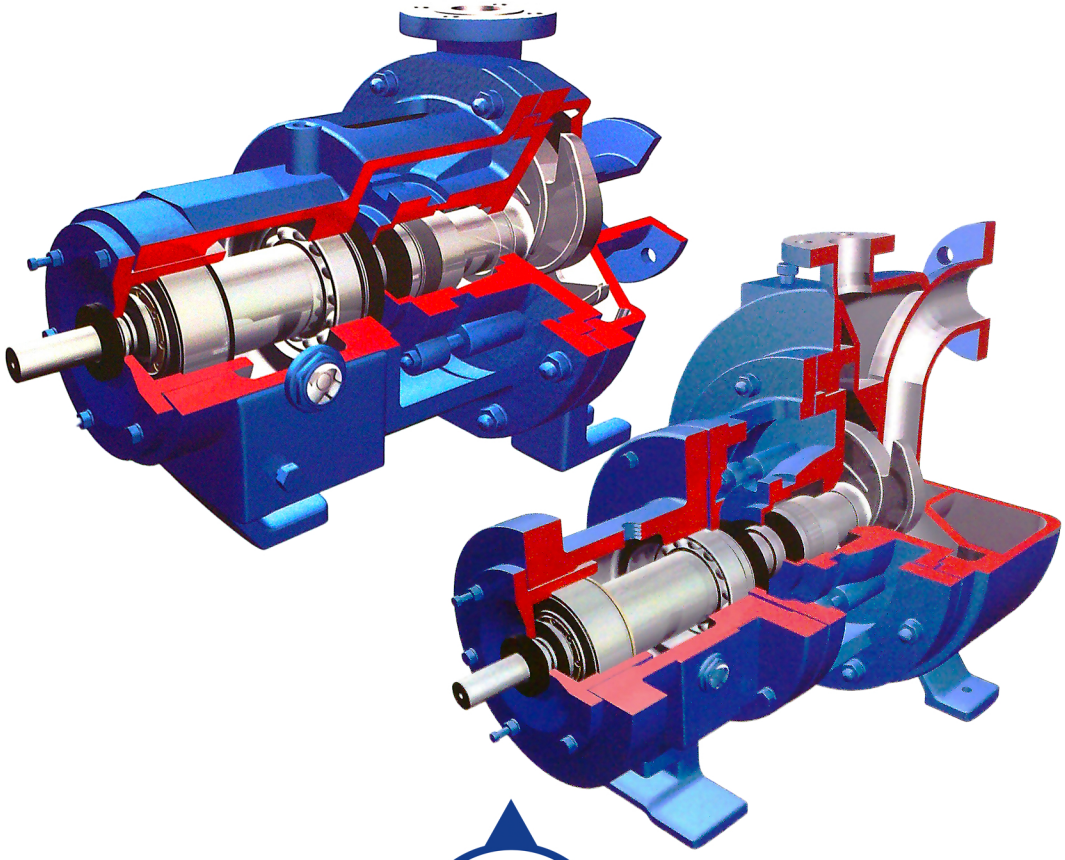
DA/DSP Series

Centrifugal Process Pumps
ANSI & ASME B73.1

Installation, Operation, & Maintenance Manual



TRUFLO™
QUALITY ○ VALUE ○ SERVICE

A New Vision For Quality Pumps

This manual provides instructions for the Installation, Operation, and Maintenance of the TRUFLO DAP ANSI Centrifugal Process Pump. This manual covers the standard production and common options that are available. For special options, supplemental instructions are supplied. This Manual must be read and fully understood before installation and start-up.

The design, materials, and workmanship incorporated in the construction of TRUFLO pumps make them capable of giving, trouble-free service. The life and satisfactory service of any mechanical unit, however, are enhanced and extended by correct application, proper installation, periodic inspection, condition monitoring, and careful maintenance.

This instruction manual was prepared to assist operators in understanding the correct methods of installing, operating, and maintaining these pumps.

TRUFLO shall not be liable for physical injury, damage or delays caused by a failure to observe the instructions for Installation, Operation, and Maintenance contained in this manual.

Warranty is valid only when genuine TRUFLO parts are used.

Use of the equipment on a service other than stated in the warranty card will nullify the warranty, unless written approval is obtained in advance from TRUFLO.

Additional manuals can be obtained by contacting your local TRUFLO representative or by calling 1-800-789-7864.

CONTENTS

1. SAFETY

1-1 NOMENCLATURE

This pump has been designed for safe and reliable operation when properly used and maintained in accordance with instructions contained in this manual.

A pump is a pressure-containing device with rotating parts that can be hazardous. Operators and maintenance personnel must realize this and follow safety measures. TRUFLO shall not be liable for physical injury, damage or delays caused by a failure to observe the instructions in this manual.

Throughout this manual the words **Warning, Caution,** and **Note** are used to indicate procedures or situations that require special operator attention.

WARNING

Warning is used to indicate the presence of danger that can cause severe personal injury, death, or substantial property damage if the warning is ignored.

CAUTION

Caution is used to indicate the presence of a danger, which will, or can cause minor personal injury or property damage if the warning is ignored.

NOTE: *Operating procedure, condition, etc. which is essential to observe.*

EXAMPLES;

WARNING	**CAUTION**
Pump shall never be operated without coupling guard installed correctly.	*Throttling flow from the suction side may cause cavitation and pump damage.*

1-2 GENERAL PRECAUTIONS

WARNING
Personal injury will result if procedures outlined in this manual are not followed.

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- Never use heat to disassemble pumps due to risk of explosion from trapped liquid.
- Never operate pump without coupling guard correctly installed.
- Never operate pump beyond the rated conditions to which the pump was sold.
- Never start pump without proper prime (sufficient liquid in pump casing).
- Never run pump below recommended minimum flow or when dry.
- Always lock out and tag out power to the driver before performing pump maintenance.
- Never operate pump with discharge valve closed.
- Never operate pump with suction valve closed.
- Do not change conditions of service without approval of authorized TRUFLO representative.

2. GENERAL INFORMATION

2-1 PUMP DESCRIPTION

The Model DAP is a horizontal overhung, open impeller centrifugal pump that meets requirement of ANSI B73.1. The model is based on 6 power ends and 31 hydraulic pump sizes. Groupings are as followed.

Group 1	----------	7 Pump sizes
Group 2	----------	14 Pump sizes
Group 3	----------	10 Pump sizes

Casing**:**
The pump casing is an end-suction and top discharge ANSI B73.1 design with 150lb ANSI raised face flanges as standard inlet and outlet connections. Inlet and outlet connections are available in 150lb or 300lb flanges with raised or flat face configurations. The casing is configured with a back pull out design, which allows complete disassembly without disturbing the piping or motor. A rigid foot mount for maximum resistance to unanticipated load supports the casing. Confined gasket between casing and back cover plate insures positive seal. Unit is also supplied with 1/4" NPT tap on the discharge flange.

Impeller:
The impeller is an open design for maximum efficiency, hydraulically balanced, with the best wear characteristics and no axial adjustments. The impeller is attached to the shaft by means of a MNPT bore on reverse side. The impeller has rear pump out vanes to minimize back cover plate pressure. The impeller clearances can be set externally via jack bolts on outboard side of the pump. Standard material for the impeller is 316 stainless steel (CF8M) unless the pump material is of higher grade alloy. All impellers are dynamically balanced.

Back Cover Plate:
Standard design is cylindrical bore and oversized for increased circulation. Back cover plate can accept a variety of mechanical seals, such as single, double (inside and out) unbalanced or balanced in any materials available. Flush plans are available.

Bearing Housing:
The bearing housing shall be sealed with labyrinth style bearing isolators to prevent contamination of the bearing lubricant. A large and easy to read 1" NPT sight glass and a magnetic filter shall be used.

Shaft:
Shaft is a heavy duty, solid shaft design with maximum diameter in critical areas and with minimum shaft overhang. Maximum shaft deflection is less then 0.002" at the face of the back cover plate. Shaft is also stepped to fit a variety of seal types. Standard shaft material is 316 stainless steel (CF8M) unless the pump material is of higher grade alloy.

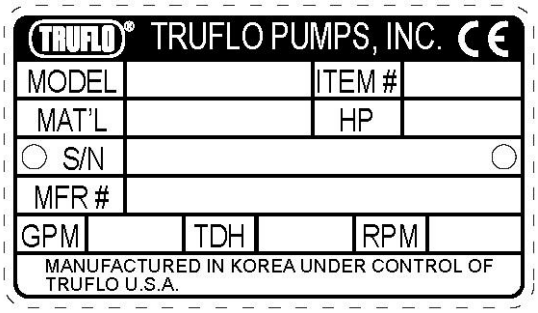
Bearings:
The inboard bearing carries only radial load, it is free to float axially in the frame. The outboard bearing is shouldered and locked to the shaft and housing to enable it to carry radial and thrust loads. All fits are precision machined to industry standards. The inboard bearing is a single row deep groove ball bearing. The outboard bearing is a double row angular contact bearing.

Shaft Sealing:
The back cover plate is available to fit a component seal, cartridge seal or packing.

Direction of Rotation:
Counterclockwise as viewed from casing, looking at the driver shaft.

2-2 ATTACHED INFORMATION

2-2.1 Pump Nameplate



Every pump has a TRUFLO nameplate that provides information about the pump. The nameplate is located on the bearing adaptor.

The nameplate provides information about the pump's characteristics. Note the format of the pump size: Suction Diameter x Discharge Diameter - Impeller Diameter (inches). (Example: 3 x 1.5 - 6)

When ordering spare parts you will need to identify pump model, size, serial number, and the item number of required parts. Information can be taken from the pump nameplate. Item numbers can be found in this manual.

2-2.2 Included Information

Each pump is sent with the following information in the form of attached tags, stickers and manuals:

1. Installation, Operation and Maintenance Manual
2. Stainless Steel Nameplate
3. Direction of Rotation Sticker
4. Label stating that the pump has been shipped without oil and requires oil before start up
5. Label stating that the pump needs to be realigned & rotation checked before start-up.

2-3 TRANSPORTATION & STORAGE

Inspect the pump as soon as it is received. Carefully check that everything is in good order. Make notes of damage or missing items on the receipt and freight bill. File any claims with the transportation company as soon as possible.

2-3.1 Storage Requirements

Short Term: (less than 6 months) TRUFLO's normal packing procedure is designed to protect pump during shipping. Upon delivery of equipment, store in a covered and dry location.

Long Term: (more than 6 months) Preservative treatment of bearings and machined surfaces will be required. Rotate shaft several times every 3 months. Refer to driver and coupling manufacturers for their long-term storage procedures. Store in a covered dry location.

2-3.2 Handling / Lifting

WARNING	CAUTION
Pump and components are heavy. Failure to properly lift and support equipment could result in serious physical injury or damage to the equipment. Steel-toed shoes must be worn at all times.	*Use a forklift or an overhead crane with sufficient capacity to move the equipment. Failure to do so can result in physical injury or equipment damage.*

WARNING:

- All applicable regulations and standards must be followed when lifting equipment.
- Assembled equipment and their components are very heavy. Failure to properly lift and support equipment can result in serious physical harm and/or damage to the equipment.
- Lift equipment only at the identified lifting points. Devices such as hoist rings, shackles, slings, straps, chains, spreaders, etc. must be rated to support the entire weight of equipment.
- Equipment and their components can be heavy. Use proper lifting methods and wear steel-toed shoes at all times.
- Do NOT lift equipment by shaft ends.
- Do NOT combine or interchange different lifting methods.

Pump Type	Lifting Method
Bare Pump Only	Use a suitable sling attached properly to the casing, flanges, and/or frame.
Base Mounted Pump	Use suitable slings attached properly to the casing and the motor or baseplate. Use lifting lugs or rings on the baseplate when available. For concrete polymer baseplates, see the baseplate IOM manual for additional lifting instructions.

Proper Lifting Method Examples

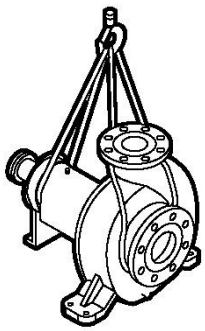


Figure 1:
Bare Pump Lifting Method

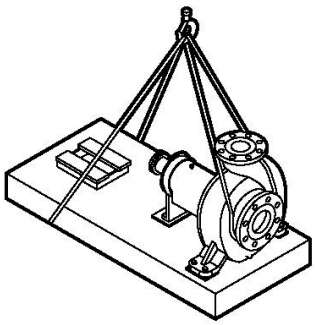


Figure 2:
Pump and baseplate lifting method.

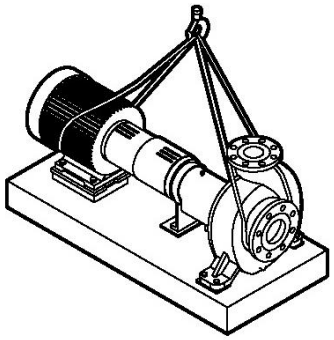


Figure 3:
Pump, base and motor lifting method.

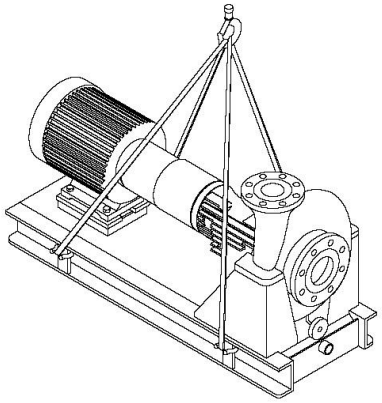


Figure 4:
Lifting method for baseplates using lifting lugs or rings.

3. INSTALLATION

3-1 SITE / FOUNDATION

A pump should be located near the supply of liquid and have adequate space for operation, maintenance, and inspection.

1. Baseplate mounted pumps are normally grouted on a concrete foundation, which has been poured on a solid footing. The foundation must be able to absorb any vibration and to form a permanent, rigid support for the pumping unit.
2. The location and size of foundation bolts are shown on the outline assembly drawing provided with the pump data package.
3. Foundation bolts most commonly used are sleeve type and J-type. Bolt designs permit movement for final bolt adjustment.

3-2 LEVEL BASEPLATE

1. After mounting on the foundation examine the baseplate and make sure it is as level as possible.
2. Place 2 sets of wedges or shims on the foundation, one set on each side of every foundation bolt.
3. The wedges should extended 3/4 in (20mm) to 1.5 in (40mm) above foundation, to allow for adequate grouting. This will provided even support for the baseplate once it is grouted.
4. Remove water and/or debris from anchor bolt holes/sleeves prior to grouting. If the sleeve type bolts are being used, fill the sleeves with rags to prevent grout from entering.
5. Carefully lower baseplate onto foundation bolts.
6. Level baseplate to within 1/8 inch (3.2mm) over length of the baseplate and to within 0.088 inch (1.5mm) over the width of the base by adjusting wedges.
7. Tighten bolts by hand.

3-3 GROUT BASEPLATE

1. Clean areas of baseplate that will contact grout. Do not use oil-based cleaners because grout will not bond to it. (*Refer to grout manufacturer's instructions*)
2. Build a dam around foundation. Thoroughly wet pump foundation.
3. Pour grout through grout hole in the baseplate, up to level of dam. Remove air bubbles from grout as it is poured by patting, using a vibrator, or pumping the grout into place. *Non-shrink grout is recommended*.
4. Allow grout to set.
5. Fill remainder of baseplate with grout. Again remove air.
6. Allow grout to set at least 48 hours.
7. Tighten foundation bolts.

3-4 ALIGNMENT PROCEDURE

WARNING
Before beginning any alignment procedure make sure that drive power is shut down. Failure to shut down driver power will result in serious physical injury.

Alignment is achieved by adding or removing shims from under the feet of the driver/motor and adjusting equipment horizontally as needed.

Note: Even though the pump was aligned after assembly prior to shipment, proper field alignment is the responsibility of the installer and user of the unit.

Accurate alignment of the equipment must be attained. Trouble free operation can be accomplished by following these procedures.

3-4.1 Alignment Check

Proper total alignment calls for alignment checks several times during the installation/start-up process. Below are recommended points for which alignment is performed.

- *Before Grouting Baseplate* – To ensure alignment can be obtained.
- *After Grouting Baseplate* – To ensure no changes have occurred during grouting process.
- *After connecting pipe* – To ensure pipe strains have not altered Alignment. If changes have occurred, alter piping to remove pipe strains on pump flanges.
- *Final Alignment* -Hot Alignment with pump heated to normal operating temperature.
- *Break In Period* – Alignment check at this point will determine if pump system has moved out of alignment. Obtain alignment when both pump and driver are at operating temperature. Thereafter, alignment should be checked periodically according to plant operating procedures.

Note: Alignment check must be made after a process temperature change, piping changes and or pump service is performed.

Note: Please refer to Appendix for Alignment Procedures and Guidelines

3-5 PIPING

3-5.1 General Notes

Guidelines for piping are given in the "Hydraulic Institute, Standards" available from: Hydraulic Institute, 30200 Detroit Road, Cleveland, OH. 44145-1967 and must be reviewed prior to pump installation.

WARNING
Never draw piping into place by forcing at the flanged connections of the pump. This may impose dangerous strains on the unit and cause misalignment between pump and driver. Pipe strain will adversely effect the operation of the pump resulting in physical injury and damage to the equipment.

1. All piping must have an adequate number of pipe hangers and be aligned both axially and radially with the pump flanges.
2. Piping runs should be as short as possible to minimize friction loss.
3. Do not connect piping to pump until grout has hardened and pump and driver hold-down bolts have been tightened.
4. It is suggested that expansion loops or joints be properly installed in suction and/or discharge lines when handing liquids at elevated temperatures, so linear expansion of piping will not draw pump out of alignment.
5. The piping should be arranged to allow pump flushing prior to removal of the unit on services handling corrosive liquids.
6. Carefully clean all pipes, parts, valves and fittings, and pump branches prior to assembly.

3-5.2 Suction Piping

WARNING
$NPSH_A$ must always exceed $NPSH_R$ as shown on TRUFLO performance curves received with order. (Reference Hydraulic Institute for NPSH and pipe friction values needed to evaluate suction piping.

Properly installed suction piping is a necessity for trouble-free pump operation.
Suction piping should be flushed before connection to the pump.

1. Use of elbows close to the pump suction flange should be avoided. There should be a minimum of 2 pipe diameters of straight pipe between the elbow and suction inlet. Where used, elbow should be long radius.
2. Use suction pipe one or two sizes larger than the pump suction, with a reducer at the suction flange. *Suction piping should never be a smaller diameter than the pump suction*.
3. **Reducers, if used, should be eccentric, at the pump suction flange, with sloping side down.**
4. **Pump must never be throttled on suction side.**
5. Suction strainers, when used, must have net "free area" of at least three times the suction pipe area.
6. Separate suction lines are recommended when more than one pump is operating from the same source of supply.

Suction lift conditions

1. Suction pipe must be free from air pockets.
2. Suction pipe must slope upwards to pump.
3. All joints must be airtight and tested
4. A means of priming the pump must be provided, such as a foot valve.
5. Piping allowances must be considered to allow air in case and suction piping to vent during priming.

Suction head/Flooded suction conditions

1. An isolation valve should be installed in the suction line at least two pipe diameters from the suction to permit closing of the line for pump inspection and maintenance.
2. Keep suction pipe free from the air pockets.
3. Piping should be level or slope gradually downward from the source of supply.
4. No portion of the piping should extend below pump suction flange.
5. The size of entrance from supply should be one or two sizes larger than the suction pipe.
6. The suction pipe must be adequately submerged below the liquid surface to prevent vortices and air entrainment at the supply.

3-5.3 Discharge Piping

Isolation and check valves should be installed in discharge line. Locate the check valve between isolation valve and pump; this will permit inspection of the check valve. The isolation valve is required for priming, regulation of flow, inspection and maintenance of pump. The check valve prevents pump from receiving damage due to reverse flow through the pump when the driver is turned off.

- *Increasers if used, should be placed between pump and check valves.*
- *Cushioning devices should be used to protect the pump from surge and water hammer if quick-closing valves are installed in system.*

3-5.4 Final Piping Check

After connecting the piping to the pump

1. Rotate shaft several times by hand to be sure that there is no binding and all parts are free.
2. Check alignment, per the alignment procedure outlined in section 3-5 to determine absence of pipe strain. If pipe strain exists, correct piping.

Table 2
Alignment Troubleshooting

Problem	Probable Cause	Treatment
Unable to obtain horizontal alignment, angular or parallel	Driver feet bolt bound	Loosen pump hold down bolts and slide pump and driver until horizontal alignment is achieved
	Base plate not leveled properly, Probably twisted.	Determine which corners of the baseplate are high or low and remove or add shims at the appropriate corners and realign.
Unable to obtain vertical alignment, angular or parallel	Base plate not leveled properly, Probably tilted	Determine if center of baseplate should be raised or lowered and correct by evenly adding or removing shims at the center of the baseplate.

4. OPERATION

4-1 PREPARATION FOR START-UP

4-1.1 Motor Rotation Check

CAUTION
Serious damage may result if pump is running in the wrong rotation.

1. Lock out power to driver.

WARNING
*Shut out driver power to prevent accidental start-up, equipment damage and serious physical injury***.**

2. Make sure motor and pump are not coupled together before checking rotation of motor.
3. Make sure coupling hubs are securely fastened to shafts.
4. Unlock driver power.
5. Make sure everyone is clear. Jog driver just long enough to determine direction of rotation. Rotation must correspond to arrow on bearing housing.
6. Shut out power to driver.

4-1.2 Impeller Clearance Check

Prior to starting the pump the impeller clearance must be checked. The pump efficiency is maintained when the proper impeller clearance is set. The optimum hydraulic performance is attained by setting the impeller clearance at the factory to predetermined limits that are consistent with service conditions.

The maximum impeller setting should not exceed more than 0.005 inch (0.13mm) above the values in table or significant performance degradation will occur. TRUFLO pumps are designed such that, when new, the additional 0.005 inch clearance maybe set between the pump casing and impeller.

For pumpage temperatures above 200°F (93°C) the cold (ambient) setting must be increased shown in *Table 3*. This is necessary to prevent the impeller from contacting the casing due to expansion from the higher operating temperatures. See Preventive Maintenance section for impeller adjustment procedure.

Table 3
Impeller Clearances

Cold temperature clearances for various service temperature			
Service Temperature	**Group 1**	**Group 2**	**Group 3**
-20 to 200°F (-29 to 93°C)	0.005" (0.13mm)	0.008" (0.20mm)	0.015" (0.38mm)
200 to 250°F (93 to 121°C)	0.006" (0.15mm)	0.009" (0.22mm)	0.016" (0.41mm)
250 to 300°F (121 to 149°C)	0.007" (0.18mm)	0.010" (0.25mm)	0.017" (0.43mm)
300 to 350°F (149 to 177°C)	0.009" (0.22mm)	0.012" (0.30mm)	0.019" (0.48mm)
350 to 400°F (177 to 204°C)	0.010" (0.25mm)	0.013" (0.33mm)	0.020" (0.50mm)
400 to 450°F (204 to 232°C)	0.011" (0.28mm)	0.014" (0.35mm)	0.021" (0.53mm)
450 to 500°F (232 to 260°C)	0.012" (0.30mm)	0.015" (0.38mm)	0.022" (0.56mm)
500 to 550°F (260 to 288°C)	0.013" (0.33mm)	0.016" (0.41mm)	0.023" (0.58mm)
550 to 600°F (288 to 316°C)	0.014" (0.36mm)	0.017" (0.43mm)	0.024" (0.61mm)
600 to 650°F (316 to 343°C)	0.016" (0.40mm)	0.019" (0.48mm)	0.026" (0.66mm)
650 to 700°F (343 to 371°C)	0.017" (0.43mm)	0.020" (0.50mm)	0.027" (0.69mm)

4-1.3 Couple Pump and Driver

WARNING
Shut down driver power to prevent accidental rotation and physical injury.

1. Install coupling per manufacturer's instructions.
2. Install coupling guard. Refer to Coupling guard installation and Disassembly section

WARNING
Never operate a pump without coupling guard properly installed. Refer to Appendix ll for coupling guard installation instructions. Personal injury will occur if pump is run without coupling guard.

4-1.4 Lubricating bearings

CAUTION
Pumps are shipped without oil in the bearing frame.

Oil Lubrication: Fill bearing frame with oil, through filler connection (located on top of bearing frame), until oil level reaches the middle of the sight-glass. High quality turbine type oil, with rust and oxidation inhibitors should be used.

If pump is put into operation after prolonged shutdown. Flush out bearings and bearing frame with a light oil to remove contaminants. During flushing, rotate shaft slowly by hand. Finally, flush bearing housing with proper lubricating oil to ensure oil quality after cleaning.

See Preventive Maintenance section for lubrication recommendations.

WARNING
Operation of the unit without proper lubrication will cause bearing failure, and pump seizure.

4-1.5 Shaft Sealing

TRUFLO ANSI Pumps may be supplied with either packing or Mechanical seals.

Packing Option: TRUFLO pumps may be sent with or without packing. Please examine the back cover plate upon arrival to determine the status of packing material.

*Mechanical Seal Option***:** Pumps may be shipped with or without mechanical seals installed. A common seal with this model is the cartridge type. Cartridge seals are preset at the seal manufacturer's facility and require no field settings. Cartridge seals installed by the user require removal of handling clips prior to operation, allowing the seal to slide into place. If the seal has been installed in the pump at the TRUFLO factory, these clips may have already been removed. For other types of mechanical seals, refer to seal manufacturer's instructions for installation and setting.

Connection of Sealing liquid

For satisfactory operation, there must be a liquid film seal between the faces to lubricate them. Refer to seal manufacturer's drawing for location of taps. Some methods that may be used to flush/cool the seal are:

1. Product Flushing – In this arrangement, the pumpage is piped from the casing (and cooled in an external heat exchanger when required) then injected in seal gland.
2. External Flushing – A clean, cool compatible liquid is injected from an outside source directly into seal gland. Flushing liquid must be a pressure 5-15 PSI (0.35-1.01 kg/cm^2) greater than the back cover plate pressure. Injection rate should be 0.5-2 GPM (2-8LPM).
3. Other methods may be used which make use of multiple gland connections and/or back cover plate connections. Refer to documentation supplied with the pump, mechanical seal reference drawing, and standard ANSI sealing piping diagrams.

   Note: For further reference to sealing options please refer to section 6-2.3 seal testing, section 5-4.1 mechanical seals and section 6-2.2 seal assembly.

4-2 START-UP

4-2.1 Priming the Pump

Never start the pump until it is properly primed. Several different methods of priming are used each depending upon type of installation and service involved.

Suction Supply above Pump

1. Slowly open the suction valve.
2. Open air vents on the suction and discharge piping until liquid flows out.
3. Close the vent valves
4. Pump case is now full of liquid.

Suction Supply below pump

1. Close discharge valve and open-air vents in casing.
2. Open valve in outside liquid supply line until only water flows out from the vent valves.
3. Close the vent valves and then the outside supply line.
4. Pump case is now full of liquid.

Note: it is recommended that there be a foot valve on the suction side to help maintain a full case of liquid.

4-2.2 Starting the Pump

1. Make sure suction valve and any re-circulation or cooling lines are open.
2. Fully close or partially open discharge valve as dictated by system conditions.
3. Start Driver.

CAUTION
Immediately observe pressure gauges. If discharge pressure is not quickly attained, stop driver, reprime and attempt to restart.

4. Slowly open discharge valve until the desired flow is obtained.

CAUTION
Observe pump for vibration levels, bearing temperature and excessive noise. If normal levels are exceeded, shut down and resolve.

4-3 OPERATION

4-3.1 General Considerations

Always vary capacity with regulating valve in the discharge line. Never throttle flow from the suction side.

Driver may overload if the pumpage specific gravity (density) is greater than originally assumed, or the rated flow rate is exceeded.

Always operate the pump at or near the rated conditions to prevent damage resulting from cavitation or recirculation.

4-3.2 Break In Period

- Observe the pressure and suction gauges. If they are not at the design conditions then refer to the instruction manual for trouble shooting.
- Examine the mechanical seal. If the seal has a quench injection system, tighten the auxiliary packing to reduce the drip rate to approximately 10 drops per minute.
- After the pump has been operating and is at the expected temperature a final coupling check can be made.
- After the pump has been running for two hours it is recommended to perform a routine check.
- Check pressure gauges on both the suction and discharge gauges.
- Check the pressure on any seal or packing injection systems. It should generally be 15 to 25 PSI higher then the calculated seal chamber pressure.
- Check flow indications on any seal injection system.
- Check the pump operating temperature.
- Listen for any excessive noises.
- Check for any excessive vibration.
- Inspect the pump and piping for leakage.
- Check for any mechanical seal leakage.

4-3.3 Operating at Reduced Capacity

WARNING
Do not operate pump below minimum rated flows or with suction and/or discharge valve closed. These conditions may create an explosive hazard due to vaporization of pumpage and can quickly lead to pump failure and physical injury. Refer to Appendix lll.

Damage occurs from:

- Increased vibration levels – Affects bearings, back cover plate (or seal chamber), and mechanical seal.
- Increased radial thrusts: Stresses on shaft and bearings.
- Heat built up – Vaporization causing rotating parts to score or seize.
- Cavitation – Damage to internal surface of pump.

4-3.4 Operating under Freezing Conditions

Exposure of freezing conditions, while pump is idle, could cause liquid to freeze and damage the pump. Liquid inside pump should be drained. Liquid inside cooling coil, if used, should also be drained.

4-4 SHUT DOWN

1. Slowly close discharge valve.
2. Shut out and lock driver to prevent accidental rotation.

WARNING
When handling hazardous and/or toxic liquids, proper personal protective equipment should be worn. If pump is being drained, precaution must be taken to prevent physical injury. Pumpage must be handled and disposed of in conformance with applicable environmental regulation.

4-5 FINAL ALIGNMENT

1. Run the unit under actual operating conditions for a sufficient length of time to bring the pump and driver up to operating temperature.
2. Check alignment according to alignment procedure in Appendix A while unit is still at the operating temperature.
3. Reinstall coupling guard.

5. PREVENTIVE MAINTENANCE

5-1 GENERAL COMMENTS

A routine maintenance program can extend the life of your pump. Well-maintained equipment will last longer and require fewer repairs. You should keep maintenance records; this will help pinpoint potential causes of problems.

5-2 MAINTENANCE SCHEDULE

5-2.1 Break In Period

Covered in section 4-3.2.

5-2.2 Routine Maintenance Summary

- Bearing lubrication
- Seal monitoring
- Vibration analysis
- Discharge pressure
- Temperature monitoring

5-2.3 Routine Inspection

- Check level and condition of oil through sight glass on bearing frame.
- Check for unusual noise, vibration and bearing temperature.
- Check for pump and piping leakage.
- Check for seal chamber/back cover plate leakage.
- Mechanical Seal: Should be no leakage.
- Packing: Excessive leakage requires adjustment or possible packing replacement. Refer to Section 5-4.2 Operating for packing gland adjustment.

5-2.4 Monthly inspections

- Check foundation and hold-down bolts for tightness.
- If pump has been left idle, check packing. Replace if required.
- Oil should be changed at least every 3 months (200 hours) or more often if there are any adverse atmospheric conditions or other conditions which could cause cloudiness or contamination of the oil as seen by inspection through the sight glass.
- Check shaft alignment and realign if required.

5-2.5 Annual Inspections

- Check pump capacity, pressure and power. If pump performance does not satisfy your process requirements, and process requirements have not changed, pump should be disassembled, inspected, and worn parts should be replaced, otherwise a system inspection should be done.

5-3 MAINTENANCE OF BEARINGS

5-3.1 Oil Lubricated Bearings

WARNING
TRUFLO® Pumps are shipped without oil. Oil lubricated bearings must be lubricated at the job site.

1. Remove fill plug and add oil until level is at the center of sight glass. Replace fill plug.
2. Change the oil after 200 hours for new bearings, thereafter every 2000 operating hours or 3 months. (Whichever comes first.)

Table 4
Oil Volumes

Frame	Pints	Milliliters
Group 1	1.0 pt.	400 mL
Group 2	2.6 pt.	1250 mL
Group 3	3.0 pt.	1400 mL

Note: High quality turbine oil with rust and oxidation inhibitors should be used. For the majority of operational conditions, bearing temperature will run between 120°F (50°C) and 180°F (82°C). In this range, an oil of ISO viscosity grade 68 at 100°F (40°C) is recommended. If bearing temperatures exceed 180°F (82°C) use ISO viscosity grade 100 with bearing frame cooling or finned-tube oil cooler. For operating temperatures above 350°F (177°C), synthetic lubrication is recommended.

Acceptable lubricants:

Exxon	Teresstic EP 68
Shell	Tellus Oil 68
Philips	Mangus Oil 315
Chevron	GTS Oil 68
Mobil	DTE 26 300 SSU @ 100°F (38°C)
Sunoco	Sunvis 968
Royal Purple	SYNFILM ISO VG 68 Synthetic Lube

Acceptable synthetic lubricants:

Mobil	DTE Oil BB or SHC 630
Shell	Marlina 220 or Tellus 220
Royal Purple	Synfilm GT 220 or Synergy 220

5-4 MAINTENANCE OF SHAFT SEALS

5-4.1 Mechanical Seals

When mechanical seals are installed, a manufacturer's reference drawing is supplied with the data package. This drawing should be kept for future use when performing maintenance and adjusting the seal. The seal drawing will also specify required flush liquid and attachment points. The seal and all flush piping must be checked and installed as needed prior to starting the pump.

Note: *The life of a mechanical seal depends on various factors such as cleanliness of liquid handled and its lubricating properties. Due to the variety of operating conditions it is, however, not possible to give definite indications as to its life.*

WARNING
Never operate the pump without liquid supplied to mechanical seal. Running a mechanical seal dry, even for a few seconds, can cause seal damage and must be avoided. Physical injury can occur if the mechanical seal fails.

5-4.2 Packed Back Cover

WARNING
Shut down driver power to prevent accidental start up and physical injury.

1. The back cover plate is not packed at the factory and must be packed properly before operation of pump. The packing is furnished in a box of fittings that accompany the pump. The packing used must be suitable for the pumpage. Make sure the back cover plate is clean. Examine shaft-sleeve for wear or scoring, replace if necessary. Starting from the innermost ring, the packing is usually arranged as two packing rings, lantern ring, and three packing rings, followed by the split gland. Insert single packing rings by twisting. Press each ring to ensure proper compression in the back cover plate. Stagger joints 90°.
2. Lightly and evenly tighten the gland. Excessive tightening will result in premature failure of the packing and shaft-sleeve. After packing is installed it must be possible to rotate the shaft by hand. Final adjustment of packing gland is made after pump is started.

6. BREAKDOWN

6-1 DISASSEMBLY

6-1.1 Pump from Baseplate

1. Lockout motor following all recommended plant procedures.
2. Block out the pump by closing the suction and discharge valves.
3. Open the ports and completely drain the pump including the back cover plate.
4. Disassemble any attached auxiliary seal piping.
5. Drain oil from bearing housing.
6. Remove coupling guard.
7. Remove coupling spacer and hub from shaft.
8. Remove stud bolts from seal gland. Position the seal against the inboard bearing by gently pulling it from the back cover plate along the shaft and towards the bearing housing. Clean shaft prior to sliding seal back.
9. Remove casing bolts.
10. Tighten jack-out bolts on casing and separate the case from the frame adaptor, leaving the case bolted in place.
11. Take back pull out to clean work area.
12. Loosen impeller by placing a shaft wrench on the coupling end of the shaft. Quickly turn the shaft wrench against the work surface. The impeller should loosen after a few thrusts.
13. Continue loosening the impeller. Remove and discard the gasket on the backside of the impeller.

WARNING
Do not apply heat to impeller.

6-1.2 Disassembly of Bearing Housing

1. Before pulling the shafts and the bearing arrangement from the bearing housing, the labyrinth bearing isolator on the inboard side must first be removed. Step one is to clean the free ends of the shaft, removing all grit and burrs that may cut the labyrinth seal O-ring.
2. With equal forces around the circumference of the seal, slowly and evenly pull the bearing isolator away from the bearing housing to the open end of the shaft.
3. On the outboard bearing side, turn the jackscrews in, effectively pulling the bearing cap and shaft assembly away and out from the bearing housing.
4. Remove the outboard labyrinth seal in the same, cautious manner as the inboard seal. If required, remove and discard old bearings.

6-2 REASSEMBLY

6-2.1 Inspections

Before the seal is installed on the rebuilt pump the following examinations will determine the integrity of the rotating elements

1. Examine both the inside and outside of the bearing frame. Look for excessive rust, corrosion or nicks.
2. Clean surfaces of all dust, dirt and shavings.
3. Examine the shaft for visible defects. Look for nicks, corrosion, cracks, stripped threads or stress marks.
4. Examine coupling spacer for nicks, cuts or chemical wear.
5. Examine motor risers and check for soft foot.
6. Examine base and the foundation grouting. Make sure there is not any rust or chemical wear. If so, make necessary repairs.

7. Examine motor for grease leakage beyond the seals.
8. Examine motor for bearing wear.
9. Clean all mating surfaces of the pump including the seal faces.
10. Examine the impeller vanes for wear. Replace it if there is more than 1/4″ of wear.
11. If impeller shows sign of wear, but is within limits, check for dynamic balance. If it is out of tolerance, have it rebalanced. If it remains out of limits, replace it.
12. Inspect labyrinth seal for cuts or cracks.
13. Inspect the casing gasket for cuts, flattened areas, etc. (Standard gaskets are glass filled Teflon – they may be used more than once.)
14. Inspect the impeller gasket. Look for cuts, flattened out areas, etc.
15. Examine the pump for shaft/sleeve run out. (Figure 6.1)

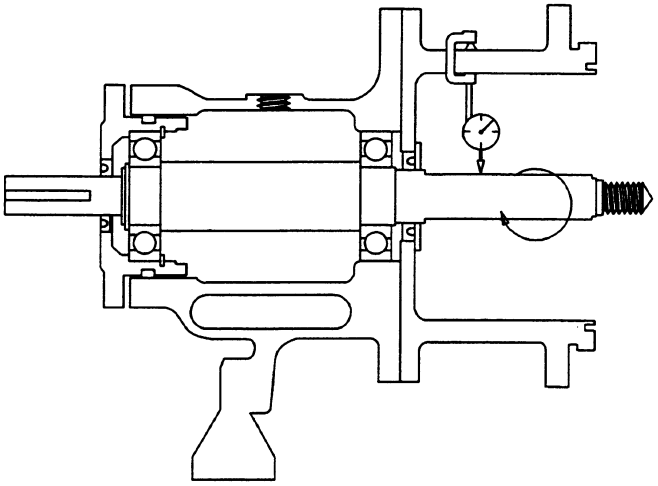


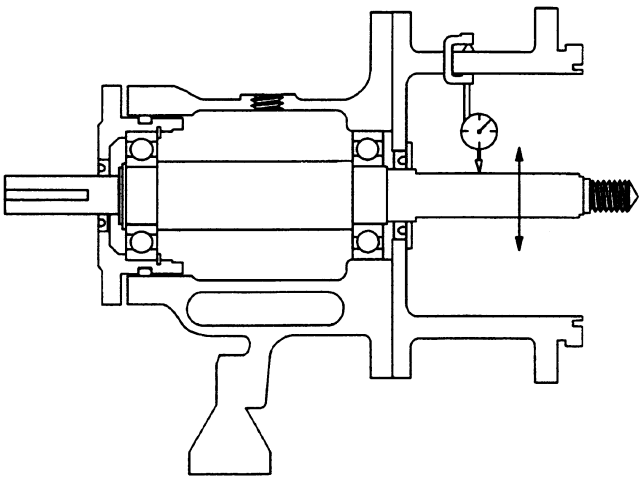
Figure 6.1: Shaft Run Out

Checking for shaft run out. Run out should not be more then 0.0015″

16. Examine pump for radial bearing fit (Figure 6.2)

Figure 6.2: Radial Play

Checking for play on radial bearing. End play should not be more then 0.0015″



17. Examine pump for thrust bearing endplay. (Figure 6.3)

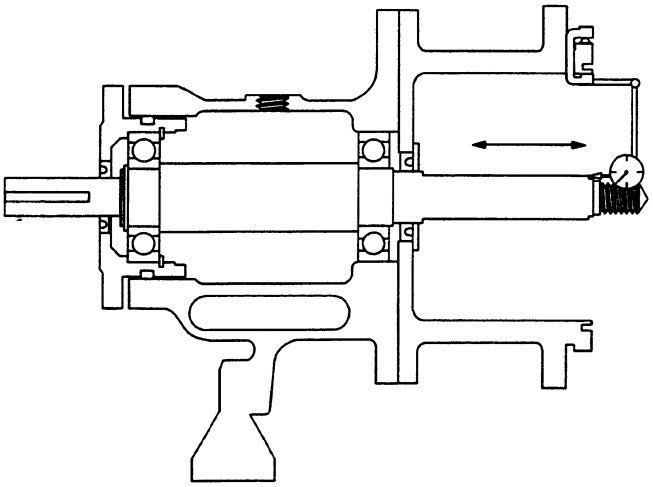


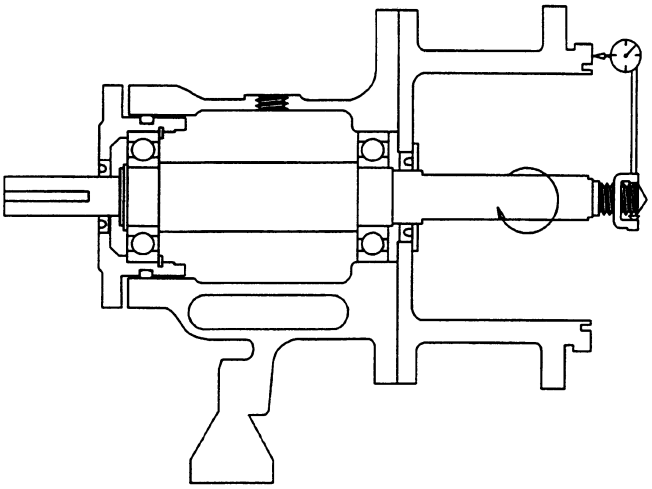
Figure 6.3: Thrust Play

Checking endplay on thrust bearing. Thrust play should not be more then 0.0015″

18. Examine pump for bracket/frame perpendicularity. (Figure 6.4)

Figure 6.4: Frame Adaptor/Case Perpendicularity

Checking frame adaptor perpendicularity. This value should not be more then 0.005″



If any of the above measurements are out of specification please refer to table 6-1

Table 6-1
Assembly Measurement Troubleshooting Chart

Symptom	Cause	Remedy
Shaft Run Out	Shaft bent	Replace
Radial Play	Inboard or radial bearings are worn. Bearing housing is worn	Replace bearing Replace bearing housing
Axial Play	Outboard or axial bearings are worn. Steps in shaft are worn	Replace bearing Replace shaft
Frame Adaptor/case not Perpendicular	Irregular machined mating surfaces Frame adaptor warped	Clean machine surfaces Replace bearing housing

6-2.2 Seal assembly

Generic Cartridge Seal

1. Tighten the impeller to the end of the shaft. This will allow the proper final weight adjustment required to evenly secure the seal in the back cover plate. After the pump has been checked with the above steps proceed with the following assembly steps.
2. Break open seal assembly. Examine and ensure that all of the parts are included.
3. If a shaft is used, install over shaft. Be sure to include any shaft sleeve o-rings.
4. Apply a slight amount of lubrication on the seal O-ring.
5. Slide the cartridge seal onto the shaft with the cartridge drive collar forward.
6. Rotate the gland plate to properly orient any auxiliary piping connections.
7. Attach the back cover plate to the frame adaptor.
8. Before securing the seal gland to the back cover plate, perform the following checks to the impeller and screw and then secure the impeller to the shaft assembly.
    a. Align the seal gland to the back cover plate studs and slide the seal assembly into the seal chamber.
    b. Evenly tighten the gland nuts until the gland plate is engaged and compressed. See the recommended torque rating. (See table 6.2)
    c. Evenly tighten the setscrews in the seal drive collar.
    d. After studs and setscrews have been tightened remove the spacer cap screws and loosen the spacers from the collar.
9. The seal assembly is now ready to be tested.

6-2.3 Seal Testing

There are several methods for testing the integrity of the mechanical seal. Look for cracks in the seal faces, nicks in the secondary seals or improper setting of the seal depth (component seals).

1. The easiest way is to place blind flanges on the inlet and outlet of the pump, making sure they are sufficiently gasketed and pressure the casing with water. If there is a compromise in the seal installation water may be leaking from the back cover plate.

2. A second way is to place blind flanges on the inlet and outlet of the pump, making sure they are sufficiently gasketed, place a nipple to the flush ports on the seal gland assembly and pressurizing the back cover plate with air. (40 pounds for 20 minutes should show problems, if any.) Inflate to a desired pressure and maintain for several minutes. Watch the maintained pressure and if there is pressure reduction disassemble and examine the O-rings and faces for nicks or cracks.

6-2.4 Pump assembly

1. Bring rebuilt back pull-out to the baseplate/foundation and attach the pump to the bolted case by aligning the bearing frame bracket to the casing bolt studs and tightening the stud nuts down firmly. (For proper torque setting see table 6.2)

Table 6-2
Bolts Torque Values

Components	***ft-lbs***
Casing Bolts	30
Frame Adaptor	40
Bearing End Cover	16
Seal Gland	20

2. Check the measurement between the impeller and case. There are two ways of determining this, feeler gauge and dial indicator.

The most concise method to perform in the field is the use of dial indicators to measure the bearing rotor movement and location inside the bearing assembly. A second method requires a feeler gauge to measure the gap between case and impeller.
(Note: The maximum impeller setting should not be set more than 0.0052 in. (0.15mm) above the values stated in Table 3. Significant performance degradation will result).

3. **Feeler Gauge Method.** (*This method requires the back pull out to be attached to the and the entire pump assembly to be disconnected to the suction/discharge piping)*
    a. Use the feeler gauge and take a measurement of the gap between the impeller and front case. This will require the removal of the suction and discharge piping.
    b. If out of specifications, adjust the impeller/case tolerance by the bearing cap jackscrews. (*Proper gap values are listed in table 3)*
    c. Loosen the bearing cap lock bolts and the jack bolts several turns. These are evenly spaced bolts on the bearing cap.
    d. Tighten each bearing cap bolt. These are also three evenly bolts spaced on the bearing cap. *(Please note the jackscrews have an additional nut on the bolt)*. Remember each turn of the bolt is approximately 5/100". Evenly tighten each bolt until each bolt gives tight resistance. *(At this point the entire rotating assembly has been pushed its entire allowable distance forward. The impeller is fully pushed against the case and further travel is not possible. Trying to force the bearing cap lock screws may damage the pump)*
    e. Evenly tighten each jackscrew, pulling the rotating assembly from the case towards the motor. Continue tightening jackscrews making periodic measurements until the impeller/case space is the amount stated in Table 3.
    f. Tighten the bearing case lock nuts and jack bolts until tight. This step will keep the rotating assembly secured in its proper place. The impeller tolerance is now set.
    g. Reassemble any disconnected suction piping.

4. **Dial Indicator Method.** *(This method may used when the back pull is still attached to the case and the case may or may not be attached to the suction and discharge piping.)*
    a. Remove the coupling spacer, hub and bushing.
    b. Tighten each bearing cap bolt. These are also three evenly spaced bolts on the bearing cap. *(Please note the jackscrews have an additional nut on the bolt)*. Remember each turn of the bolt is approximately 5/100". Evenly tighten each bolt until each bolt they give tight resistance. *(At this point the entire rotating assembly has been pushed its entire allowable distance forward. The impeller is fully pushed against the case and further travel is not possible. Trying to force the bearing cap lock screws may damage the pump)*
    c. Place the dial indicator base securely on the base or some other surface not attached to the rotating assembly and set the rotating dial to zero.
    d. Evenly tighten each jackscrew, pulling the rotating assembly from the case and towards the motor. Continue tightening jackscrews making periodic dial indicator measurements until the impeller/case space measurement is as stated in *Table 3*.
    e. Tighten the bearing case lock nuts taking care not to over tighten and moving the rotating assembly. The impeller tolerance is now set.
    f. Reassemble the coupling

5. **Laser Alignment Method.** *(This method should be performed in accordance with equipment instructions.)*

6-2.5 Motor and Coupling assembly

1. Reattach the coupling and guard
2. For alignment refer to section 3-3.
3. Refer to start up instructions in section 4.

7. TROUBLESHOOTING

7-1 PUMP TROUBLESHOOTING GUIDE

Problem	Cause	Remedy
No Liquid Delivered.	Pump not primed.	Re-prime pump, check that pump and suction line are full of liquid.
	Suction line clogged.	Remove obstructions.
	Impeller clogged with foreign material.	Back flush pump to clean impeller.
	Pump is vapor locked	Cool pumped fluid and/or Increase NPSHa
	Bottom of suction pipe out of liquid.	Consult factory for proper depth. Use baffle to eliminate vortices.
	Suction lift too high.	Shorten suction pipe.
Pump not producing rated flow or head.	Air leak through gasket.	Replace flange and seal gaskets.
	Air leak through back cover plate.	Replace or readjust packing/mechanical seal.
	Impeller partly clogged.	Back flush pump to clean impeller.
	Worn suction side plate or wear rings.	Replace defective part as required.
	Insufficient suction head.	Ensure that suction line shutoff valve is fully open and line is unobstructed.
	Worn or broken impeller.	Inspect and replace if needed.
Pump starts then stops pumping.	Improperly primed pump.	Re-prime pump.
	Improper lubrication.	Check lubricant for suitability and level.
	Lube cooling.	Check cooling system.
	Improper pump/driver alignment.	Align shafts.
Pump is noisy or vibrates.	Partly clogged impeller causing imbalance.	Back flush pump to clean impeller.
	Broken or bent impeller or shaft.	Replace as required.
	Foundation not rigid.	Tighten hold down bolts of pump and motor or adjust stilts.
	Worn bearings.	Replace.
	Suction or discharge piping not anchored or properly supported.	Anchor per Hydraulic Institute Standards Manual recommendations.
	Pump is cavitating.	System problem.
	Packing gland improperly adjusted.	Tighten gland nuts.
Excessive leakage from back cover plate/seal chamber.	Back cover plate improperly packed.	Check packing and replace box.
	Worn mechanical seal parts.	Replace worn parts.
	Overheating mechanical seal.	Check lubrication and cooling lines.
	Shaft sleeve scored.	Re-machine or replace as required.
	Head lower then designed. Pumps too much liquid.	Consult factory, Install throttle valve, and trim impeller.
Motor requires excessive power	Liquid heavier than expected.	Confirm specific gravity and viscosity.
	Stuffing packing too tight.	Readjust gland and packing.
	Rotating parts bind.	Check internal wearing parts for proper clearances.

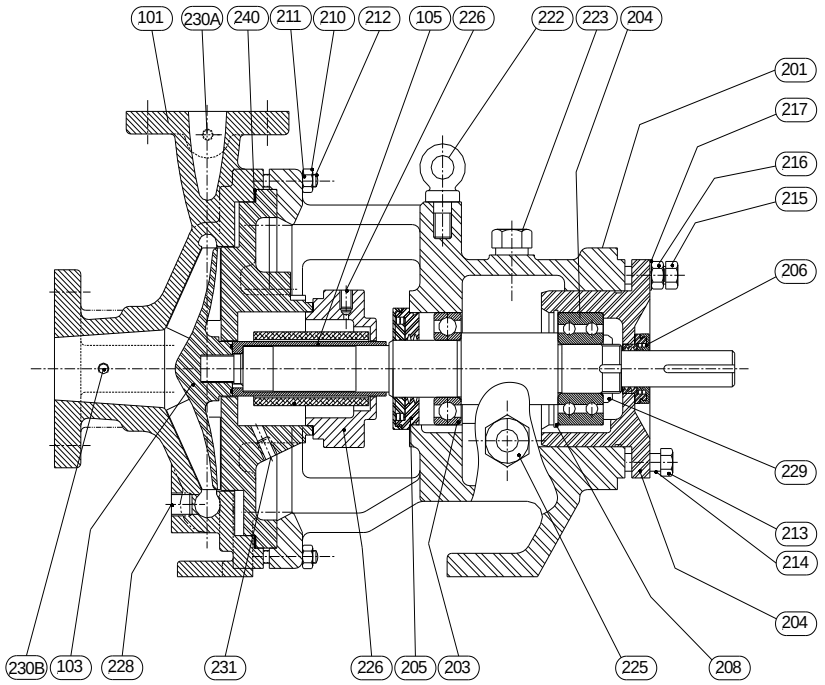
7-2 MECHANICAL SEAL TROUBLESHOOTING GUIDE

Problem	Cause	Remedy
Broken metal bellows	Running too close to vapor point	Identify cause and correct
	Chemical attack	
	Over pressurized back cover plate	
	High/low viscosity pumpage	
Broken ceramic	Ceramics are exposed to different temperatures, thermal shock	Reduce differential temperatures
Broken metal bellows primary front ring adapter	Liquids with high pH, chlorides or sulfides	Change material, check temperature
Broken spring	Stress corrosion by over torqueing, high speeds	Change materials and check installation procedures.
Chipped faces on the OD	Face separation because of pressure distortion	Control the pressure
Chipped faces on the ID	Face striking the shaft or sleeves on the ID, temperature distortion, running dry, poor flush	Confirm the pump alignment, check operating temperature
Clogged springs	Particles collecting in small places	Confirm and check the flush
Coated or discolored metal	Excessive heat or sealed fluid deposits	Eliminate heat, change metal, use a clean flush
Coking	Fluid decomposition	Reduce temperature, use steam quench, use rotating seal design or use dual arrangement.
Cut elastomer	Damage during installation	Chamfer the shaft shoulder, use assembly lubricant
Elastomer out of shape or hardened	Excessive heat or chemical attack	Change the elastomer, reduce the heat
Eroded carbon	Flush impingement, chemical attack, incorrect pipe connections	Redirect or reduce the flush, remove the abrasives
Excessive face wear	Heavy load or poor lubrication	Check seal flush, check springs
Excessive outboard temperature	Inadequate buffer/barrier flow	Check for piping restrictions, check for correct piping plan, and check pump rotation vs. tangential gland porting, check for gas entrainment in the barrier fluid.
Frozen Seal	Clogged small springs, wrong seal selection	Use flush injection, select a different seal
Hard face wear	Abrasives trapped between the faces, poor lubrication	Use flush or change face materials
High primary ring wear	Seal chamber too close to product vapor pressure, incorrect seal selection, product contaminants or gas in barrier fluid.	Decrease seal chamber temperature, increase seal chamber pressure using throat bushing, examine the flush arrangements and eliminate air
Heat check	Wrong material or excessive heat	Change materials, reduce heat generation, increase heat removal
Pitted carbon	Media attack on the carbon	Change the grade of carbon
Pitting and corrosion of metal parts	Wrong choice of materials, scratched surfaces on passive stainless steel, galvanic corrosion or stress corrosion	Change materials
Seal leaks	Nothing appears to be wrong	Check for squareness of seal chamber to shaft; align shaft, bearing, and impeller to eliminate shaft vibration.
Seal locked on shaft	Fretting	Change to a non-pusher seal
Shaft damage under seal	Fretting	Check alignment, change to a non-pusher seal
Steady dripping	Faces not flat, faces blistered, thermal distortion	Check installation dimensions, check for distortion
	Secondary seals nicked or scratched during installation, aged o-rings, chemical attack	Replace secondary seals, check for chamfers burrs, etc.
Sticky or swollen elastomer	Chemical incompatibility with secondary seals	Replace secondary seal

8. PARTS BREAKDOWN

SECTIONAL VIEW - GROUP 1

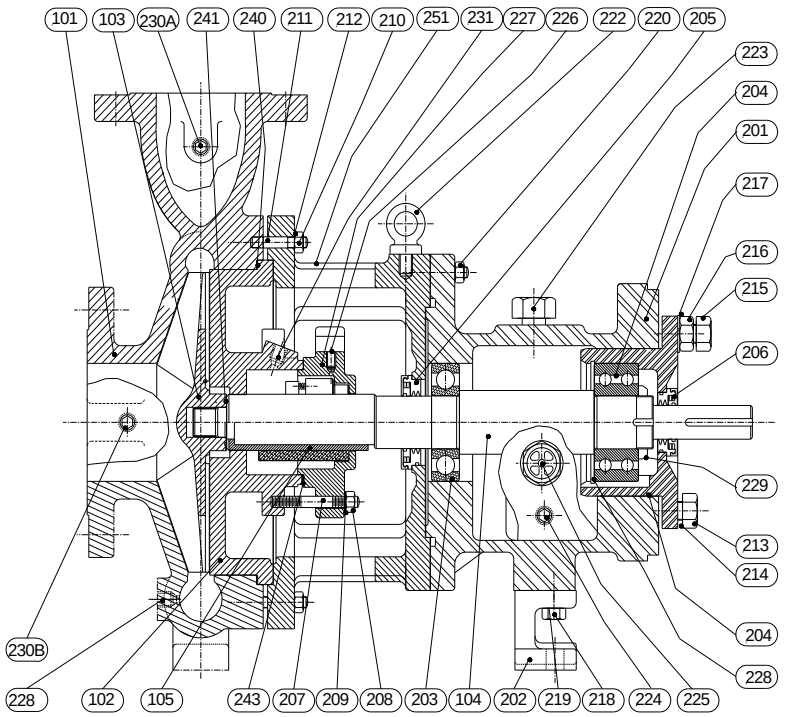
GRP 1



ITEM	QTY	PART NAME / DESCRIPTION	ITEM	QTY	PART NAME / DESCRIPTION
101	1	Casing	231	1	Back Cover (End-Cover) Flush & Drain Plug
230A	1	Discharge Tap Plug	228	1	Pump Case Drain
240	1	Case Gasket	230B	1	Suction Tap Plug
211	8	Casing Stud Lock Washer			
210	8	Casing Stud Nut			
212	8	Casing Stud			
105	1	Shaft Sleeve			
226	1	Seal/Packing Gland Flush Plug			
222	1	Lifting Eye			
223	1	Oil Vent Cap			
204	1	Thrust Bearing Carrier			
201	1	Bearing Housing			
217	3	Jacking Bolt Lock Washer			
216	3	Jacking Bolt nut			
215	3	Jacking Bolt Nut			
206	1	Outboard bearing isolator			
229	1	Bearing Retaining Nut			
213	3	Bearing Carrier Bolt			
214	3	Bearing Carrier Lock Washer			
204	1	Thrust Bearing			
228	1	Bearing Retaining Snap Ring			
225	1	Oil Sight Glass			
203	1	Radial Bearing			
205	1	Inboard Bearing Isolator			
226	1	Seal Gland Plug			

SECTIONAL VIEW - GROUP 2

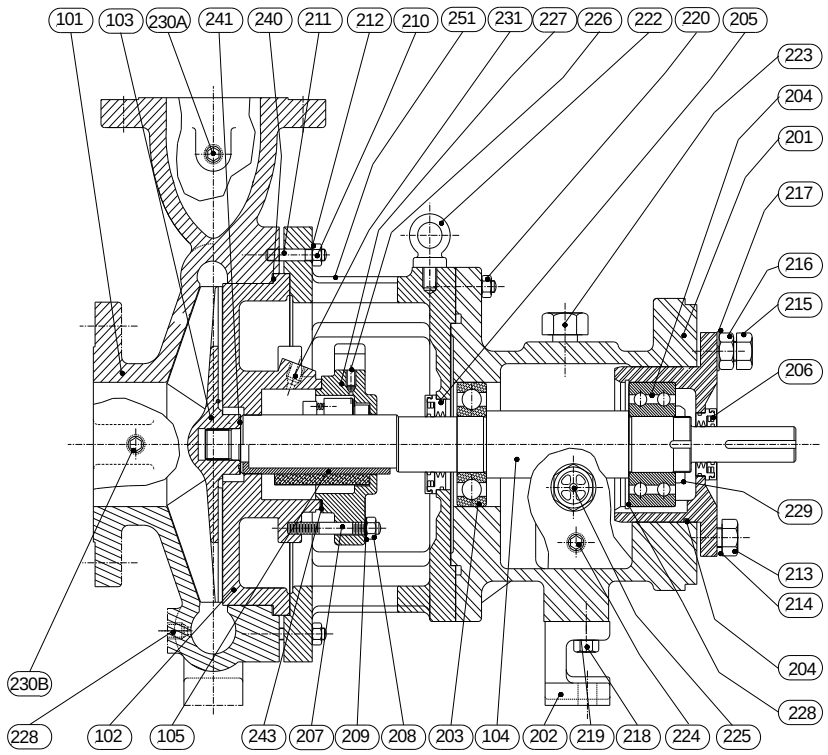
GRP 2



ITEM	QTY	PART NAME / DESCRIPTION	ITEM	QTY	PART NAME / DESCRIPTION
101	1	Casing	233	1	Bearing Carrier
103	1	Impeller	228	1	Thrust Bearing Snap Ring
230A	1	Discharge Tap Plug	225	1	Oil Sight Glass
241	1	Impeller gasket	224	1	Oil Drain Plug
240	1	Case gasket	218	1	Bearing Housing Foot Bolt
211	8	Casing Stud Lockwasher	219	1	Bearing Housing Foot Bolt Lockwasher
212	8	Casing Stud	202	1	Bearing Frame Support Foot
210	8	Case Stud Nuts	104	1	Shaft
231	2	Back Cover Plate Flush & Drain Plug	203	1	Radial Bearing
227	1	Seal/ Packing Gland	208	1	Seal Gland Stud Nut
226	1	Seal/Packing Gland Flush Plug	209	1	Seal Gland Stud Lockwasher
222	1	Lifting Eye	207	1	Seal Gland Retaining Studs
220	2	Frame Adaptor – Backcover Bolts	243	1	Seal Gland Gasket
221	2	Frame Adaptor – Backcover Lockwasher	105	1	Shaft Sleeve
205	1	Inboard Bearing Isolator	102	1	Back Cover Plate
223	1	Oil Vent Cap	228	1	Pump Drain Plug
233	1	Thrust Bearing Carrier	230B	1	Suction Tap Plug
201	1	Bearing Housing	214	3	Bearing Carrier Lockwasher
217	3	Jacking Bolt Lockwasher	214	3	Bearing Carrier Lockwasher
216	3	Jacking Bolt Nut	214	3	Bearing Carrier Lockwasher
215	3	Jacking Bolt Nut			
206	1	Outboard Bearing Isolator			

Sectional View of GROUP 3

GRP 3



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230A	1	Discharge Tap Plug	225	1	Oil Sight Glass
241	1	Impeller gasket	224	1	Oil Drain Plug
240	1	Case gasket	218	1	Bearing Housing Foot Bolt
211	8	Casing Stud Lockwasher	219	1	Bearing Housing Foot Bolt Lockwasher
212	8	Casing Stud	202	1	Bearing Frame Support Foot
210	8	Case Stud Nuts	104	1	Shaft
231	2	Back Cover Plate Flush & Drain Plug	203	1	Radial Bearing
227	1	Seal/ Packing Gland	208	1	Seal Gland Stud Nut
226	1	Seal/Packing Gland Flush Plug	209	1	Seal Gland Stud Lockwasher
222	1	Lifting Eye	207	1	Seal Gland Retaining Studs
220	2	Frame Adaptor – Back cover Bolts	243	1	Seal Gland Gasket
221	2	Frame Adaptor – Back cover Lock washer	105	1	Shaft Sleeve
205	1	Inboard Bearing Isolator	102	1	Back Cover Plate
223	1	Oil Vent Cap	228	1	Pump Drain Plug
233	1	Thrust Bearing Carrier	230B	1	Suction Tap Plug
201	1	Bearing Housing	213	3	Bearing Carrier Bolt
217	3	Jacking Bolt Lock washer	214	3	Bearing Carrier Lockwasher
216	3	Jacking Bolt Nut			
215	3	Jacking Bolt Nut			
206	1	Outboard Bearing Isolator			
229	1	Bearing Retaining Nut			

APPENDIX

General Alignment Criteria

Good alignment is achieved when the dial indicator readings are 0.002 inch (0.05mm) as specified in the alignment procedure.

During the installation phase, however, it is necessary to set the parallel alignment in the vertical direction to different criteria due to difference in expansion rates of the pump and driver. *Table 1* shows recommended preliminary (cold) settings for electric motor driven pumps base on different pumpage temperature. Driver manufacturers should be consulted for recommended cold settings for other type of drivers (steam turbines, engines, etc.)

Table 1
Cold setting of Parallel
Vertical Alignment

PUMPAGE TEMPERATURE	SET DRIVER SHAFT
50°F (10°C)	0.002 (0.05mm) High
150°F (65°C)	0.001 (0.03mm) High
250°F (120°C)	0.005 (0.12mm) High
350°F (175°C)	0.009 (0.23mm) High
450°F (218°C)	0.013 (0.33mm) High
550°F (228°C)	0.017 in (0.43mm) High
650°F (343°C)	0.021 in (0.53mm) High
700°F (371°C)	0.023 in (0.58mm) High

Set Up

1. Mount two dial indicators on one of the coupling halves so they contact the other coupling half.
2. Check setting of indicators by rotating one coupling half to ensure indicators stay in contact with the other coupling half but do not bottom out. Adjust indicators accordingly.

Measurement

1. To ensure accuracy of indicator readings, always rotate both coupling halves together so indicators contact the same point. This will eliminate any measurement problems due to run out.
2. Move or shim only the motor to make adjustments in order to prevent strain on the piping.
3. Take indicator measurements with driver feet hold-down bolts tightened. Loosen hold down bolts prior to making alignment corrections.
4. Take care not to damage indicators when moving driver during alignment corrections.

Angular Alignment

A unit in angular alignment when the indicator does not very by more than 0.002inch (0.05mm) as measured at four points 90°apart.

Vertical Correction (Top-to-bottom)

1. Zero the indicator at top dead center (12 O'clock) of coupling half.
2. Rotate indicator to bottom dead center (6 O'clock), observe needle and record reading.
3. ***Negative reading*** – The coupling halves are further apart at the bottom than at the top. Correct by either raising the driver feet at the shaft end (add shims) or lowering the driver feet at the other end (remove shims).

4. ***Positive Reading*** – The coupling halves are closer at the bottom than at the top. Correct by either lowering the driver feet at the shaft end (remove shims) or raising the driver feet at the other end (add shims)
5. Repeat steps 1-3 until the indicator reads 0.002 inch (0.05 mm) or less.

Horizontal Correction (Side-to-Side)

1. Zero the indicator on left side of coupling half, 90° from top dead center (9 O'clock).
2. Rotate indicators though top dead center to the right side, 180° from the start (3 O'clock), observe needle and record reading.
3. ***Negative Reading*** – The coupling halves are further apart on the right side than the left. Correct by either sliding the shaft end of the driver to the left or the other end to the right.
   Positive Reading – The coupling halves closer together on the right side than the left. Correct by either sliding the shaft end of driver to the right or the other end to the left.
4. Repeat steps 1 through 3 until the indicator reads 0.002 inch (0.05mm) or less.
5. Re-check both horizontal and vertical readings to ensure adjustment of one did not disturb the other. Correct as necessary

Parallel Alignment

A unit is in parallel alignment when the indicator (parallel indicator) does not very by more than 0.002 inch (0.05mm) as measured at four points 90° apart at operating temperature. *Note the preliminary vertical cold setting criteria, Table 1.*

Vertical Correction (Top-to-Bottom)

1. Zero the indicator at top dead center of coupling (12 O'clock) half.
2. Rotate indicator to bottom dead center (6 O'clock). Observe needle and record reading.
3. ***Negative reading –*** One coupling half is lower than the other half. Correct by removing the shims of the thickness equal to half of the indicator reading under each driver foot.
4. ***Positive reading –*** One coupling half is higher than the other half. Correct by adding the shims of the thickness equal to half of the indicator reading from each driver foot.
5. Repeat steps 1 though 3 until the indicator reads within 0.002inch (0.05mm) or less when hot, or per Table 1 when cold.

Note: *Equal amount of shims must be added to or removed from each driver foot; otherwise the vertical angular alignment will be affected.*

Horizontal Correction (Side-to-Side)

1. Zero the indicator on the left side of the coupling half 90° from top dead center. (9 O'clock)
2. Rotate indicators through top dead center to the right side, 180° from the start (3 O'clock). Observe needle and record reading.
3. ***Negative Reading*** – One **c**oupling half is to the left of the other. Correct by sliding driver evenly in the appropriate direction.
4. ***Positive Reading*** – One coupling half is to the right of the other. Correct by sliding driver evenly in the appropriate direction.
5. Repeat steps 1 through 3 until the indicator reads 0.002inch (0.05mm) or less.
6. Recheck both horizontal and vertical readings to ensure adjustment of one did not disturb the other. Correct as necessary.

Note: *Failure to slide motor evenly will affect horizontal angular correction.*

Complete Alignment

A unit is in complete alignment when both indicators (angular) and (parallel) do not vary by more than 0.002 inch (0.05mm) as measured at four points 90° apart.

Vertical Correction (Top-to-bottom)

1. Zero indicators at top dead center (12 O'clock) of the coupling half.
2. Rotate indicator to bottom dead center (6 O'clock). Observe the needle and record readings.
3. Make corrections as outlined previously.

Horizontal Correction (Side-to-Side)

1. Zero indicators on the left side of the coupling half, 90° from top dead center (9 O'clock).
2. Rotate indicator through top dead center to the right side, 180° from the start (3 O'clock). Observe needle and record reading.
3. Make corrections as outlined previously
4. Recheck both vertical and horizontal readings to ensure adjustment of one did not disturb the other. Correct as necessary.

Note: With experience, the installer will understand the interaction between angular and parallel and will make corrections appropriately.

DSP SERIES (Self-Priming ANSI Pump)

Note: The only difference in the DSP and the DAP series and procedures are outlined below. The DSP assembly has a different casing only; the remaining parts are identical to DAP parts.

Discharge Tap/Air bleed valve

It is recommended that a tap with a tap (1/4" for group 1 pumps, 1/2" for group 2 pumps) with an air bleed valve be installed in the discharge piping between the pump and the discharge check valve. This will allow air that is built up in the pump casing and suction line to be released. Elimination of the valve may result in the pump not re-priming.

Start Up Procedure

Before starting the pump for the first time, remove the priming plug from the top of the casing. Then fill the casing with the liquid to be pumped (or compatible equal) to the suction pipe centerline. Replace the plug and open the air bleed valve. Turn the pump on and run it until liquid is expelled from the valve; close the valve. The pump can then be safely run.

WARNING
Failure to follow this start up procedure may result in seal failure.

Troubleshooting

In addition to section 7-1, if the pump will not prime, check the suction lines for leaks.

COMMON CONVERSIONS

Flow (capacity)

GPM (US)	m^3/h	l/min	GPM (UK)
1	0.2271	3.785	0.8327
4.403	1	16.6	3.666
0.2642	0.06	1	0.2200
1.201	0.2727	4.5458	1

GPM (US) x 0.2271 = m^3/h l/min x 0.2642 = GPM (US)
m^3/h x 4.403 = GPM (US) GPM (US) x 3.785 = l/min
m^3/h x 16.6 = l/min l/min x 0.06 = m^3/h

Head (pressure / vacuum)

Ft (H^2O)	M (H^2O)	PSI	Kg/cm^2	KPa	inch Hg	mmHg	bar
1	0.3048	0.4335	0.03048	2.989	0.8851	22.48	0.02987
3.281	1	1.422	0.100	9.807	2.904	73.76	0.3685
2.307	0.7031	1	0.07031	6.895	2.042	51.87	0.0690
32.83	10.01	14.23	1	98.07	29.04	737.6	3.685
0.3349	0.1020	0.1450	0.01020	1	0.2961	7.521	0.01
1.132	0.3450	0.491	0.03443	3.377	1	25.4	0.0339
0.04457	0.5339	0.01933	0.001356	0.1330	0.03937	1	0.005
33.5	2.714	14.50	0.2714	100	29.5	200	1

Ft (in water) x 0.3048 = m (in water) PSI x 2.307 = Ft (in Water)
M (in water) x 3.2808 = Ft (in water) Ft (in water) x .433 = PSI
Kg/cm^2 x 0.328 = Ft (in water) PSI x 6.895 = KPa
Ft (in water) x 3.049 = Kg/cm^2 KPa x 0.1450 = PSI

Volume

Ft^3	M^3	liter	gallon (US)	gallon (UK)	lbs of water
1	0.02832	28.32	7.481	6.229	62.44
35.31	1	1000	264.2	220.00	2205
0.03531	0.001	1	0.2642	0.2200	2.204
0.1337	0.003785	3.785	1	0.8327	8.347
0.1606	0.004545	4.548	1.201	1	10.025
0.01620	0.0004537	0.4537	.1198	0.09975	1

Temperature Conversions

F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	ΔF	ΔC
-60	-51	0	-18	60	15.6	120	48.9	180	82.2	240	116	300	149	360	182	1	0.6
-55	-48	5	-15	65	18.3	125	51.7	185	85.0	245	118	305	152	365	185	2	1.1
-50	-46	10	-12	70	21.1	130	54.4	190	87.8	250	121	310	154	370	188	3	1.7
-45	-43	15	-9.4	75	23.9	135	57.2	195	90.6	255	124	315	157	375	191	4	2.2
-40	-40	20	-6.7	80	26.7	140	60.0	200	93.3	260	127	320	160	380	193	5	2.8
-35	-37	25	-3.9	85	29.4	145	62.8	205	96.1	265	129	325	163	385	196	6	3.3
-30	-34	30	-1.1	90	32.2	150	65.6	210	98.9	270	132	330	166	390	199	7	3.9
-25	-32	35	1.67	95	35.0	155	68.3	215	102	275	135	335	168	395	202	8	4.4
-20	-29	40	4.44	100	37.8	160	71.1	220	104	280	138	340	171	400	204	9	5.0
-15	-26	45	7.22	105	40.6	165	73.9	225	107	285	141	345	174	405	207	10	5.6
-10	-23	50	10.0	110	43.3	170	76.7	230	110	290	143	350	177	410	210	11	6.1
-5	-21	55	12.8	115	46.1	175	79.4	235	113	295	146	355	179	415	213	12	6.7

F=(9/5)C+32 C=(5/9) x (F-32)

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