland assembly
High solids ingestion through the inlet pipe	Regularly flush the housing and consider installing a dirt trap in the inlet pipe. Improve the water quality if needed
Motor protection enabled	If no faults are detected on the machine, check the motor protection settings, and consider using a motor protection unit with a higher operating current if necessary. Motor size is inadequate: If no faults are found on the machine, evaluate the motor size, and consider using a drive motor with a higher output if needed
Housing Erosion	Assess the material's wear resistance and consider installing a filter in the operating liquid feed pipe. If required, replace the housing with a higher-quality design
Maximum permitted pressure difference surpassed	Exclude unnecessary throttle points, such as closed lines or incorrectly adjusted gate valves, on the inlet and/or discharge side to avoid exceeding the maximum pressure difference
Too Low Capacity	
Possible causes:	**Solutions:**
Presence of calcification or deposits	Perform decalcification on the machine. If necessary, dismantle and clean the machine. Consider using methods to soften the operating Liquid
Incorrect measuring devices display	Verify the functionality of the measuring devices and perform calibration if necessary
Excessive discharge pressure	Inspect the system and identify the cause of high pressure
High internal clearance losses	Rectify the impeller gap by checking and adjusting it. If the gap is too large, consider reducing the length of the housing by dismantling and modifying it
Low inlet pressure	Verify the system and adjust the feeding capacity, such as reducing the rotation speed or installing a bypass
Internal leaks	Dismantle the machine and inspect the sealing surfaces. Look for resistance, substitute affected parts if there is corrosion
Defective valves on the discharge side	Replace the faulty valves with new ones
Leaky inlet flange	Examine the seal on the inlet flange and the seal on the inlet-side inspection cover, replacing them if required
Leaky stuffing box/mechanical seal	Readjust the packing gland assembly. Check the condition of the stuffing box packing/mechanical seal and replace them if needed
Insufficient seal liquid flow	The volumetric flow of the operating liquid should be increased. Raise the supply pressure or adjust the volumetric flow of the operating Liquid

High output operating liquid temperature	Lower the temperature of the operating liquid. The volumetric flow of the operating liquid should be increased
Exceeding maximum permissible pressure difference	Exclude unnecessary throttle points, such as closed lines or incorrectly adjusted gate valves, on the inlet and/or discharge side to prevent exceeding the maximum pressure difference
Vacuum not attained	
Possible causes:	**Solutions:**
Seal Liquid not adequate	Inspect the seal liquid piping
Presence of air in the system	Examine all connections and seals and securely tighten if required
Reverse rotation	Exchange any two leads to correct the reveres rotation
Wear and tear of the machine	Disassemble the machine
Vacuum pump stops suddenly with increased power consumption	
Possible causes:	**Solutions:**
Defective valves on the discharge side	Replacement of the valves is necessary
Housing becomes excessively hot	
Possible causes:	**Solutions:**
Level of seal fluid flow is low	Volumetric flow of the seal liquid should be increased. Feeding pressure of the seal fluid needs to be increased
Seal fluid temperature too high	Volumetric flow of the seal liquid should be increased. Decrease the temperature of the seal fluid needs to be increased
Bearing overheated	
Possible causes:	**Solutions:**
There is an excessive amount of grease in the bearing	Excess grease should be removed
Axial forces are present in the coupling	Align the machine more precisely
The belt tension may be too high for the v-belt units	Readjust the belt tension accordingly
The bearing is soiled	Clean or change the bearing and inspect the seals
Surrounding temperature is much higher than the permitted limit	If required use high-temperature grease
Lubrication not sufficient	Follow the specified lubrication instruction
Rusty bearing	Change the bearing and examine the seals
The bearing emits a whistling sound	
Possible causes:	**Solutions:**
Lubrication not sufficient	Check the bearings and follow the specified lubrication instruction
Rusty bearing	Change the bearing and examine the seals
Bearing scoring	
Possible causes:	***Solutions:***
There is wear on the bearing running surfaces	Change the bearing

The bearing knocks or experiences scoring (damage on the bearing running surfaces due to jolts during storage)	Change the bearing. Avoid jolt during storage
Impeller stuck	
Possible causes:	**Solutions:**
Deposits from the seal liquid occurred during storage	Loosen the rotor mechanically by loosening the mounting screws of the guide bearing, removing compensating washers, and unscrewing the cover of the guide bearing. Move the rotor back and forth by light strokes with a lead hammer on both faces of the shaft. Manually turn on the rotor Then, reassemble or secure the originally removed or loosened parts
Possibly due to solid materials ingestion	Clean and decalcify the machine

Section 7: Preventive Maintenance

7.1 Periodic Maintenance

After approximately 150 operating hours, it is recommended to conduct the first general inspection of the machine. During this inspection, the following aspects should be checked:

1. Impurities in Feeding Fluids and Operating Liquid:
• Ensure that no major impurities are present in the feeding fluids or operating Liquid.
2. Compliance with Technical Data:
• Verify that the machine is operating within the specified technical data, such as power consumption and temperature. Any deviations should be addressed and corrected if necessary.
3. Leakage:
• Check for any impermissible leakage and take appropriate measures to resolve the issue if it is detected.
4. Operation and Noise:
• Assess the smooth Operation of units and monitor the operating noises of the bearings. Any changes or worsening of operating noises should be investigated and addressed promptly.
5. Foundation:
• Inspect the foundation for any signs of settling or cracks. Address any issues with the foundation to ensure the stability and proper functioning of the machine.
6. Valves, Filters, and Sieves:
• Check that valves, filters, and sieves are free of foreign bodies. If any foreign bodies are found, clean them, and specify a corresponding period for the next inspection.
When cleaning the screens, it is important to remove them with a small piece of piping instead of pulling them out directly. This method prevents any dirt present on the screen surface from entering the machine.
Note: Always refer to the instructions and specifications provided in the assembly manual and operating manual of the machine and its system components.
For any disturbances or unusual conditions that cause stress on the machine, it is necessary to perform appropriate inspections or overhauls to address and rectify the issues promptly.
By conducting the first general inspection and addressing any identified issues, the machine can be maintained in optimal condition for continued reliable Operation.

WARNING!

Special precautions and safety measures are required for machines that handle hazardous liquids or operate with such liquids. These precautions should be in accordance with the safety regulations specific to the industry.

Before performing any procedures on the machine or the piping system, ensure the following:

•Take measures to prevent any disruption to the system during the intended procedure.

•Ensure that the driving motor is turned off and securely protected against accidental start-up.

•Secure and depressurize the relevant piping systems before opening them.

•When opening the piping system, ensure there is no risk of emission from the pumped Liquid, and follow all necessary safety measures.

Maintenance or repair personnel should be informed about the current condition of the machine.

WARNING!

If hazardous liquids have been used, the responsible individuals for the machine's Operation (such as when sending it to a service branch) must provide a declaration stating that the machine has not been contaminated during previous operations with substances that are toxic, caustic, microbiological, radioactive, or otherwise harmful to health. If such hazards exist, the declaration must confirm that no danger is present after appropriate decontamination or specify the detailed measures required to safely carry out maintenance work.

This legally binding declaration must be issued by authorized and qualified individuals responsible for the operation, using the VDMA notification form sheet. Two copies of the declaration should be prepared: one should be attached directly to the machine's accompanying papers, and the other should be sent to the maintenance department or company through regular communication channels.

It is important to note that specific regulations may apply to maintenance or repair measures within a company's internal policies.

It is crucial to perform careful and regular maintenance, inspections, and overhauls to detect and address any potential issues before they escalate into significant damages. For all activities related to inspection, overhaul, and repairs, it is highly recommended to seek the services of NES Service. They have the expertise and experience to effectively handle these tasks and ensure the optimal functioning of the machine.

CAUTION!

Please note that this list may not cover all possible tests and inspections. It is important to refer to the additional manuals provided, such as those for mechanical seals, and follow any special specifications specific to your system.

During inspections, it is essential to promptly address any deviations or changes that are deemed unacceptable. Take immediate action to rectify and resolve any identified issues to ensure the proper functioning of the machine.

7.2 Six-Month Intervals

Every six months, perform the following maintenance tasks:

i) If lubrication is required for the drive coupling, apply oil or grease according to the instructions provided by the coupling manufacturer. ii) Inspect the pump bearings and apply lubrication if necessary. iii) Follow the instructions from the motor manufacturer to relubricate the drive motor bearings. iv) Ensure that the orifice plug in the body, specifically the 3/8-inch orifice of the lobe unloader, is not obstructed. To check this:

1. Remove the pipe plug located in the fixed bearing end head to access the orifice plug.
2. Examine the orifice plug for any obstructions or blockages.
3. If you find any obstructions, carefully use a rod or similar tool to remove them and clear the orifice.
4. In case the obstructions cannot be cleared with a rod, use a wrench to safely remove the orifice plug.
5. Clear any obstructions from the plug if possible, and then reinstall it securely.
6. Finally, reinstall the pipe plug back into the fixed bearing end head, ensuring it is properly tightened.

7.3 Twelve-Month Intervals

At twelve-month intervals, perform the following maintenance tasks:

a. Examine the pump bearings and, if required, apply lubrication following the provided guidelines in section 5.4.

b. Stuffing box packing may be replaced as specified in section 7.5.

7.4 Bearing Lubrication

All models of the NBE series are supplied with a re-lubricating device. To track the lubrication intervals, we recommend maintaining an inspection log. The inspection log should include the following details:

- Date
- Machine type designation and serial number
- Grease type (manufacturer and designation)
- Grease quantity for each lubrication point
- Person responsible for lubrication

Lubrication intervals: The rolling bearings must be re-lubricated at least:

- Either every 2000 operating hours
- Or twice a year (NBE3) or twice a half year (NBE4), whichever occurs first.

Grease type: Refer to the list below in the Table 3 and Figure2-4 for data on lubricating greases. The following lubricating greases are suitable for lubricating the rolling bearings.

GENERAL REQUIREMENTS:

A. Premium quality industrial bearing grease.
B. Consistency grade: NLGI #2
C. Oil viscosity (minimum):
   @100˚(38˚C)- 500 SSU (108 cSt)

   @ 210˚(99˚C)- 58 SSU (10c St)
D. Thickener (Base): Lithium or Lithium Complex for optimum WATER RESISTANCE.
E. Performance characteristics at operating temperature:
   1. Operating temperature range; at least 0˚to 250˚(18˚to 121℃)
   2. "Long-Life" performance
   3. Good mechanical and chemical stability.
F. Additives – Mandatory:
   1. Oxidation inhibitors
   2. Rust inhibitors
G. Additives – Optional:
   1. Anti-wear agents
   2. Corrosion Inhibitors
   3. Metal deactivators
   4. Extreme Pressure (E.P.) agents
H. Additives – Objectionable:
   1. Molybdenum disulfide
   2. Tackiness agents

NES STANDARD GREASE RECOMMENDATIONS:

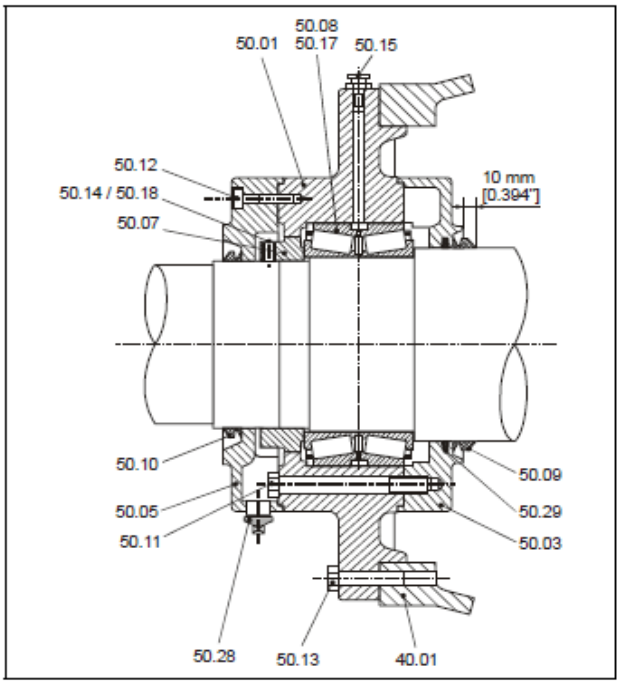
The following is a list, by manufacturer, of some grease that exhibits the desired characteristics required by N.E.S.

Grease Manufacturer	Product
AMOCO	Super Permalube or Amolith 2EP
B.P. Oil	Energrease LS-EP2
Castrol Oil	Spheerol SW 2 E.P.
Chevron Oil	Ulti-Plex Synthetic EP2
Exxon	Unirex N2 or Unirex EP2
Mobil Oil	Mobilith SHC 100 or Mobilith AW2
Shell Oil	Alvania 2 or Alvania EP2
Texaco Oil	Starplex 2 or Marfak MP2
Thames	Lithium EP2

Table 3: General Grease Specifications- Types & Quantities

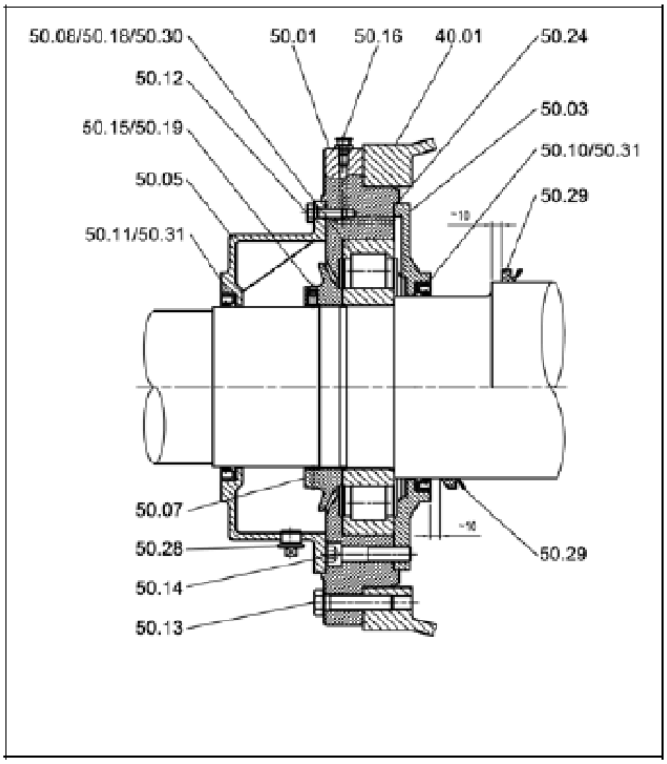
Type	Grease Quantity per Lubricating Point	
	in g	in oz
NBE3 30. / 32.	90 g	3.2 oz
NBE3 40. / 42.	100 g	3.5 oz
NBE3 50. /52.	140 g	5.0 oz
NBE3 60. / 62.	160 g	5.7 oz
NBE3 67. / 72.	240 g	8.5 oz

Type	Grease Quantity per Lubricating Point	
	in g	in oz
NBE4 30. / 32.	40 g	1.5 oz
NBE4 40. / 42.	40 g	1.5 oz
NBE4 50. /52.	60 g	2.2 oz
NBE4 60. / 62.	60 g	2.2 oz
NBE4 67. / 72.	90 g	3.2 oz



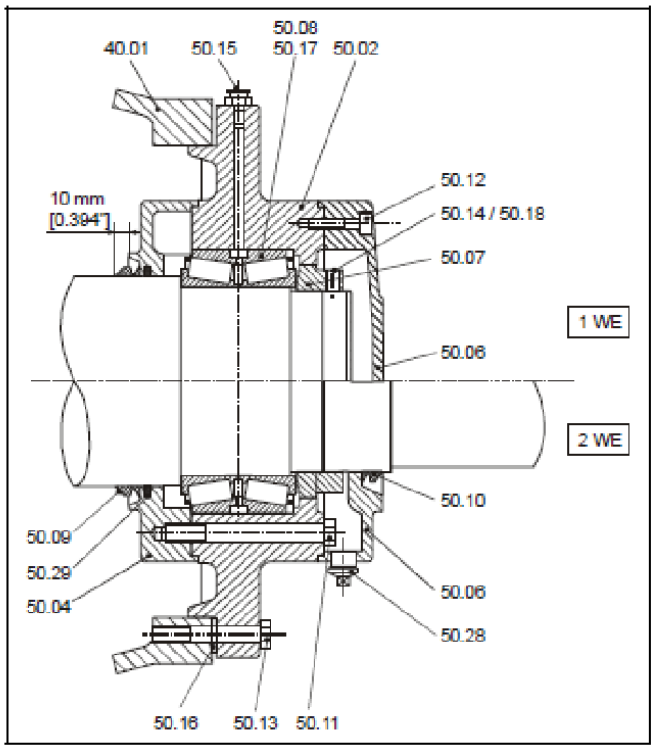
40.01 End shield
50.01 Bearing housing, driving side
50.03 Bearing cover, driving side, inside
50.05 Bearing cover, driving side, outside
50.07 Grease slinger
50.08 Taper roller bearing
50.09 Axial shaft sealing ring, inside
50.10 Axial shaft sealing ring, outside
50.11 Hexagon bolt
50.12 Cap screw with Allen head
50.13 Hexagon bolt
50.14 Threaded pin
50.15 Flat grease nipple
50.17 Lubricating grease
50.18 Liquid thread locking compound, normally separable
50.28 Plug
50.29 Felt ring

Fig. 2. Bearing insert on drive side NBE3



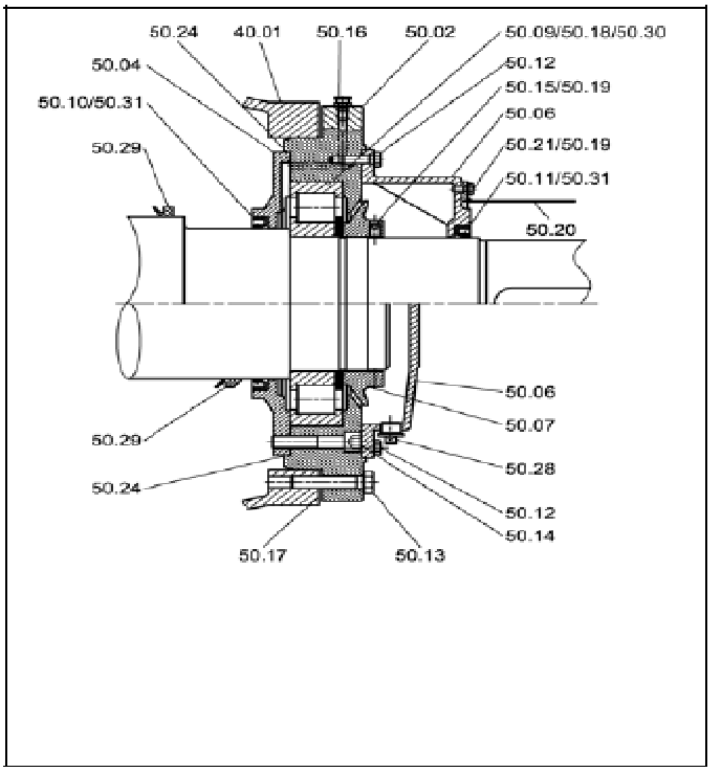
40.01 End shield
50.01 Bearing housing, driving side
50.03 Bearing cover, driving side, inside
50.05 Bearing cover, driving side, outside
50.07 Grease slinger
50.08 Cylindrical roller bearing, NU
50.10 Axial shaft sealing ring, inside
50.11 Axial shaft sealing ring, outside
50.12 Hexagon bolt, bearing cover
50.13 Hexagon bolt, bearing housing
50.14 Cap screw, bearing housing
50.15 Threaded pin
50.16 Flat grease nipple
50.18 Lubricating grease
50.19 Liquid thread locking compound, normally separable
50.24 Sealant, bearing cover
50.28 Plug
50.29 Slinger
50.30 Molykote paste
50.31 Anti-corrosion agent, shaft seal rings

Fig. 3. Bearing insert on drive side NBE4



40.01	End shield
50.02	Bearing housing, non-driving side
50.04	Bearing cover, non-driving side, inside
50.06	Bearing cover, non-driving side, outside
50.07	Grease slinger
50.08	Taper roller bearing
50.09	Axial shaft sealing ring, inside
50.10	Axial shaft sealing ring, outside
50.11	Hexagon bolt
50.12	Cap screw with Allen head
50.13	Hexagon bolt
50.14	Threaded pin
50.15	Flat grease nipple
50.16	Compensating washer
50.17	Lubricating grease
50.18	Liquid thread locking compound, normally separable
50.28	Plug
50.29	Felt ring
1 WE	Design with one shaft end (no shaft end on non-driving side)
2 WE	Design with two shaft ends (second shaft end on non-driving side)

Fig. 4. Bearing insert on non-drive side NBE3



40.01	End shield
50.02	Bearing housing, non-driving side
50.04	Bearing cover, non-driving side, inside
50.06	Bearing cover, non-driving side, outside
50.07	Grease slinger
50.09	Cylindrical roller bearings, NUP
50.10	Axial shaft sealing ring, inside
50.11	Axial shaft sealing ring, outside
50.12	Hexagon bolt, bearing cover
50.13	Hexagon bolt, bearing housing
50.14	Cap screw, bearing housing
50.15	Threaded pin
50.16	Flat grease nipple
50.17	Compensating washer
50.18	Lubricating grease
50.19	Liquid thread locking compound, normally separable
50.20	Shaft protection cap
50.21	Hexagon bolt, shaft protection cap
50.24	Sealant, bearing cover
50.28	Plug
50.29	Slinger
50.30	Molykote paste
50.31	Anti-corrosion agent, shaft seal rings
1 WE	Design with one shaft end (no shaft end on non-driving side)
2 WE	Design with two shaft ends (second shaft end on non-driving side)

Fig. 5. Bearing insert on non-drive side NBE4

7.5 Stuffing Box Packing

To ensure the proper functioning of the stuffing box gland after extended Operation, avoid readjusting it. If readjustment becomes necessary, the packing will need to be added to or replaced. Refer to Figure. 6 & 7 and Table 4.

To replace the packing in the stuffing box, follow these steps:

1. Remove the old packing materials and clean the packing space.
2. Insert new packing rings, ensuring that the joint gaps are offset by 90 degrees. Take care not to disrupt the distribution of the seal water in the packing.
3. It is recommended to have NES Service perform the packing replacement and adjustment.

TYPE NBE3/4...	30. / 32.	40. / 42.	50. / 52.	60. / 62.	67.	72.
Nominal diameter of shaft bushing						
in inches	6.102	8.07	9.646	10.63	11.417	12.008
Total length of packing rings per machine						
in feet	15.09	19.36	23.29	25.26	27.23	28.54
Length of individual packing ring						
in inches	22.05	27.95	33.46	37.00	39.37	40.94
Cross-section of packing rings						
in inches	0.47 x 0.47	0.55 x 0.55	0.63 x 0.63	0.63 x 0.63	0.63 x 0.63	0.71 x 0.71
Number of inner packing rings per stuffing box	2	2	2	2	2	2
Number of outer packing rings per stuffing box	2	2	2	2	2	2

Table 4: Packing Box Information

CAUTION!

Please exercise caution when working with sharp edges as there is a risk of injury. It is essential to wear appropriate personal protective equipment, such as protective gloves, when performing tasks in this area.

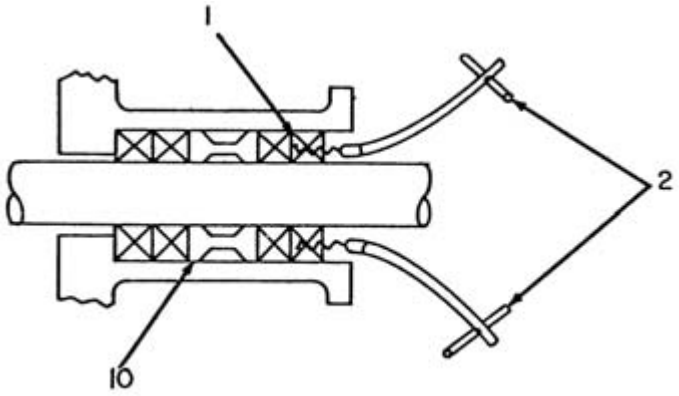


Figure 6. Removing of stuffing box packing

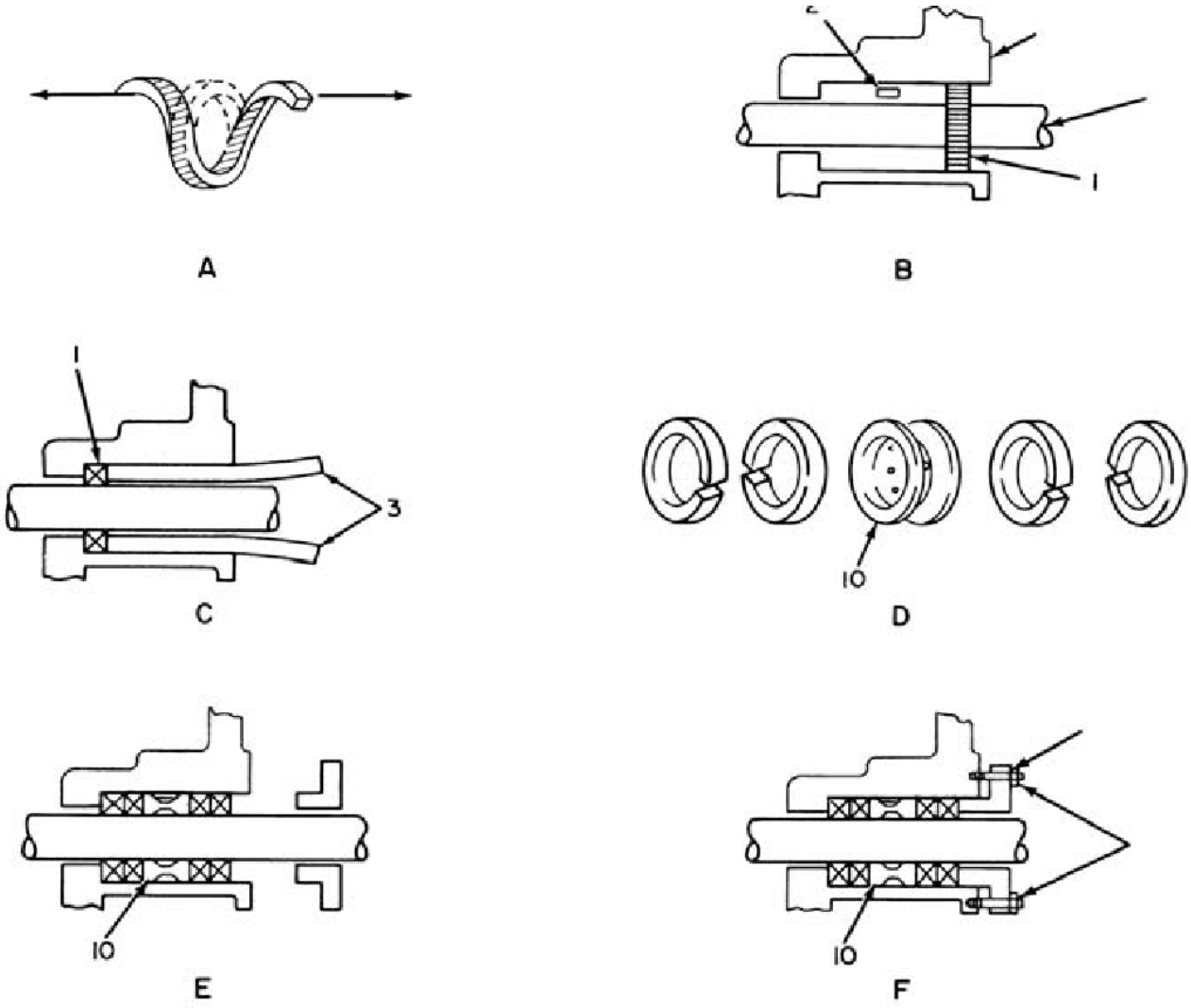


Figure 7: Stuffing of box packing

7.6 Shutdown Periods

For a brief standstill period of 2 to 3 weeks, take the following precautionary measure:

Rotate the shaft of the machine a few turns at least once a week. This helps prevent the formation of rust between the parts and reduces the risk of possible jamming.

For a longer standstill period, there is two options:

Machine remains connected to the system or removed for storage.

For stainless-steel machines, no special preparations are required.

For machines with parts that are not corrosion-resistant (all other material variants), follow these steps: a. Neutralize the machine using a harmless fluid such as clean water, which is safe for both the machine and the process. b. Drain the machine as described in Section 5.3.

Note: The periods/intervals for these measures may need to be adjusted based on environmental conditions such as high humidity, salty air, or dusty/sandy air. Please refer to Table 5 for preservative quantities. If uncertain, it is recommended to contact NES Service for further guidance.

Model	Preservative Required (Gallons)
NBE3/NBE4 30	0.5
NBE3/NBE4 32	0.7
NBE3/NBE4 40	0.8
NBE3/NBE4 42	1.2
NBE3/NBE4 50	1.3
NBE3/NBE4 52	1.6
NBE3/NBE4 60	1.85
NBE3/NBE4 62	2.1
NBE3/NBE4 67	2.9
NBE3/NBE4 72	3.7

Table 5: Preservative Quantity

If the pump is shut down for 2 to 3 weeks, rotate the vacuum pump and recirculating pump (if applicable) by hand at least once every week to prevent rust buildup between cast iron parts, which could lead to seizing.

If the pump needs to be taken out of service for a period ranging from 3 weeks to one year and it is a standard cast iron or all-cast iron pump maintained in covered storage, follow the preservation procedures outlined below:

1. Remove all pipe plugs and drain the pump as thoroughly as possible. Rotate the shaft by hand 5 to 10 revolutions after draining to remove remaining moisture.
2. Replace the drain plugs and pour in the specified amount of preservative as listed in the provided table. Fill the pump through the flange or inspection openings.
3. Rotate the shaft by hand 5 to 10 revolutions. Install flange covers and seal covers with tape.
4. Brush or spray Houghton's Rust Veto #342 (or equivalent) onto all exposed machined, ferrous surfaces, including flange faces and shaft surfaces. Allow it to dry.
5. Pumps with carbon steel shafts should receive additional treatment with Houghton's Rust Veto #342 or equivalent.
6. After preservation, remove the stuffing box packing and lantern gland (if applicable). Blow and wipe away any remaining water. Apply Rust Veto #342 or equivalent to the shaft surface and reinstall new packings.
7. Rotate the pump shaft by hand at least once every month to prevent the formation of rust between tight tolerances and avoid pump seizing.

Note: If the Cortec VCI-379E preservative is used, which is a waterborne vapor phase corrosion inhibitor, flushing before start-up is not required for pumps preserved with this material.

Adhering to these procedures will help ensure proper preservation and minimize the risk of rust and corrosion during the standstill period.

Section 8: Disassembly, Reassembly, and Inspection

Prior to performing any operations on the pump, ensure that all power to the pump is disconnected.

8.1 Pump Disassembly:

1. Remove the rear bearing cover by loosening the nuts securing the bearing and pedestal, and then remove both.
2. Unscrew the gland nuts and remove the stuffing box gland.
3. Loosen the nuts securing the pump casing to the pump cover, along with the mounting bolts, and remove the rear cover.
4. Take out the coupling, shaft locating groove, and fore bearing component.
5. Disassemble the front cover and remove the shaft and rotor assembly.

8.2 Pump Reassembly:

1. Place the shaft and rotor assembly into position and firmly attach the front cover to the pump casing.
2. Connect the shaft locating groove and coupling.
3. Ensure the pump is positioned on a level surface and securely affix the rear cover to the casing.
4. Assemble the stuffing box gland, pedestal, and bearing.
5. Install the rear bearing cover.

8.3 Pump Inspection:

When it comes to inspection, maintenance and inspection intervals can be planned based on relubrication or grease change intervals, provided that no shorter periods are specified after the first inspection.

In addition to the inspection measures mentioned earlier, inspection should also include the following checks:

• Impeller Alignment: Ensure that the impeller alignment remains within the permitted tolerance zones.
• Mounting Screws/Bolts: Verify that all mounting screws/bolts are firmly tightened, except for stuffing box-shaft seals if necessary.

During normal inspections, it is generally not necessary to dismantle the machines, unless specific issues or circumstances require it.

9. Technical data for NBE3 & NBE4

9.1 Spare Parts List:

Part Item No.	Part Designation	Part Item No.	Part Designation	Part Item No.	Part Designation
10.01	Impeller	35.02	Tie-rod	40.23	Sealing compound for installation
10.02	Shaft	35.03	Hexagon nut	40.24	PTFE seal strip
10.03	Feather key, DIN 6885	35.04	Washer	48.01 1)	Blind flange for partial draining
15.01	Packing gland assembly	35.05	Sealing compound for installation	48.02 1)	Welding neck flange
15.02	Sealing-water distribution ring	35.06 [2])	O-ring	48.03 1)	Hexagon bolt
15.03	Stuffing box packing	37.01	Intercepting plate	48.04 1)	Hexagon nut
15.04	Hexagon bolt	37.02	Valve plate	48.05 1)	Gasket
15.05	Washer	37.03	Threaded spacer pin	50.01	Bearing housing, driving side
15.06	Plug for shaft seal with external. sealant supply	37.04	Hexagon nut	50.02	Bearing housing, non-driving side
		40.01	End shield		
15.07	PTFE seal strip	40.02	Inspection cover	50.03	Bearing cover, driving side, inside
20.00	Mechanical seal assembly	40.06	Blind flange, access to "increased volumetric flow of operating liquid" ("increased cooling")		
22.01	Shaft bushing			50.04	Bearing cover, non-driving side, inside
22.02	Drive End Shaft Key				
22.03	O-ring	40.07	Gasket	50.05	Bearing cover, driving side, outside
22.04	Cap screw with Allen head	40.10 **)	Blind flange (inlet side, bottom)		
22.07	Sealing compound for installation	40.12 **)	Blind flange (discharge side, top)	50.06	Bearing cover, non-driving side, outside
22.08					

	Sealant with sliding paste for installation	40.13	Gasket	50.07	Grease slinger
30.01	Port plate, driving side	40.14	Hexagon bolt	50.08	Cylindrical roller bearing
30.02	Port plate, non-driving side	40.15	Hexagon bolt	50.09	Cylindrical roller bearings, NUP
30.03	Cap screw with Allen head	40.16	Hexagon bolt	50.10	Radial shaft sealing ring, inside
30.04	Spring-type straight pin	40.17	Hexagon nut	50.11	Radial shaft sealing ring, outside
30.05	Spring-type straight pin	40.18	Pipe plug	50.12	Hexagon bolt
30.06	Sealing compound for installation	40.19	Plug for “increased cooling", refrigeration circuit	50.13	Hexagon bolt
30.09	Cap screw with Allen head			50.14	Cap screw with Allen head
30.10	Reducing plug	40.20	Plug for complete draining	50.15	Threaded pin
30.11 [2])	O-ring	40.21	Plug for connecting pressure gauges	50.16	Flat grease nipple
30.13 [2])	Pipe plug			50.17	Compensating washer
30.14 [2])	Pipe plug	40.22	Plug for shaft seal, with internal sealant supply (removal of the	50.25	Sealing compound for installation
35.01 *)	Housing without/with partition			50.28	Plug
				50.29	V-ring

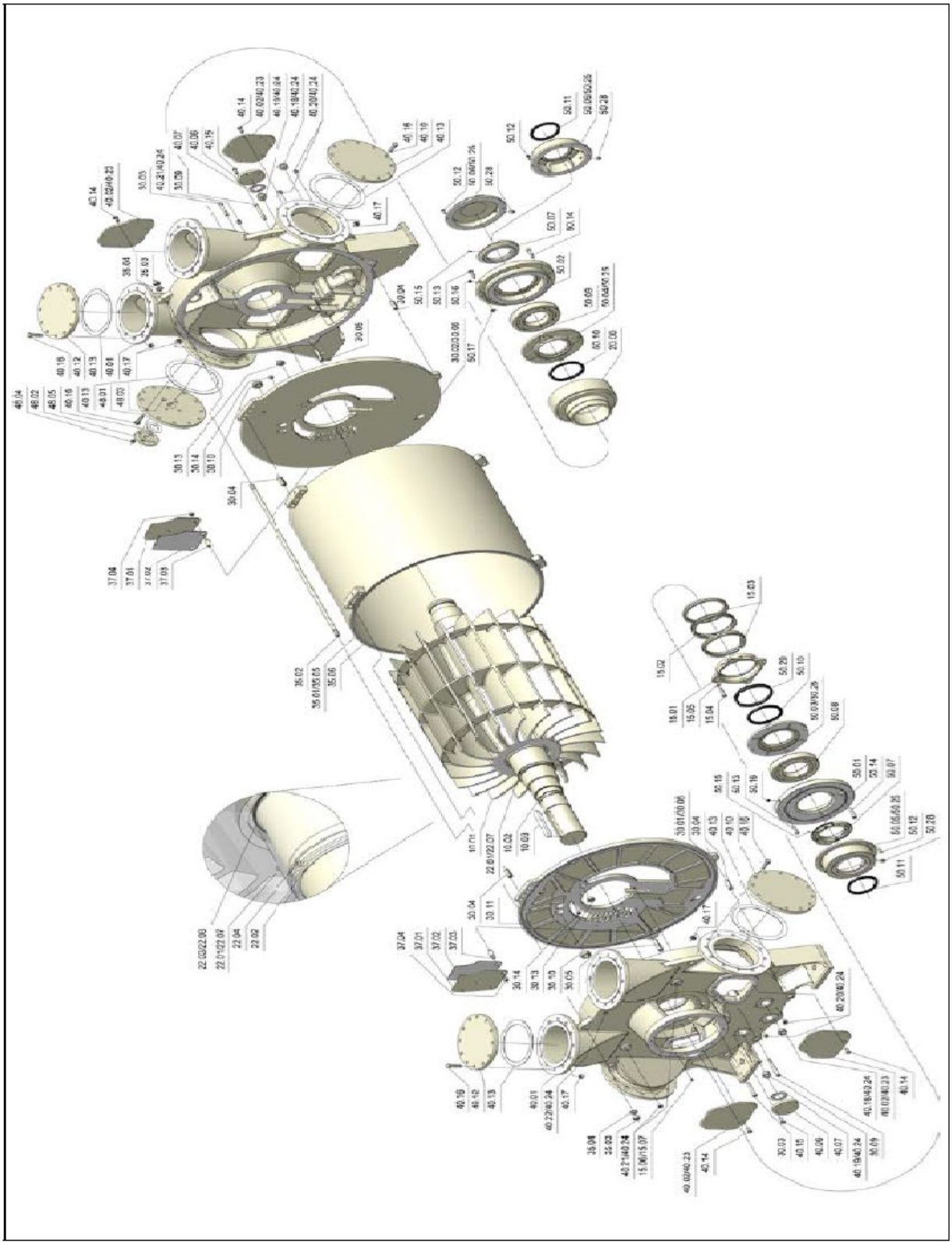


Figure 8: Vacuum pump NBE3/4

9.2 Dimensions & Specifications:

A separate dimensional drawing, from which the machine's main grounding connections are to be taken, is provided in the delivery documentation.

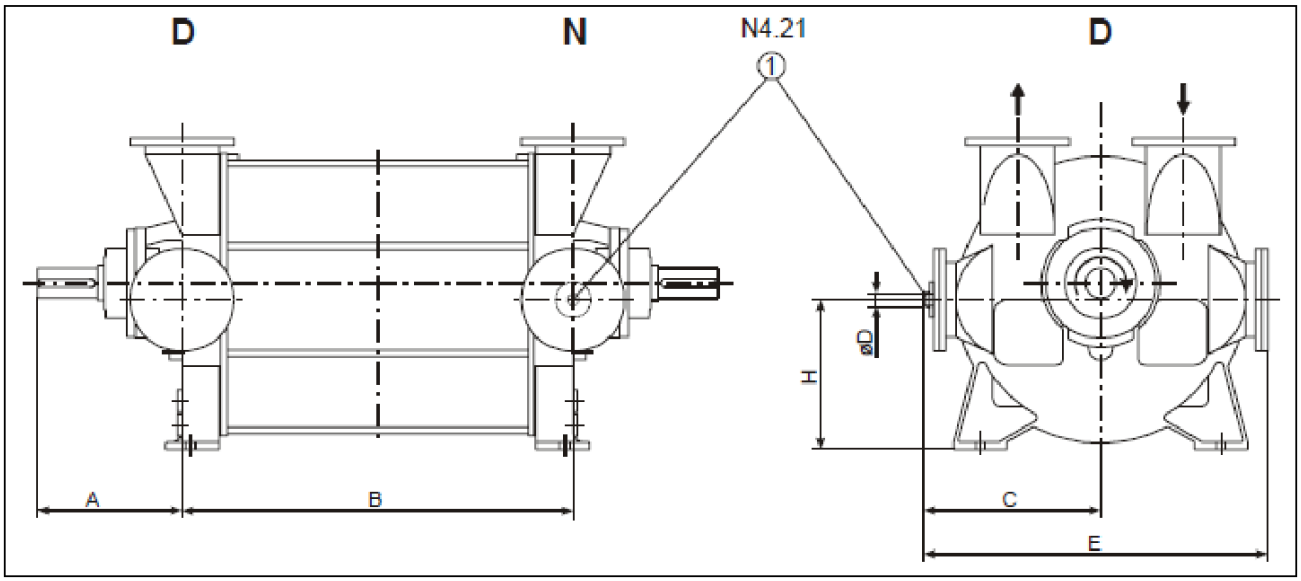


Figure 9: Main Dimensions

Main Dimensions

Specifications in inches										
Type NBE3/4 ...	30.	32.	40.	42.	50.	52.	60.	62.	67.	72.
A	19.3	19.3	23.4	23.4	26.5	26.5	25.6	25.6	28.9	28.4
B	35.1	44.4	46.0	57.4	61.7	71.6	72.6	84.2	89.8	98.4
C	21.3	21.3	27.1	27.1	32.2	32.2	37.2	37.2	39.5	43.1
E	41.0	41.0	53.1	53.1	63.3	63.3	73.2	73.2	78.1	85.2
H	16.9	16.9	22.0	22.0	27.5	27.5	31.9	31.9	34.5	37.5
ØD	2⅜	2⅜	2⅜	2⅜	2⅜	2⅜	2⅜	2⅜	2⅜	2⅜

Weighs/Masses

Mass/Weight in short tons (1 sh tn = 2000 lbs.)										
Type NBE3/4 ...	30.	32.	40.	42.	50.	52.	60.	62.	67.	72.
Without accessories	1.7	2.1	3.2	3.6	6.0	6.6	9.0	10.0	12.6	15.7
With separator and Y-pipe	2.0	2.5	3.8	4.3	6.8	7.5	10.1	11.2	14.0	17.3

9.3 Forces & Torques on Flanges

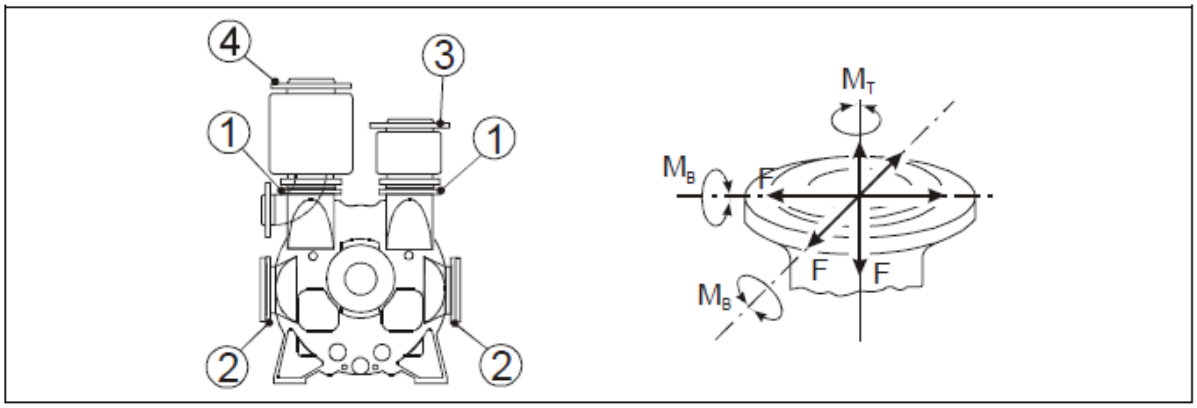


Figure 10: Forces & Torques on Flanges

Specifications in lbs. and ft lbs.							
Type NBE3/4		30. / 32.	40. / 42.	50. / 52.	60. / 62.	67.	72.
Flange 1	DN	6	10	12	14	14	16
	F in lbs.	540	990	990	1575	1575	1575
	MB in ft lbs.	735	2210	2580	4940	4940	5385
	MT in ft lbs.	995	3025	3465	6635	6635	7190
Flange 2	DN	6	10	12	14	14	16
	F in lbs.	425	810	1170	1370	1370	1370
	MB in ft lbs.	605	1845	3100	4200	4200	4570
	MT in ft lbs.	810	2470	4130	5600	5600	6050
Flange 3	DN	8	12	14	16	20	20
	F in lbs.	945	1280	1280	1685	2045	2045
	MB in ft lbs.	1770	3690	3835	5825	8480	8480
	MT in ft lbs.	2360	4865	5090	7375	11100	11100
Flange 4	DN	8	12	14	16	20	20
	F in lbs.	785	1280	1280	1685	2045	2045
	MB in ft lbs.	1900	3690	3835	5825	8480	8480
	MT in ft lbs.	1845	4865	5090	7375	11100	11100

9.4 Circuit diagrams

9.4.1 Examples of Vacuum Pump circuit diagrams

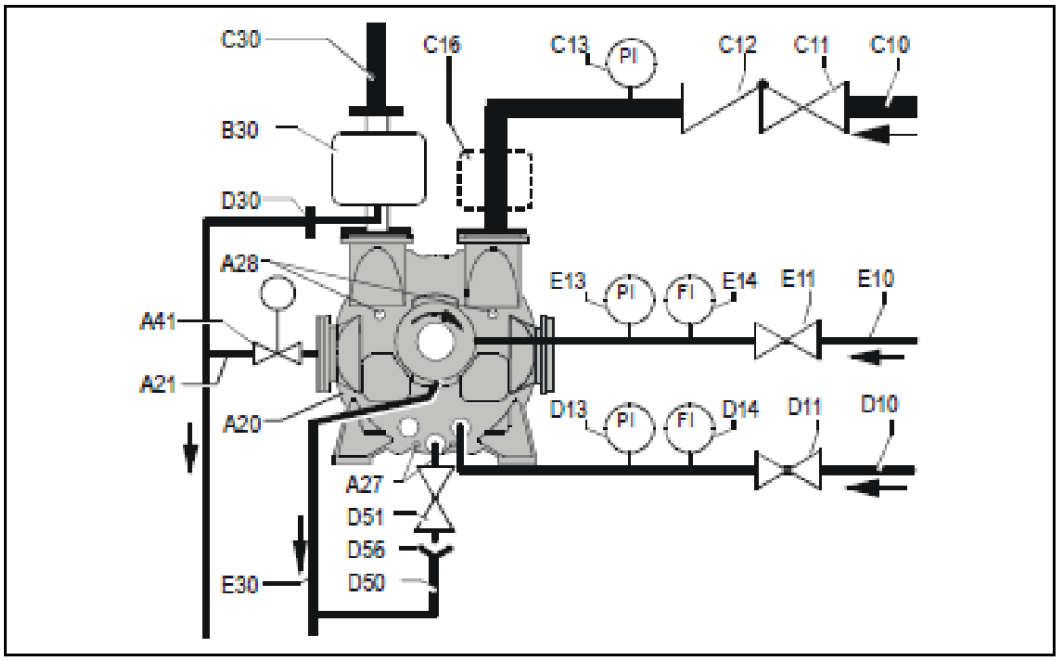


Figure 11. Connection with top mounted liquid separator

The flange connection should be linked to the discharge pipe, specifically for the separated operating Liquid (D30), using the line designated for partial draining (A21).
To enable partial draining effectively, it is necessary to incorporate automatically actuated shut-off fittings (A41). These fittings serve the following purposes: It remains open when the machine is at a standstill, close during machine operation, immediately after it is switched on, as this prevents continuous leakage of liquid and gas during the operational phase.

A20 Vacuum pump/compressor
A21 Line for partial draining
A27 Plug for complete draining
A28 Plug for connection of pressure gauges
A41 Shut-off fitting (for ensuring partial draining)
B30 Liquid separator (assembled)
C10 Inlet pipe
C11 Shut-off fitting
C12 Non-return fitting
C13 Pressure gauge
C16 Y-pipe
C30 Discharge pipe (gas)
D10 Feed pipe for operating Liquid
D11 Shut-off fitting
D13 Pressure gauge
D14 Volume flow meter
D30 Discharge pipe for separated operating Liquid
D50 Discharge pipe for draining and flushing
D51 Shut-off fitting
D56 Funnel or sight glass
E10 Feed pipe for sealing Liquid (only for design with external sealant supply)
E11 Shut-off fitting
E13 Pressure gauge
E14 Volume flow meter
E30 Discharge pipe for seepage liquid of shaft seal

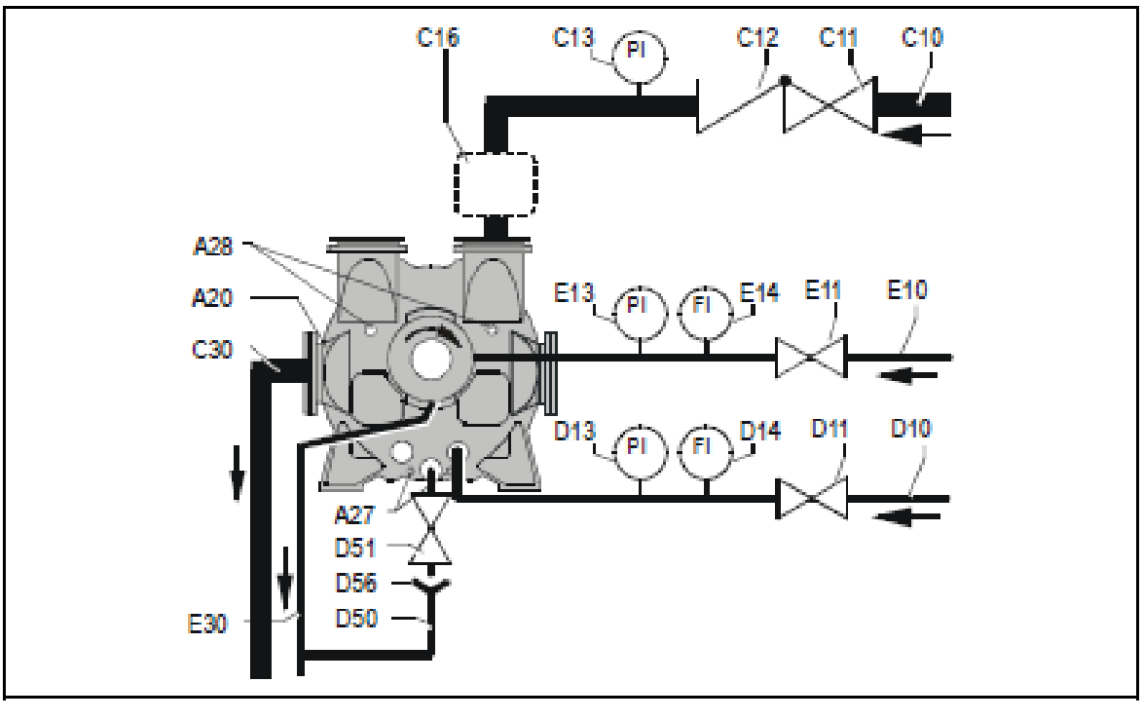


Figure 12: Connection without liquid separator

Partial draining is carried out via the discharge pipe (C30).
Partial draining is accomplished through the utilization of the feed pipe for operating Liquid (D10). Consequently, this line should not include any valves or shut-off devices.
It is essential that the liquid level in the operating liquid tank and the overflow level are aligned precisely with the shaft center of the machine.

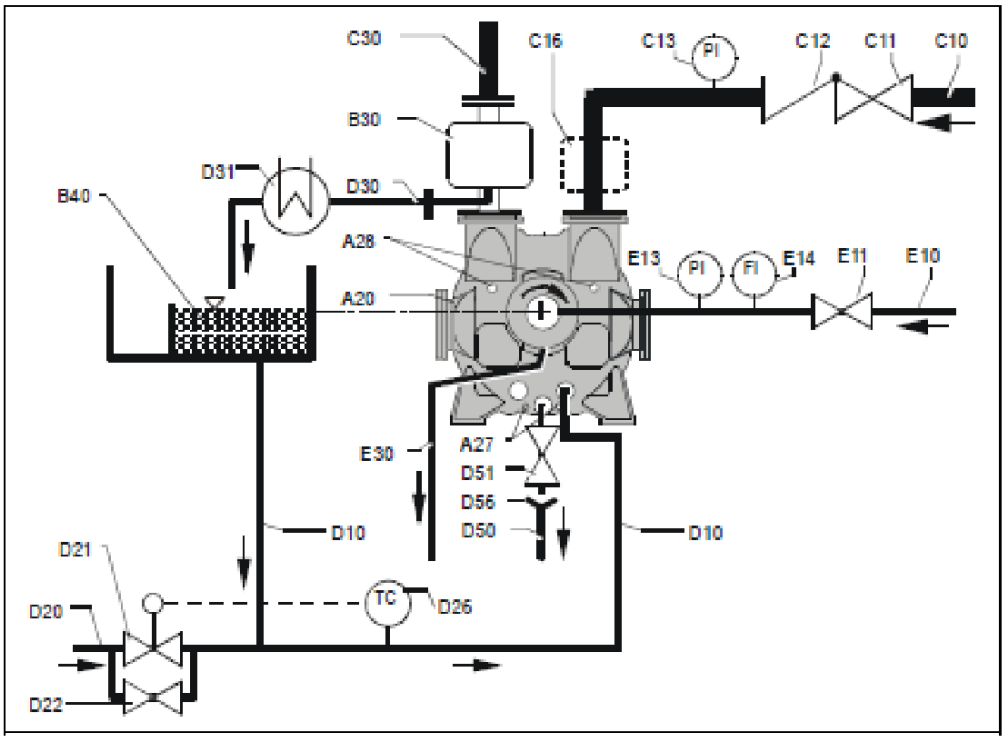


Figure 13: Connection with top-mounted liquid separator and self-regulating operating-liquid circuit

A20 Vacuum pump/compressor
A21 Line for partial draining
A27 Plug for complete draining
A28 Plug for connection of pressure gauges
A41 Shut-off fittings (for ensuring partial draining)
B30 Liquid separator (assembled)
B40 Operating-liquid feed tank
C10 Inlet pipe
C11 Shut-off fitting
C12 Non-return fitting
C13 Pressure gauge
C16 Y-pipe
C30 Discharge pipe (gas)
D10 Feed pipe for operating Liquid
D20 Feed pipe for additional operating Liquid
D21 Shut-off fitting
D22 Bypass valve
D26 Thermostat
D30 Discharge pipe for separated operating Liquid
D31 Cooling tower or heat exchanger
D50 Discharge pipe for draining and flushing
D51 Shut-off fitting
D56 Funnel or sight glass
E10 Feed pipe for sealing Liquid (only for design with external sealant supply)
E11 Shut-off fitting
E13 Pressure gauge
E14 Volume flow meter
E30 Discharge pipe for seepage liquid of shaft seal

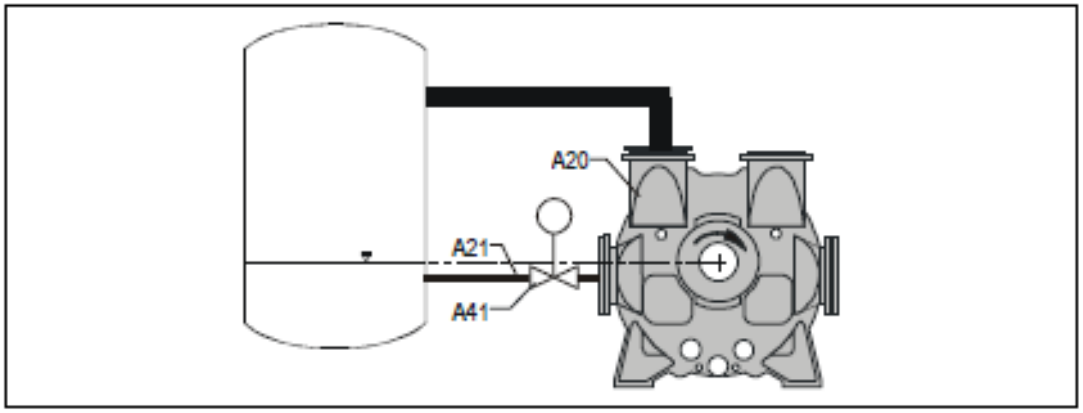


Figure 14: Connection with side separator

The liquid level inside the separator should be at a maximum level equal to the shaft center.
To enable partial draining, the flange connection must be connected to the separator using the designated line for partial draining (A21). For this connection, automatically actuated shut-off fittings (A41) are necessary to ensure proper partial draining.
These shut-off fittings (A41) should be adjusted as follows:
Open position during standstill or when the machine is not operating.
Closed position during machine operation, closing right after the machine is switched on, to prevent constant leakage of liquid and gas during Operation.
If a self-regulating operating-liquid circuit is employed, it eliminates the need for partial draining through the line (A21). In this case, the side discharge connections must be securely sealed off.
The diagram depicting the supply of operating liquid and sealing liquid has not been provided.

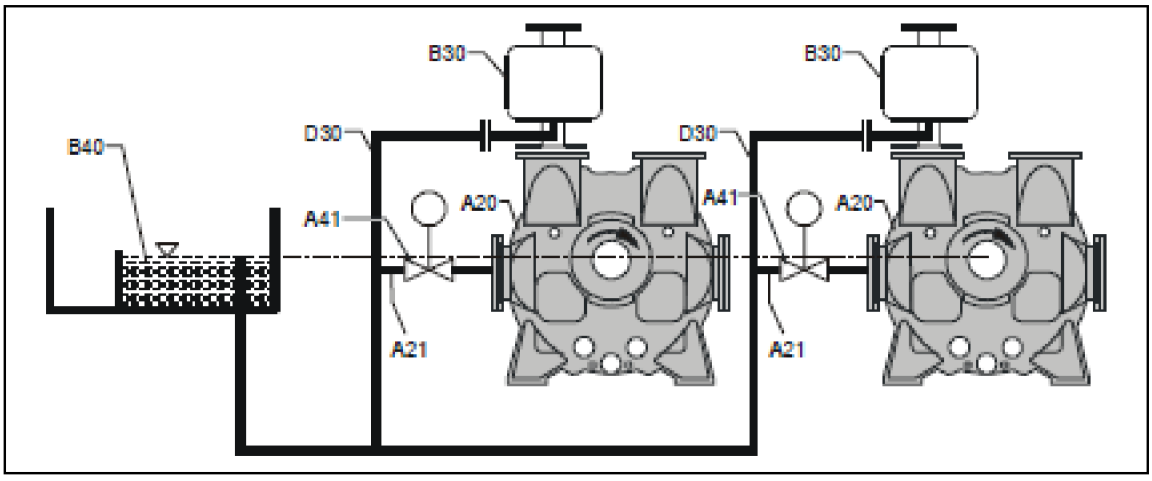


Figure 15: Connection for several machines with shared liquid tank

The liquid level inside the operating-liquid feed tank (B40) should be maintained at a maximum level equal to the shaft center.

To enable partial draining, the flange connection must be linked to the operating-liquid feed tank (B40) using the specified line for partial draining (A21). In this setup, automatically actuated shut-off fittings (A41) are necessary to ensure proper partial draining.
The shut-off fittings (A41) should be adjusted as follows:
In the open position during standstill or when the machine is not operating.
In the closed position during machine operation, closing immediately after the machine is switched on, to prevent continuous leakage of liquid and gas during Operation.
If a self-regulating operating-liquid circuit is employed, the need for partial draining through the line (A21) can be eliminated. However, it is crucial to seal off the side discharge connections when this option is chosen.
Please note that the supply of operating liquid and sealing liquid have not been given.

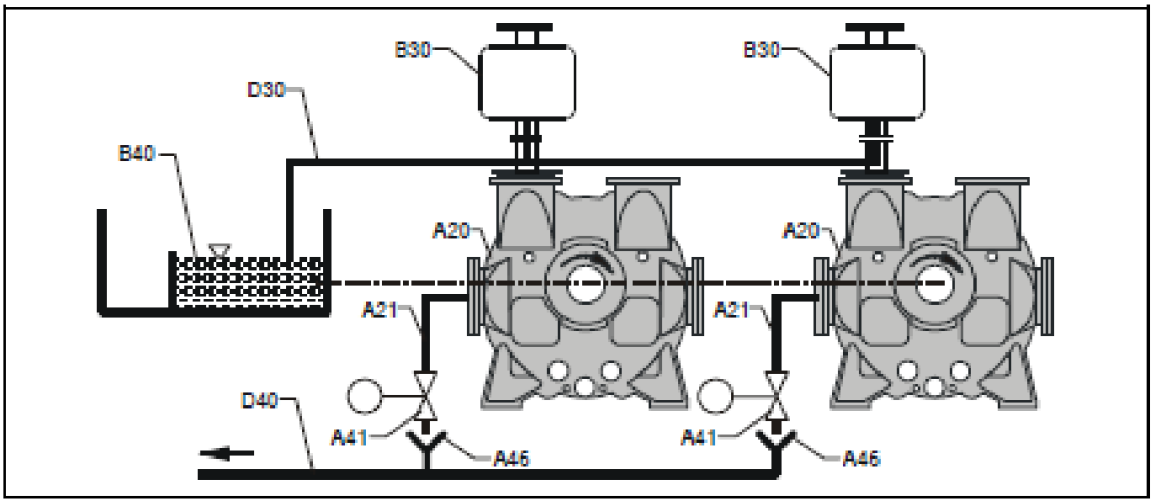


Figure 16: Connection for several machines with raised liquid tank

The liquid level in the tank should be maintained above the shaft center.
For this specific connection setup, it is necessary to include automatically actuated shut-off fittings (A41) to ensure proper partial draining. The adjustments for these shut-off fittings (A41) are as follows:
Open position during standstill or when the machine is not operating.
Closed position during machine operation, closing immediately after the machine is switched on, to prevent constant escape of liquid and gas during Operation.
Please note that with this connection variant, partial draining via the feed pipe for operating liquid is not possible.
The diagram or details depicting the supply of operating liquid and sealing liquid have not been provided.

A20 Vacuum pump/ Compressor
A21 Line for partial draining
A41 Shut-off fittings (for ensuring partial draining)
A46 Funnel or sight glass
B30 Liquid separator (assembled)
B40 Operating-liquid feed tank
D30 Discharge pipe for separated operating Liquid
D40 Discharge pipe for excess operating Liquid

9.4.2 Examples of circuit diagrams of compressors

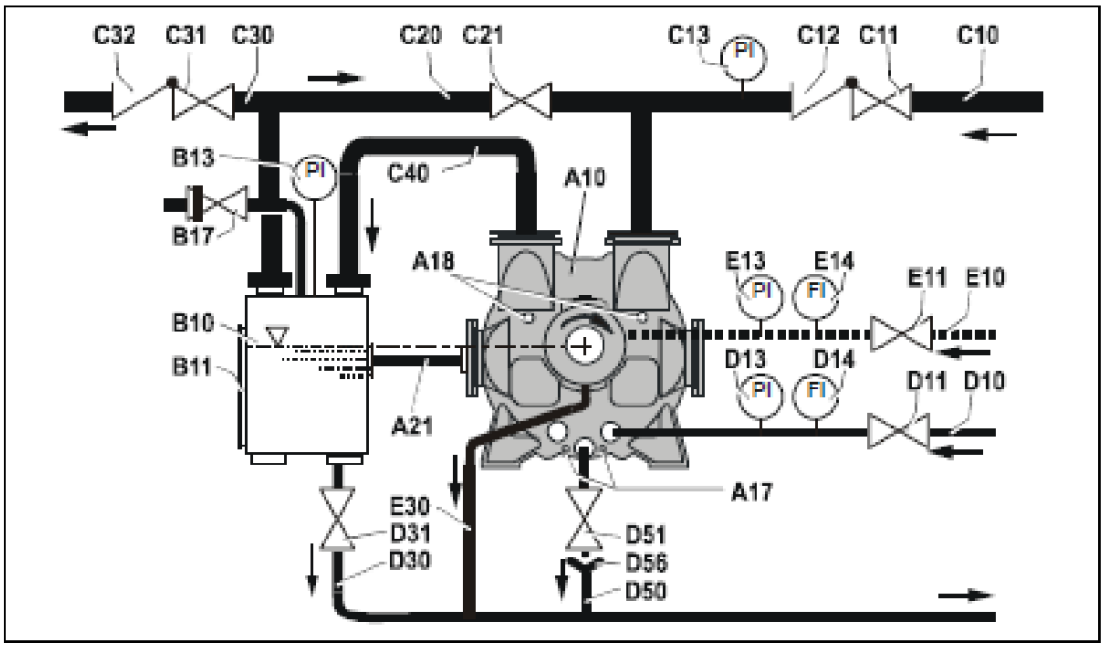


Figure 17: Diagram with discharge connection at top

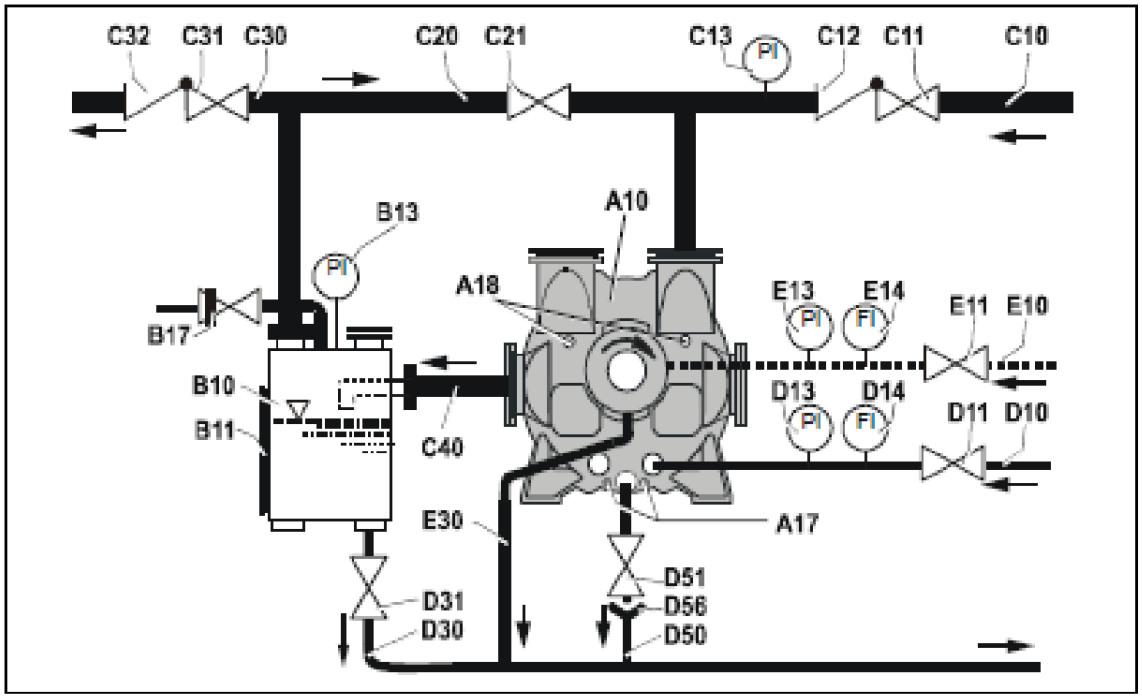


Figure 18: Diagram with discharge connection at bottom

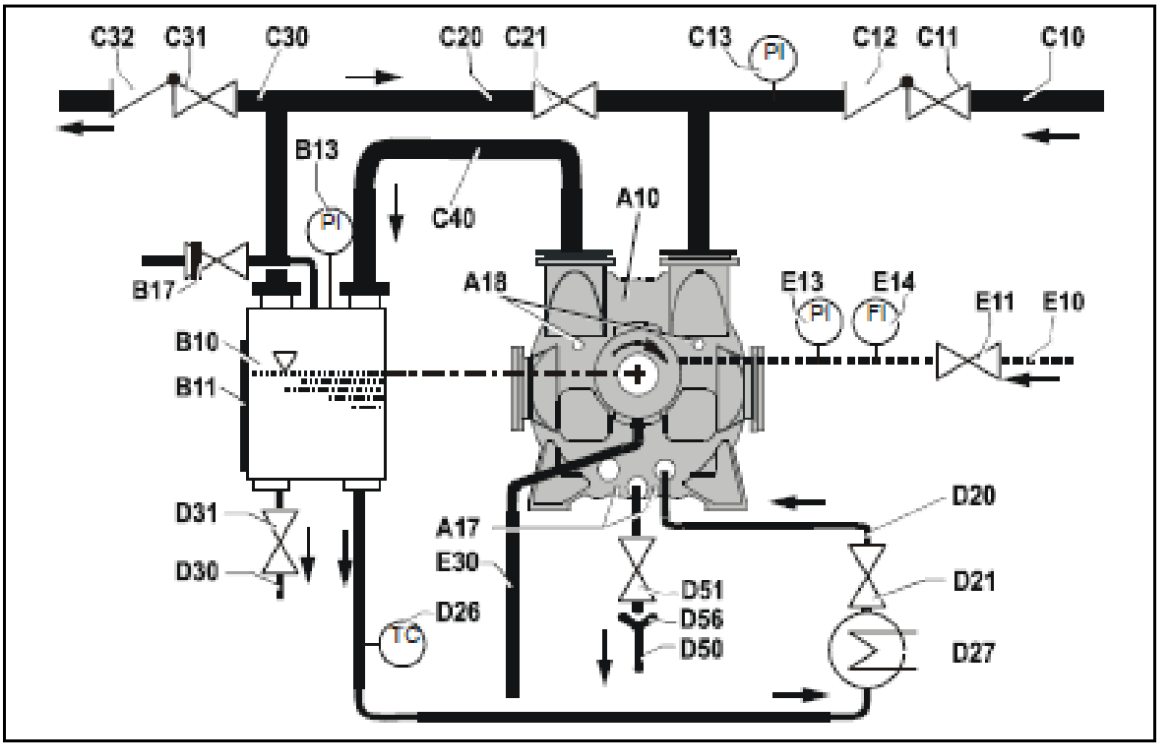


Figure 19: Connection with self-regulating operating-liquid circuit