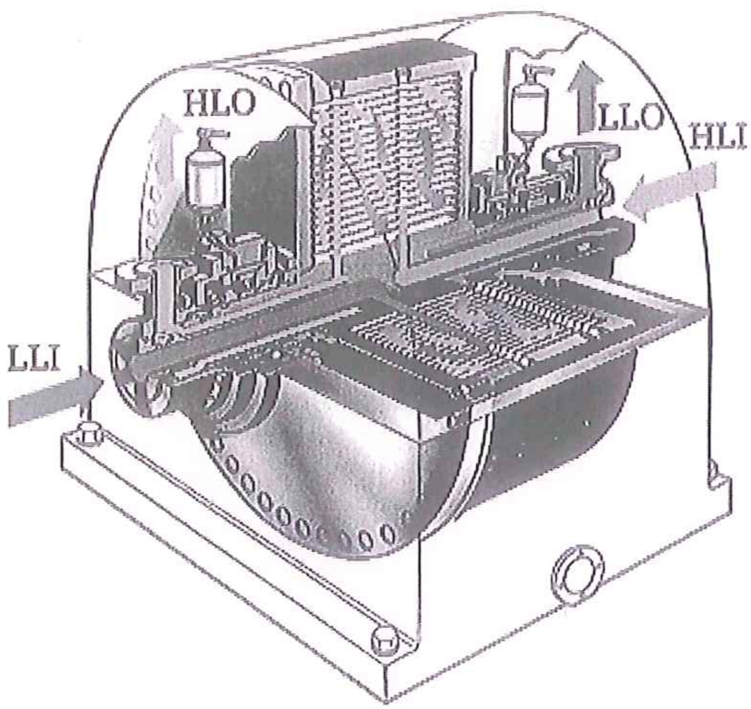
B&P Podbielniak®
Centrifugal Contactor



User Manual

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holder and no infringement is intended.

Preface

This user manual contains operating and maintenance information for the B&P Podbielniak® centrifugal contactor and should be considered a permanent part of this equipment. **The manual must remain with the equipment at time of transfer or resale.** These instructions should be followed to ensure dependable performance.

The user manual provides instructions and information pertinent to optional equipment, which might or might not have been included in the original purchase. The specification sheets that follows lists specific information about the equipment for which this copy of the manual was issued. The specification sheets also cover optional equipment included with the original purchase and space to add optional equipment installed at a later date.

The warranty applies only if the equipment is operated within the rating and service conditions for which it was specifically sold. The purchaser must prevent the existence of any destructive external conditions, which typically include:

- Operating close to critical speed
- Severe shock loading
- Mechanical or thermal overloads
- Other conditions of which the seller was not fully advised

The unit must be installed, operated, and maintained in accordance with the instructions in this manual.

Adequate installation, maintenance, and safety instructions should be provided to personnel directly responsible for the operation of the equipment.

Please remember that when service is required, B&P Process Equipment and Systems knows your equipment best. Consult B&P for assistance.

Table of Contents

Section 1: Safety

1.1 Overview

Introduction

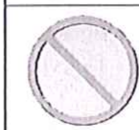
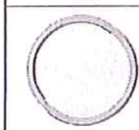
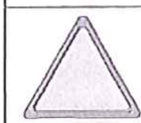
Employers are responsible for meeting safety and health regulations. B&P equipment is designed and built to meet safety and health standards in effect at the time of manufacture. However, industrial equipment neither lasts forever nor is designed to be self-restoring. B&P expects that its equipment, when properly installed, operated, and maintained, will enable employers to comply with applicable safety regulations.

User Manual

This manual should be a permanent part of the equipment and must remain with the equipment in case of transfer or resale.

Symbols

In this manual, statements preceded by certain symbols are of special significance.

Symbol	Meaning
	**PROHIBITED: Action represents an immediate potential hazard.**
	**MANDATORY: Failure to act represents an immediate potential hazard.**
	**WARNING: Potential hazard, unsafe situation, or equipment damage could result.**
	NOTE: Point of interest for efficient operation and/or maintenance.

Equipment Modifications

Where possible, B&P, at the buyer's request and at prices in effect at that time, will modify equipment so that it meets required safety and health standards.

Safety Devices

Guards, alarms, interlocks, and other safety devices furnished by B&P must be installed. Procedures in the operating instructions must be carefully followed. The user also is responsible for furnishing and installing guards or other safety equipment needed to protect operating personnel, even though such safety equipment might not have been furnished by B&P.

1.2 Safety Guidelines

General Guidelines

Specific operating instructions for the use of this equipment should be prepared by the user to include the following requirements:

- Compliance with applicable safety regulations and codes
- Personal protection of employees and use of hard hats, safety glasses, ear protection, etc.
- Protection of employees from exposure to hazards (hot surfaces, etc.)
- Clearly visible safety signs
- Alarm systems to alert employees that equipment is being started
- Venting equipment away from work areas
- Instructing operators on emergency response

Before Starting

Check the following:

- Operator has received adequate instruction for safe operation.
- All access openings are closed and properly secured.
- Area is free of slipping and tripping hazards.

Operating or Servicing

Observe the following precautions:

- **Leave rotor cover closed while rotor is turning.**
- **Do not remove belt guard while equipment is operating.**
- **Conduct repair or maintenance work only after the rotor has completely stopped. Block out inlet and effluent lines and lock out drive motor.**
- **Observe appropriate safety procedures:**
  - **Handling materials**
  - **Operating and maintaining pressurized equipment**

Additional Cautions

- Keep clear of moving parts when stopping equipment. Rotating parts can continue rotating for 30 minutes or more after power has been shut off.
- Lock out equipment to prevent accidental restarting during maintenance.
- Replace any guard, shield, or barrier before resuming operation.
- Do not operate equipment with interlocks, guards, shields, barriers, chains, and similar devices removed or altered.
- Provide adequate installation, maintenance, and safety instructions to personnel operating the equipment.
- Keep unauthorized personnel at a safe distance from operating equipment.

Section 2: System Description

2.1 Overview

Introduction

The Podbielniak® centrifugal contactor consists of a base, rotor, and drive. Figure 2-1 shows a cutaway view of the contactor (without drive).

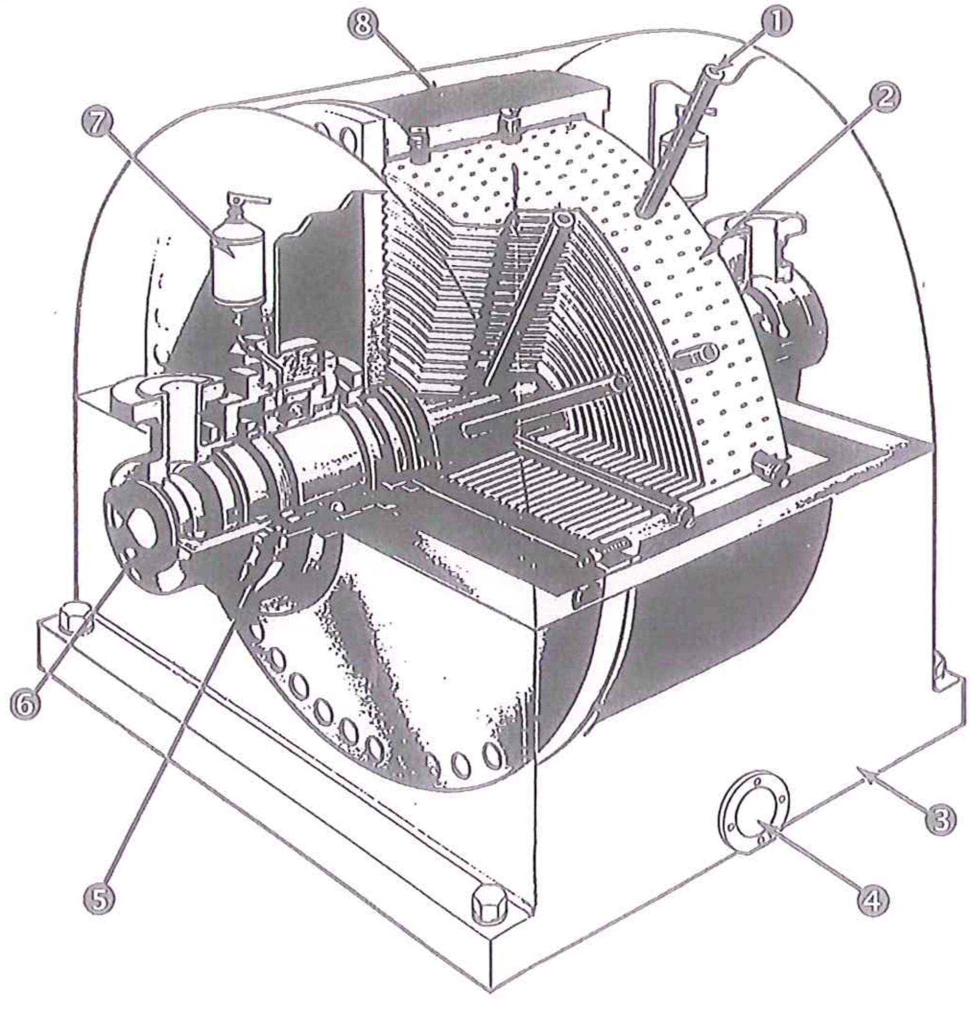


Figure 2-1 Cutaway of Podbielniak® Contactor

① = ASCO tube	② = Elements	③ = Base	④ = Drain port
⑤ = Mechanical seal	⑥ = Shaft	⑦ = Oiler	⑧ = Rotor

Base

The base is a cast-iron housing that supports the rotor assembly, bearings, and seals. It also provides connections for incoming and separated liquids and lubrication.

Rotor

The rotor is a metal cylinder that rotates on a shaft. Inside the cylinder are perforated trays, called elements, that control the separating and contacting action. Product feed tubes enter the cylinder at right angles to the shaft with holes drilled in different radial positions. These pipes distribute incoming liquid and collect separated liquids.

The shaft runs through the center of the cylinder and contains passageways for incoming and outgoing liquids. It also has provisions for mounting bearings, seals, and the drive sheave.

Drive

An electric motor is connected directly to the input shaft of a Gýrol fluid drive. The output shaft is connected to the contactor with a poly-V-belt (Figure 2-2). Inside the fluid coupling are two sets of vanes:

- Pump or impeller (attached to power source)
- Runner (attached to output shaft)

The fluid coupling contains oil such that no mechanical connection exists between the input and output shafts. The rotating force supplied by the motor is transferred only by the oil. See appendix for more information.

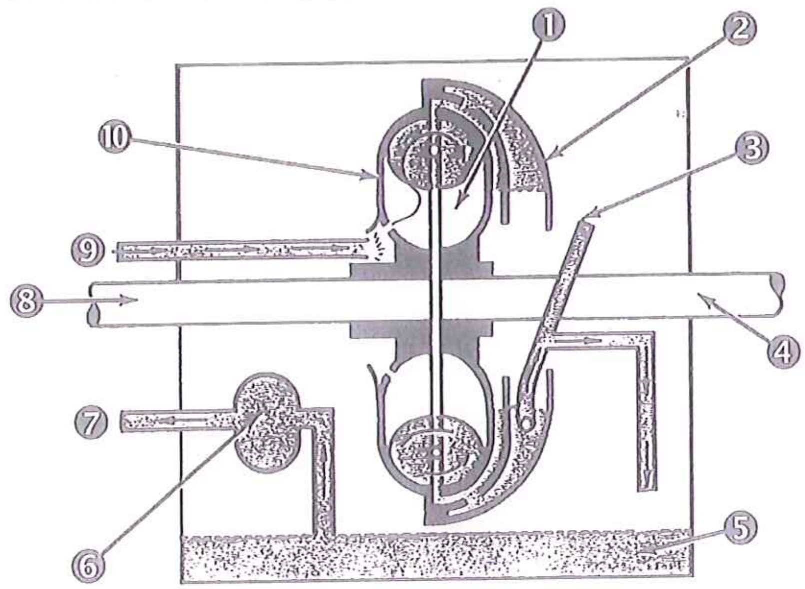


Figure 2.2 Gýrol Fluid Drive

① = Runner	② = Casing	③ = Movable scoop	④ = Output shaft
⑤ = Oil reservoir	⑥ = Circulating pump	⑦ = Oil to cooler	⑧ = Input shaft
⑨ = Oil from cooler	⑩ = Impeller		

Section 3: Principles of Operation

3.1 Basic Principles

Introduction

The Podbielniak® centrifugal contactor has been designed to perform either of the following two functions:

1. Contact two immiscible liquids countercurrently, thereby accomplishing countercurrent extraction (contactor)
2. Separate a mixture of immiscible liquids into two components (separator)

Rotor

The rotor in which the contacting or separating takes place is enclosed in a cast-iron base with protective cover. The liquids flow into and out of the rotor through specially designed passages in the shaft that are isolated from each other and from the atmosphere by mechanical seals at each end of the shaft (Figure 2-1).

Contactor

The Podbielniak® centrifugal contactor can be thought of as a perforated tray tower with the trays wrapped around the shaft. Countercurrent movement of the light and heavy liquids takes place under the influence of centrifugal force developed by rotating the contactor from about 1000 to 3200 rpm, depending on the size of the contactor and the liquids being handled. The force that moves the heavy liquid outward and the light liquid inward is much greater than the gravitational force upon which a conventional tower depends.

Fluid Coupling

The contactor is connected to an electric motor through a fluid coupling. The fluid coupling contains two sets of vanes (Figure 2-2). The first set, called the impeller or pump, is connected to the motor. The second set, called the runner, is connected to the contactor drive shaft using a poly-V-belt.

There is no mechanical connection between the input and output shafts of the fluid drive. The motor turns the impeller vanes and the torque supplied by the motor is transferred to the oil. The moving oil is forced against the runner vanes, which causes the output shaft to rotate.

With the fluid drive, starting or stopping shocks or shocks due to bearing failure or vibration are not transmitted to the drive belt or motor. This reduces wear, prevents damage, and promotes safety.

A circulating pump, usually driven by the input shaft, pumps oil from the housing reservoir through an external heat exchanger to remove excess heat, then returns it to the working elements. All moving parts in the fluid drive are either submerged in oil or pressure-lubricated. The oil transmits power, removes heat, and lubricates.

Speed Control

The speed control permits the contactor to operate at variable speeds up to the maximum noted below. Variable speed allows the speed to be optimized for a given separation.

A movable scoop tube controls the amount of oil in the working circuit of the fluid drive, which varies the output speed. The scoop tube returns the oil to the reservoir, where it flows to the pump, heat exchanger, and back to the working circuit.

The position of the scoop tube can be controlled either manually or with automatic control devices. This method gives fast response and smooth, stepless speed control over a wide range. See appendix for more information.

Model	Maximum Speed with 316SS Rotor @ Specific Gravity 1.0
B-10	3200 rpm
D-18 and D-36	2100 rpm
E-48	1600 rpm

Contactor Braking

The electric motor can be wired to be reversible, performing as a brake for the contactor. When the impeller vanes of the fluid drive are reversed while in operation, they turn in the opposite direction from the runner vanes. The impeller thereby forces oil against the runner, slowing the shaft gradually and safely. However, cooling water flow to the heat exchanger should be increased to dissipate any additional heat generated by the braking action.

If faster braking is desired, make provisions to flood the contactor base using the drain connection on the front of the contactor base.

3.2 Operation as an Separator

Introduction

When operated as an separator, the combined heavy and light liquids enter the working chamber of the rotor through inlet ports that discharge near the rim. These ports consist of the light liquid in (LLI) and heavy liquid in (HLI) (Figure 3-1).

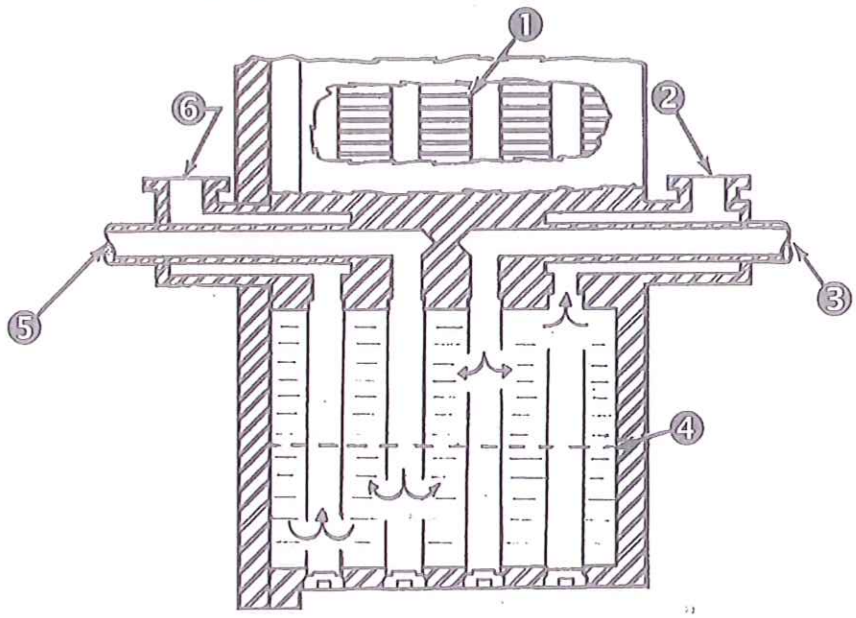


Figure 3-1 Rotor Cross Section

① = Perforated elements	② = Light liquid out (LLO)	③ = Heavy liquid in (HLI)
④ = Principal interface	⑤ = Light liquid in (LLI)	⑥ = Heavy liquid out (HLO)

Operation

Feed pump pressure forces the combined liquids to the outer rim of the chamber. Centrifugal force then causes the liquid with the higher specific gravity to separate from the light liquid and displace the light liquid toward the center of the chamber. Thus, three layers develop in the chamber:

- Heavy liquid near the rim
- Intermediate mixed heavy and light liquid
- Light liquid near the center

The feed pump also causes the liquids to exit the machine under pressure. The heavy liquid exits through the heavy liquid out (HLO) tubes with openings nearest the rotor rim. The light liquid exits through the light liquid out (LLO) tubes with openings nearest the shaft. The degree of separation can be controlled by varying rotor speed or by restricting the heavy or light liquid outlet flows.

As an extractor, either or both of the LLI and HLI tubes can supply unseparated feed.

3.3 Operation as a Contactor

Introduction

When operated as a contactor, the heavy liquid enters the working chamber through the HLI tubes (slightly longer than LLO). The light liquid enters near the rim through longer tubes called LLI tubes (Figure 3-1).

Operation

Feed pump pressure forces both liquids towards the rim. The heavy liquid enters the chamber closer to the shaft and has a greater specific gravity, so it passes through the lighter liquid. Three layers develop in the chamber:

- Nearly pure heavy liquid near the rim
- Intermediate layer of mixed heavy and light liquid
- Nearly pure light liquid near the shaft

The level in the mixed layer where the two liquids have greatest contact is called the principal interface. The reseparated, heavy liquid exits through the HLO tubes, which have holes nearest the rim. The reseparated, light liquid exits through the LLO tubes (Figure 3-1), which have holes nearest the shaft.

Purity can be controlled by restricting the heavy or light liquid outlet flows.

3.4 Operating Parameters

Introduction

Operating parameters for the contactor include pressure, temperature, and rotor speed.

Pressure

The maximum recommended operating pressure is 1825 kPa (250 psig). This limitation sets the allowable pressure for the light liquid in (P_{LLI}) port, the highest of the operating pressures, according to the formula:

$$P_{LLI} = P_f + P_c$$

where:

P_{LLI} = Pressure required for operation of contactor
P_f = Frictional pressure drop—pressure difference required to overcome frictional resistance opposing liquid flow
P_c = Centrifugal pressure drop—pressure difference required to overcome centrifugal head of heavy liquid in rotor

Frictional pressure drop depends on:

- Size and shape of passageways through the contactor
- Viscosity of liquids
- Rotor speed
- Rate of flow through contactor

Centrifugal pressure drop [psi] can be calculated from:

$$P_c = (0.513 \times 10^{-6}) R^2 N^2 \Delta S$$

where:

ΔS = Specific gravity difference between the liquids at LLI and HLO
N = Speed of rotor (rpm)
R = Radius of feed inlet (in.)

For a given contactor operating at a given maximum speed, R and N are fixed and the equation simplifies to:

$$P_c = K \Delta S$$

For typical applications, where $\Delta S = 0.2$ (kerosene and water) and the feed inlet radius (R) and rotor speed (N) are as shown, values of K and of P_c are as follows:

	R	N	K	P_c	
Model	inch	rpm	$(0.513 \times 10^{-6}) R^2 N^2$	psig	kPa
B-10	10.00	3200	525	106	832
D-18 and D-36	15.75	2100	561	112	874
E-48	20.00	1600	525	105	825

Basic Assumptions A basic assumption in the foregoing discussion is that the principal interface is inside the LLI radius. If the principal interface is outside the LLI radius (by maintaining a very high LLO back pressure), the centrifugal pressure drop will increase beyond that calculated above.

Rules of Thumb Generally, for maximum extraction efficiency, a high back pressure (for example, 90% of P_{LLI}) should be imposed when the flow of heavy liquid greatly exceeds the flow of light liquid. Conversely, a low back pressure (for example, 25% of P_{LLI}) is desirable when flow of light liquid greatly exceeds flow of heavy liquid. For simple phase separations, a high back pressure is usually best for optimum clarification of the light liquid.

Limits of pressure control at a specific rotor speed and capacity are determined by complete flooding of heavy liquid into light liquid effluent at too low a setting or complete flooding of light liquid into heavy liquid effluent at too high a setting. Process variables, such as flow rate and rotor speed, must also be considered when establishing final LLO pressure for continuous operations.

Temperature

The maximum operating temperature is 120°C (250°F). If higher temperatures are required, contact B&P.

Rotor Speed

Operate the contactor at the lowest rotor speed that provides the required extraction efficiency and clarification and promotes the maximum mechanical seal and bearing life. This speed should be established for each type of extraction and might or might not be the maximum design speed.

Required rotor speed will depend upon the liquids being handled. Since operating pressure (P_c) varies directly with the specific gravity difference (ΔS) and the square of the rotor speed, rotor speed should be adjusted for a given ΔS.

- If ΔS is large, the rotor speed should be low.
- If ΔS is small, the rotor speed should be high.

In designing commercial contactors for a specified system, B&P will establish the diameter, speed, and pressure drop for the proper LLI pressure. If other liquids are used, LLI pressure will be different unless compensating changes are made.

Contact B&P with specific gravities, viscosities, and flow rates. B&P will suggest a rotor speed to achieve a reasonable and efficient inlet pressure.

General Rule for Rotor Speed

Select a speed for which LLI pressure ranges between 1135 to 1480 kPa (150 and 200 psig). For systems with a large ΔS:

- Start with a low rotor speed (for example, 50% of maximum).
- Determine LLI pressure at this speed.
- Increase the rotor speed until LLI pressure is 1135 to 1480 kPa (150 to 200 psig).

A lower LLI pressure is appropriate if the pressure above is not obtained at the maximum speed or if the feed pump has insufficient head pressure.

Figure 3-2 gives typical relationships between the $P_{LLI} - P_{HLO}$ and the rotor speed of the models for various ΔS values. If the heavy liquid has a specific gravity greater than 1.0, the maximum speed should be reduced by an inverse ratio to the square root of the specific gravity. For example, with a Model B-10, the specific gravity of the heavy liquid effluent is 1.44, so the maximum speed will be:

$$3200/1.44^{0.5} = 2670 \text{ rpm}$$

A lower speed might be specified for contactors made of alloys other than 316 stainless steel, especially for high-temperature operation.

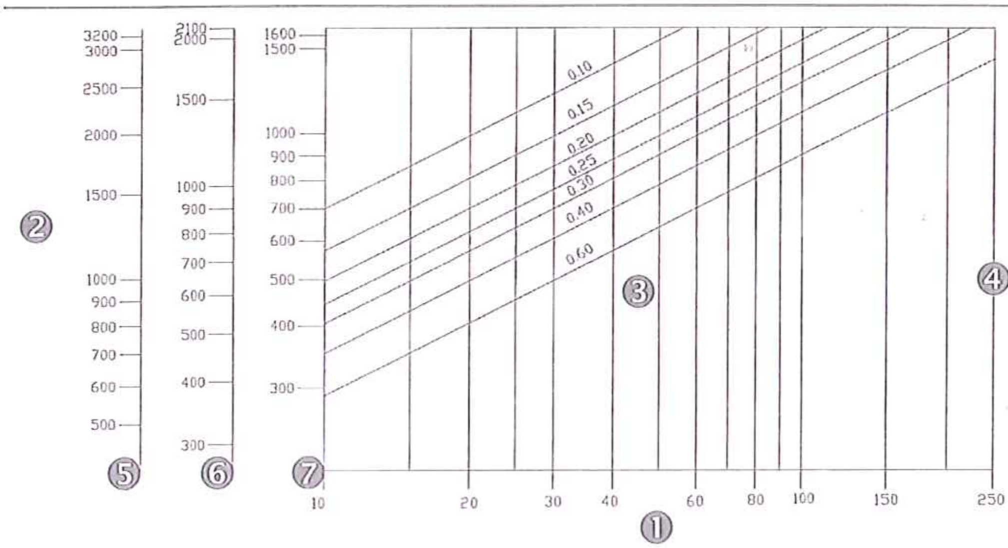


Figure 3-2 Light Liquid In Pressure Relationship

① P_{LLI}–P_{HLO} pressure (psig) ② Rotor speed (rpm) ③ Specific gravity difference
④ Maximum pressure ⑤ B series ⑥ D series ⑦ E series

3.5 Evaluating Systems with Unknown Characteristics

Introduction

Engineers should determine the optimal capacity and extraction efficiency for new or unknown systems by experimenting with rotor speed, feed rate, and back pressure. Experimentation will also evaluate system flexibility. The experiments will vary depending upon the goal of the extraction.

Goal A

Use the following steps if the goal is maximum throughput with adequate separation.

Step	Action
1	Select a series of rotor test speeds. For example, start at 25% of the maximum speed and increase at regular intervals (such as 500 rpm increments). Do not exceed nameplate maximum.
2	Operate contactor at test speed.
3	Increase feed rate stepwise until flooding occurs (separation is lost).
4	Increase back pressure.
5	Evaluate whether separation improves.
6	Note rotor speed, feed rate, and back pressure at which maximum throughput with satisfactory separation is achieved.
7	Increase rotor speed to the next increment and repeat steps 2 through 6.
8	Continue testing up to the maximum nameplate speed.
9	Determine optimum combination of rotor speed, feed rate, and back pressure to maximize throughput.

Goal B

Use the following steps if the goal is maximum throughput with best possible separation.

Step	Action
1	Select a series of rotor test speeds. For example, start at 25% of the maximum speed and increase at regular intervals (such as 500 rpm). Do not exceed nameplate maximum.
2	Operate contactor at test speed.
3	Increase feed rate stepwise until flooding occurs (separation is lost).
4	At each feed rate increase, sample and analyze the outlet streams to determine the actual separation.

!	To achieve valid results, run the contactor for several minutes at each variable combination before sampling.
5	Record the feed rate at which the best separation occurs.
6	Increase rotor speed to the next increment and repeat steps 2 through 5.
7	After testing at maximum rotor speed, determine rotor speed and feed rate and highest throughput for the best separation.

3.6 O-Ring Selection

Introduction

O-rings protect the mechanical seal components on the contactor shaft and seal housing. O-rings rarely experience dynamic loads (for example, a rotating shaft), but do protect rotating elements.

Selection Criteria

Check standard references to determine O-ring materials that are compatible with process. Elastomeric O-rings are preferred because they simplify installation. However, Teflon O-rings might be preferable if elastomers are not compatible with the process liquids,. If Teflon is used, a normal O-ring design will usually be satisfactory, but other types, such as TG or Bal Seals, might be appropriate.

O-Ring Types

The following O-ring types are available with the contactor. Make sure the parts list shows the proper O-rings and that new O-rings are always used when reassembling the contactor.

Type	Material
EPR	Ethylene-propylene rubber
Buna N	Nitrile or Buna-N elastomer
Teflon	Tetrafluoroethylene (TFE)
Viton A	Fluorocarbon elastomer
Kalrez	Perfluoroethylene elastomer
TG-type	Teflon
Spring-loaded (Omniseal or Bal Seal)	Teflon
Encapsulated	Viton encapsulated with Teflon
Other types	Other types and materials can be specified if necessary

Section 4: Installation

4.1 Structural Requirements

Introduction

Observe the following structural requirements in all installations.

General Instructions

General responsibilities of the customer:

- Providing an adequate foundation.
- Confirming that foundations and/or floors are adequate and will not resonate at the harmonic frequency of the equipment.
- Consulting B&P if a vibration isolation system is being considered.

Contactor

Refer to foundation plan (supplied with equipment) for dimensional details and the method of setting the contactor and the drive on the foundation.

Step	Action
1	Mount contactor on finished concrete surface.
2	Seal foundation with cement wash, epoxy, or other sealer to prevent deterioration from chemical spills.
3	Shim any elastomeric isolators to level. The use of anchor bolts in pipe sleeves (Figure 4-1) securely imbedded in the concrete is recommended to position the equipment.
4	Set lower isolators in place on anchor bolts.
5	Set contactor in place on lower isolators.
6	Set motor and drive in place using hoist.
7	Put nuts on anchor bolts and torque to 0.42 to 0.63 N-m (10 to 15 lb-ft).
8	Tighten anchor nuts on drive.
9	Tighten anchor nuts after start up until vibration is less than 0.01 cm (4 mils).
	Do not overtighten anchor bolts. If overtightened, the isolators will not isolate vibration and could allow fatigue failure of anchor bolts.
10	Once vibration is adequately controlled, install and tighten check nuts against the anchor nuts. Be sure anchor nuts are not tightened further.

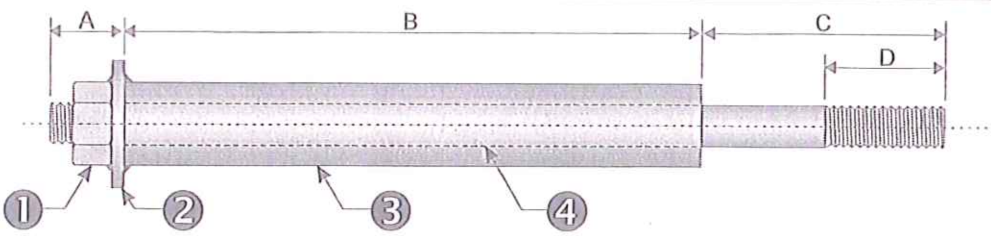


Figure 4-1 Recommended Anchor Bolt Construction

Dimension, Part	Model B-10		Model D-18/36		Model E-48		Drives	
	inch	cm	inch	cm	inch	cm	inch	cm
A	1.25	3.2	1.75	4.4	2.00	5.1	1.50	3.8
B	9.00	23.0	9.00	23.0	10.00	25.4	9.00	23.0
C	4.00	10.2	5.50	14.0	6.00	15.2	1.50	3.8
D	2.00	5.1	2.50	6.4	3.00	7.6	1.25	3.2
①	⅝″ NC hex nut		1″ NC hex nut		1¼″ NC hex nut		⅝″ NC hex nut	
②	¼ × 2½ × 2½ plate with ¾″ hole		¼ × 3 × 3 plate with 1⅛″ hole		¼ × 3 × 3 plate with 1⅜″ hole		¼ × 2½ × 2½ plate with ¾″ hole	
③	1½″ S40 pipe		2″ S40 pipe		2″ S40 pipe		1½″ S40 pipe	
④	⅝″ × 14½ Grade B2 stud NC×1¼ long thread one end NC×2 long thread other end		1″ × 16¼ Grade B2 stud NC×1½ long thread one end NC×2½ long thread other end		1¼″ × 18 Grade B2 stud NC×1¾ long thread one end NC×3 long thread other end		⅝″×12 Grade B2 stud (7.5 Hp) ¾″×12 Grade B2 stud (10, 15, 25, 40 Hp) NC×1¼ long thread both ends	

Note: Items ①, ②, and ③ are tack welded together.

Fluid Drive

Install sub-base rails for the drive, so that rails are level and securely bolted. The sub-base must be aligned so that the motor can be moved toward and away from the contactor, permitting poly-V-belt tension adjustment. Consult foundation plan for proper alignment. To install or remove poly-V-belt from the contactor shaft:

Step	Action
1	Remove seal housing on sheave side.
2	Insert belt over shaft between housing and shaft.
3	Refer to Section 6.3 for tensioning.

4.2 Utility Requirements

Introduction

The equipment will require water, drainage, and electrical power.

Drive Cooling Water

Water is required to cool the oil in the fluid drive. Cooling water connections should follow the same requirements as pipe connections (Section 4.3). Maximum rates are:

Model	Start Up		Continuous Operation	
	Lpm	gpm	Lpm	gpm
B-10	20	5	2	0.5
D-18 and D-36	60	15	2	0.5
E-48	80	20	2	0.5

Flush Water

Fresh water should be readily available for flushing and washing.

Drainage

Provide drain and drainage piping for:

- Handling wash water from cleaning contactor
- Carrying away material flushed from contactor

Drain piping should be constructed of corrosion-resistant materials. Connect drain piping directly to the connection at the front of the base (sizes listed below). The connection should not have a valve that could permit fluid to accumulate in the base.

Model	Drain Size
B-10	2-inch female NPT
D-18 and D-36	3-inch Class 150 flange
E-48	4-inch Class 150 flange

Electrical Power

Adequate electric power must be provided to operate the drive motor. Voltage should not vary more than ±10% of the nameplate voltage. Figure 4-2 is a typical starter wiring schematic.

The fluid drive should be controlled by:

- Across-the-line reversing magnetic starter with built-in overload protection
- Push-button station with stop/start/reverse positions

Reversibility allows the fluid drive to be used as a brake for the rotor. In this way, the rotor can be stopped more quickly than from friction and hydraulic resistance alone.

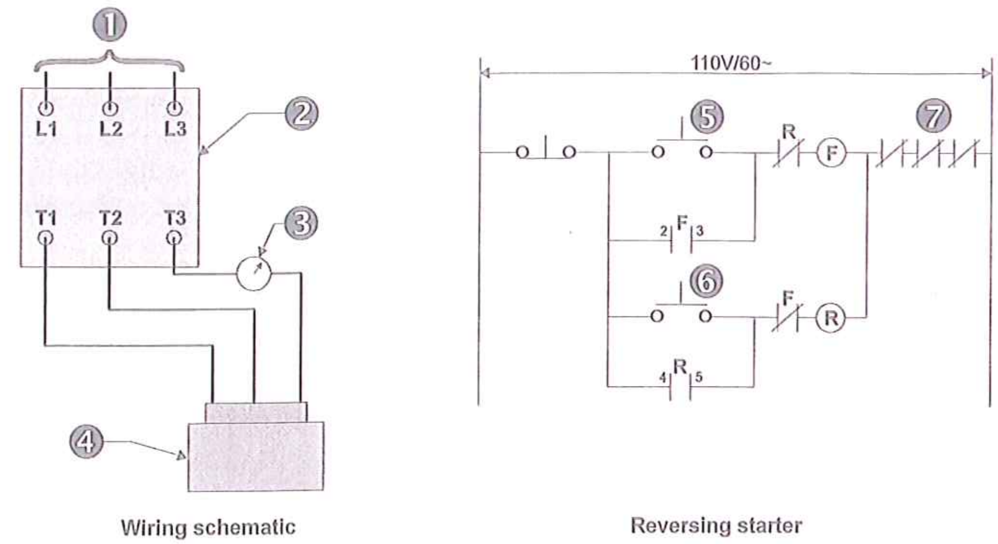


Figure 4-2 Typical Wiring Diagram for Motor Switch

① To power supply	② Magnetic starter	③ Ammeter	④ Motor
⑤ Forward	⑥ Reverse	⑦ Overloads	F = forward, R = reverse