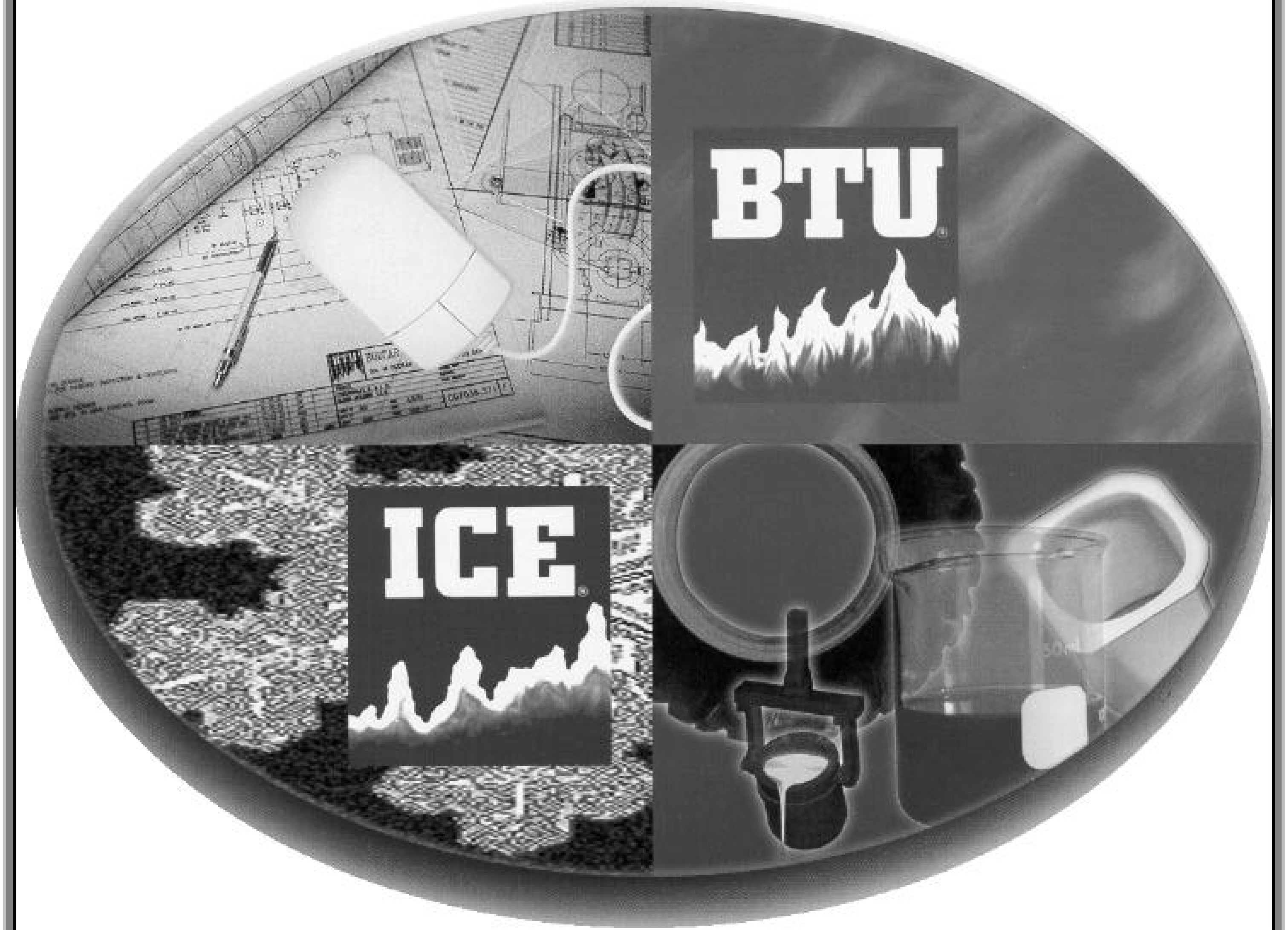
BUDZAR
INDUSTRIES, INC.



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TERMS OF SALE

Our acknowledgement and acceptance are subject to the following conditions

1. PRICE ADJUSTMENT: Up to the time of formal order acknowledgment, all prices are subject to change without notice. Acknowledged sales price(s) of equipment is subject to adjustment, to reflect increases in Seller's costs in effect at the time of shipment. The price does not include any governmental taxes, such as sales, use or transaction, which are the responsibility of the Buyer. Prices are firm for thirty (30) days from date of proposal, and become subject to change without notice after that period. Additionally, the right is reserved to correct any stenographic or clerical errors, and we assume no responsibility beyond that usual in our course of business, except as defined in detail.

2. TAXES: In case of the imposition of any additional duty tax, or other governmental charge upon raw materials entering into production of the goods represented by the invoice, and order acknowledgement, or upon or measured by the production, sale or shipment of said goods by federal, state, or municipal authorities, which would be applicable to this sale, then the contract price may be increased by the amount of such additional cost or expense to the Seller, which is caused thereby. Unless specifically exempted, all sales, use and any other federal, state, municipal or governmental tax will be invoiced to the Buyer as a separate item in addition to the price of the equipment and are to be paid by the Buyer.

3. TERMS: For new customer orders of less than $50,000 gross value, or for orders of less than $100,000 gross value placed by customers with existing accounts, terms are net cash within the earlier of thirty (30) days after shipment or after notification that Seller's ready to ship. Discount of 1-1/2% for net cash within ten (10) days. For new customer orders greater than than $50,000 but less than $100,000 gross value, thirty percent (30%) deposit is required with order and balance due within the earlier of thirty (30) days after shipment or after notification that Seller's ready to ship. For all orders of greater than $100,000 gross value, twenty percent (20%) deposit is required with order and balance due within the earlier of thirty (30) days after shipment or after notification that Seller's ready to ship. These terms apply to partial as well as complete shipments. A service charge at the rate of 1-1/2% per month (18% per annum) or the maximum rate allowed by law, whichever is less, will be made on past due accounts. In the event Seller institutes legal proceedings for collection of past due accounts, Buyer shall pay all costs of collection including reasonable attorney's fees. Seller reserves the right to ship C.O.D. or refuse shipment or delivery of the goods referred to herein, or any part thereof, in the event that it in its sole discretion decides that the outstanding indebtedness of the customer exceeds reasonable credit allowances.

4. ACCEPTANCE: All orders must be in writing and are not binding until acceptance by the Seller's office. All orders shall be deemed to be accepted if mailed and properly addressed and postage prepaid, when postmarked; if transmitted by telex, when transmitted; if transmitted by oral communication, when transmitted. Orders are accepted subject to strikes, accident, and other causes beyond Seller's control. Seller will not be liable for any delay in delivery or for any damage suffered by the Buyer for reason of such delay.

5. CANCELLATION: Buyer expressly agrees to make a net cash payment to Seller for any cancellation of Buyer's order for specifically fabricated goods within thirty (30) days after any such cancellation by Buyer. The amount of such payment shall be calculated according to the following terms: Buyer expressly agrees to make a net cash payment to Seller in the amount of fifty percent (50%) of the acknowledged sale price of the equipment for a cancellation made between fourteen (14) and twenty-one (21) days after Seller's acceptance; seventy-five percent (75%) of the acknowledged sales price for a cancellation between twenty-two (22) and twenty-eight (28) days after Seller's acceptance; and one hundred percent (100%) of the acknowledged sale price of the equipment for a cancellation made twenty-nine (29) or more days after Seller's acceptance. Buyer unconditionally agrees to make such payments regardless of the events or circumstances which led to the cancellation.

6. SPECIFICATIONS: The Seller reserves the right to change specifications as conditions warrant.

7. ROUTING: Where prices include freight, the Seller determines the routing. If special routing is requested, a charge will be made for difference between such routing costs and normal minimum freight charges to same point.

8. DELIVERY: Agreement of delivery date constitutes a portion of the contract price. Any changes in or delays to the agreed upon shipment date which are imposed by the Buyer will be subject to amendment of the contract price in accordance with the service charges listed in item (3) above. Seller will endeavor to ship by promised delivery date, but failure to do so for any cause whatever will not give Buyer right to cancel or hold Seller responsible for any damages resulting from the failure to deliver within the time stated.

9. APPROVAL OF SELLER'S DESIGN: Where approval of the Seller's design is required by the Buyer prior to manufacture of the equipment, the Seller reserves the right to postpone purchase of materials or supplies to fill the order until after receipt of Buyer approved drawings. Any delays in shipment imposed by the Buyer due to failure to approve the Seller's design within the time period agreed upon in the contract are subject to amendment of the contract price in accordance with the service charges listed in item (3) above.

10. SHIPPING: All goods are shipped at Buyer's risk and are shipped F.O.B. Point of Manufacture with no allowance for freight. Freight charges will be billed by the selected carrier. If freight charges are required to be prepaid by the Seller, Seller will invoice the freight charges at cost of freight plus fifteen percent (15%) administrative handling fee. If material is received in damaged condition, Buyer should contact and immediately file claim against the carrier.

11. WARRANTY: Seller agrees that the apparatus manufactured will be free from defects in material and workmanship for a period of one (1) year from the date of original shipment, under normal use and service and when properly installed; and Seller's obligation under this agreement is limited solely to repair or replacement at Seller's option, at Seller's factories, or any part of parts thereof, which shall within one year from date of original shipment from factory to the original purchaser, be returned to Seller with transportation charges prepaid which Seller examination shall disclose to Seller satisfaction to have been defective. The sole purpose of the stipulated exclusive remedy shall be to provide the Buyer with free repair or replacement of defective goods in the manner provided herein. The exclusive remedy shall not be deemed to have failed its essential purpose so long as the Seller is willing and able to repair or replace defective goods in the prescribed manner. This agreement to repair or replace defective parts is expressly lieu of and in disclaimer and exclusion of any implied warranties of merchantability and fitness for a particular purpose, as well as all other implied warranties, in law or equity, and of all other obligations or liabilities on Seller's part. There are not warranties which extend beyond the description hereof. No affirmation by Seller, by words or by action, other than as set forth in Paragraph 11 shall constitute a warranty. Seller neither assumes nor authorizes any person to assume for Seller any liability or obligation in connection with the sale of Seller's apparatus except said repair or replacement of the defective part as set forth above.

12. LIMITATION OF LIABILITY AND DISCLAIMER OF CONSEQUENTIAL DAMAGES: Seller's liability does not include any labor charges for replacement of parts, adjustments, repairs, or any other work done outside Seller's factories. Seller's liability does not include any consequential, incidental or resulting damage to person, property, equipment, goods, merchandise, profits, good will or reputations arising out of any defect in or failure of Seller's apparatus. Seller's obligation to repair or replace shall not apply to any apparatus which shall have been repaired or altered outside of Seller's factory in any way, or which has been or which has been subject to negligence, to misuse, or to pressure in excess of stated limits. On parts not manufactured by Seller such as motors, controls, etc., Seller extends only the same warranties given to the Seller. Seller's agreement hereunder runs only to the immediate purchasers and does not extend, expressly or by implication, to any other person. Nothing in the above warranty provisions, however, shall impose any liability or obligation of any type, nature or description upon Seller if Seller has received payment in full for the apparatus in question. This warranty does not cover refrigerant gas, nor does it cover any apparatus damaged from freezing of water or heat transfer fluid.

13. SHORTAGES: No claims for shortages will be considered unless same are made in writing to the Seller within ten (10) days of receipt of shipment.

14. RETURNS: Permission to return material plus shipping instructions and Returned Goods Tags must be secured from the factory offices of the Seller before returning any material. All returns must be unused, in new condition, and of standard manufacture. They are subject to a handling charge as stated by Seller. All authorized return shipments must be made as directed by Seller and with transportation charges prepaid to point of origin of our shipment unless instructed otherwise. Shipments of material returned without authorization or improperly tagged or not prepaid are subject to refusal and immediate return to shipper. Products which are obsolete or made to special order are not returnable.

15. SOLE TERMS: Failure of the Seller to object to provisions contained in Buyer's purchase orders or other communications shall not be deemed a waiver of the terms or conditions hereof nor acceptance of such provision. The printed terms hereon combined with the other writings entered into between the parties, are the entire contract and all the terms thereof. No oral statement, warranties, representations, stipulations or terms have any binding effect or be any part of the contract whatsoever. If any provision in this Acknowledgement and Acceptance or related writings shall for any reason be or become illegal, void or unenforceable, that illegality, voidness or unenforceability shall not effect any other provision.

16. Failure of the Buyer to object in writing within five (5) days of receipt thereof to Terms of Sale contained in the Seller's acceptance and/or acknowledgement, or other communications, shall be deemed an acceptance of such Terms of Sale by Buyer.

17. The Occupational Safety and Heath Act (OSHA) imposes certain requirements on an "employer" including many relating to the use of machinery and equipment. These requirements are directly related to the conditions under which and the manner in which the machinery or equipment is used. Seller makes no warranty, expressed or implied, under OSHA, its interpretations and/or regulations. Further, the Seller makes no warranty of any kind other than the warranty set forth in Paragraph 11 of the Terms of Sale.

18. GENERAL CONDITIONS: The sales of goods pursuant to this order shall be governed by the laws of the State of Ohio. In addition to the rights and remedies conferred upon Seller by law, Seller shall not be required to proceed with the performance of any order or contract, if Buyer is in default in the performance of any order or contract with Seller, and in case of doubt as to Buyer's financial responsibility, shipments under this order may be suspended. This contract shall be binding upon and shall inure to the benefit of the successors and assigns of Buyer and Seller, provided, however, that Buyer may not assign or transfer this contract, in whole or in part, except upon written consent of Seller

BUDZAR
INDUSTRIES, INC.

38241 Willoughby Pkwy., Willoughby, Ohio 44094-7582
Phone: (440) 918-0505 • FAX (440) 918-0606 / 918-0707

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Warranty Policy & Procedures

Warranty is a manufacturer's means of protecting the end users of our products from defects in workmanship and materials which may not be detected at the time of manufacture. The following warranty policy is Budzar Industries, Inc. method to implement the corrections of such defects and track patterns of defects to aid in ongoing product improvement. We, at Budzar Industries Inc., are committed to ongoing product improvement and realize that customer satifsfaction is of the utmost importance to insure the merchantability of our products as our future sales is built on the satisfaction of our past customers.

Consequently, to insure that our customers receive the product performance and service satisfaction expected of all Budzar Industries, Inc. products, we have produced the following warranty policy and procedures:

WARRANTY PARTS

Warranty Parts are defined as parts which were utilized in the manufacture of the original product. Only warranty parts which fall within one (1) year of the original equipment warranty period (See Terms of Sale) will be considered for warranty replacement. Budzar Industries, Inc. Service Department will, in conjunction with the manufacturer of the failed component(s), and in accordance with the conditions set forth in Term of Sale, determine on a case by case basis if the failed component is a warranty issue.

Component parts which fail within the original warranty period will be replaced with an exact duplicate part, if possible. In the event an exact replacement part cannot be provided within an equitable time period, Budzar Industries, Inc., at its option, may provide a like component equal to the failed component.

The component replaced shall be warranted for a period of ninety (90) days from the documented date of shipment from the factory or for the remainder of the original equipment warranty, whichever comes last.

THE WARRANTY REPLACEMENT PROCEDURE

Upon receipt of a confirmed customer purchase order, Budzar Industries, Inc. will enter a parts order for the perceived defective component and issue a Return Goods Authorization (RGA) for it's return. Upon receipt of the component from the customer, the component will be evaluated; it's warranty status determined, and the individual issuing the purchase order advised of the determination.

In the event that the component is determined to be defective, a credit will be issued to the customer's account to offset the customer's purchase order.

In the event that the component is found not to be defective, the customer will be contacted to determine the disposition of the customer's property. If, after being contacted, the customer does not advise Budzar Industries, Inc. within 20 working days of their chosen means of disposition, the component will be discarded.

Budzar Industries, Inc., in accordance with the Terms of Sale, cannot be liable for any additional warranty coverage either implied or extended by any individual other than those specified in the Terms of Sale. Further, the implication or use of Budzar Industries, Inc. name with any additional warranty or statement of coverage beyond the documented conditions within the Terms of Sale is specifically prohibited.

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BUDZAR INDUSTRIES, INC. TECHNICAL SERVICES

38241 Willoughby Parkway
Willoughby, Ohio 44094
Tel 440-918-4954 FAX 440-918-0606/0707

DOMESTIC FIELD SERVICE LABOR RATES

Terms & Conditions Effective 1 September 1999

*DAYS WORKED	PER DIEM RATE USD	HOURLY RATE USD
Monday thru Friday	$ 800.00	$100.00
Weekdays exceeding 8 hours	$1200.00	$150.00
Saturdays	$1200.00	$150.00
Sundays or Holidays	$1400.00	$175.00

Travel Time is billed at 1/2 the prevailing hourly rate in effect during travel.

*Normal Working hours are considered as 8:00AM to 4:30PM with 1/2 hour for lunch.

The purchase shall issue a hard copy of their purchase order to Budzar Industries Inc. for the services to be performed. Upon receipt of the said purchase order, a Service Representative will be assigned to carry out the order and a Service Confirmation will be issued.

In the event that the Purchaser is ordering "Start-Up" assistance, a "Start-Up" questionnaire will be furnished to the Purchaser's representative, which **must** be completed and returned to Budzar Industries, Inc. Service Department prior to and as a condition of field service.

The Purchaser agrees to pay Budzar Industries Inc. for the time, expenses, and materials required for each Service Representative to accomplish the work ordered by the Purchaser. Charges for time are made according to the above schedule of charges for each Service Representative. Materials are billed at Budzar Industries, Inc. current pricing.

Budzar Industries, Inc. will not be liable for damages to the customer's facility or losses of product, materials, damage to equipment or any consequential damages of any kind in execution of this service. By acceptance of service, the customer releases Budzar Industries, Inc. from and and all claims arising as a result of said service.

In addition to the above, charges will be made for the actual cost of living expenses (meals and hotels) and travel expenses (car rental, mileage, airfare,) at cost plus a 10% Administrative fee. If it is necessary to travel by Company or personal vehicle, the rate is $0.45 per mile and $0.75 per mile if a van or truck is required for service.

The minimum period of time charged for service is two (2) hours plus expenses.

Idle time during which the Service Representative cannot perform his duties because of the Purchasers or their representative's cause, request, or requirement shall be regarded as have been actually worked by him, even though his services have not, in fact, been used and will be billed accordingly.

Service billings are due and payable upon receipt of invoice.

Signed: ______________________________
Authorized Customer Representative

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SYSTEM SPECIFICATIONS FOR BUDZAR TEMPERATURE UNITS

SERIAL NUMBER:	200001-2078-1-2
MODEL NUMBER:	10T-2440-GOLSP
SUPPLY VOLTAGE:	460-3-60
FULL LOAD AMPERAGE:	37
OPERATING TEMPERATURE RANGE:	50 TO 450 F
MAXIMUM DESIGN PRESSURE:	100 PSIG
DESIGN FLOW RATE:	40 GPM @ 58’TDH
DUPONT ORDER NUMBER:	LRNC-9881W
DUPONT PROJECT NUMBER:	61135
DUPONT ENGINEERING NUMBER:	1079-61135-200/205
SHIPMENT DATE:	06/2000

BUDZAR
INDUSTRIES, INC.

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Budzar Industries
Heat Transfer Systems

If technical assistance is needed contact Budzar Industries at
Phone 440-918-0505 Fax 440-918-0606

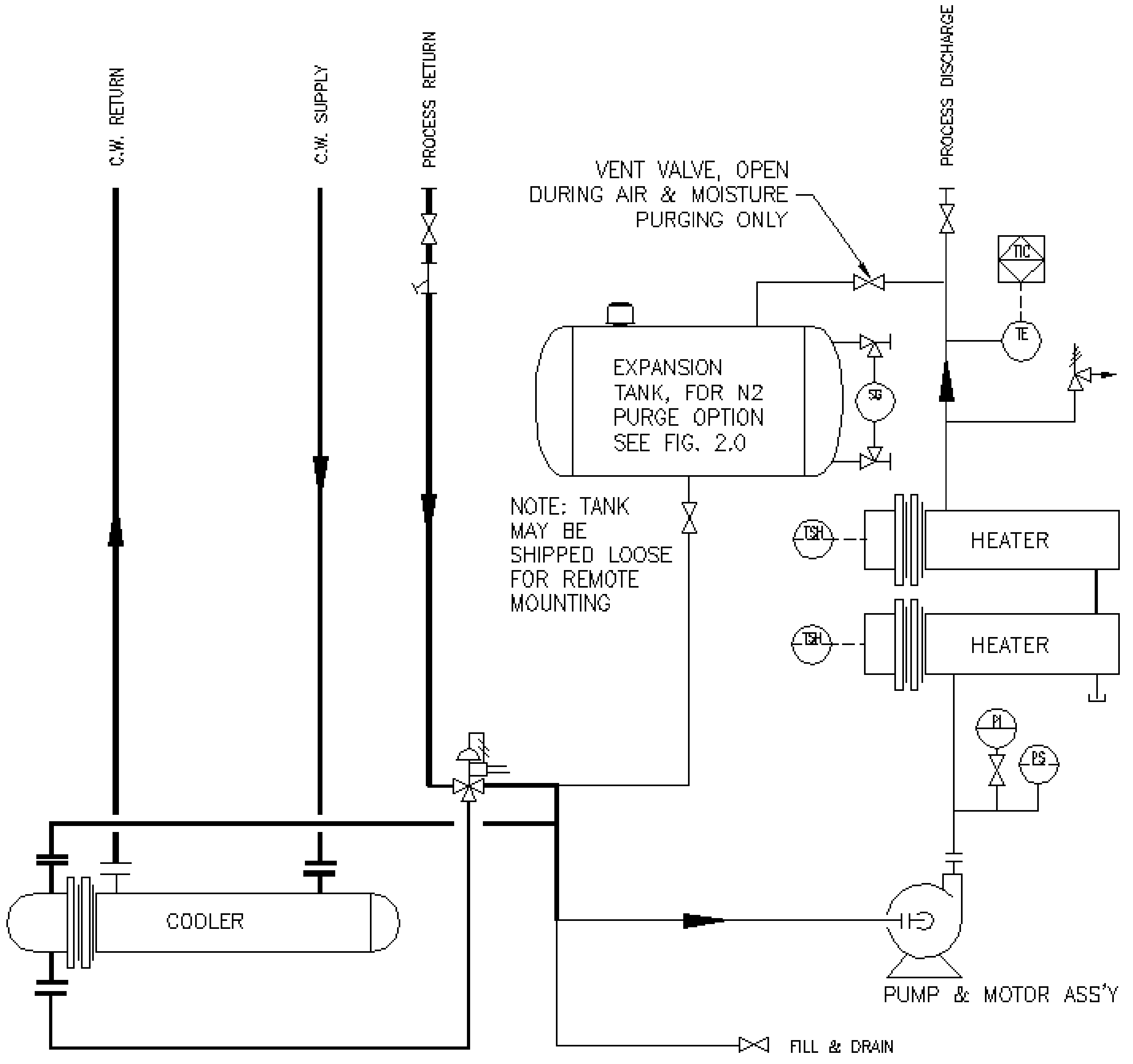

FIGURE 1.0 BASIC OIL TCU
(WITH COOLING OPTION SHOWN)

Budzar Industries
Heat Transfer Systems

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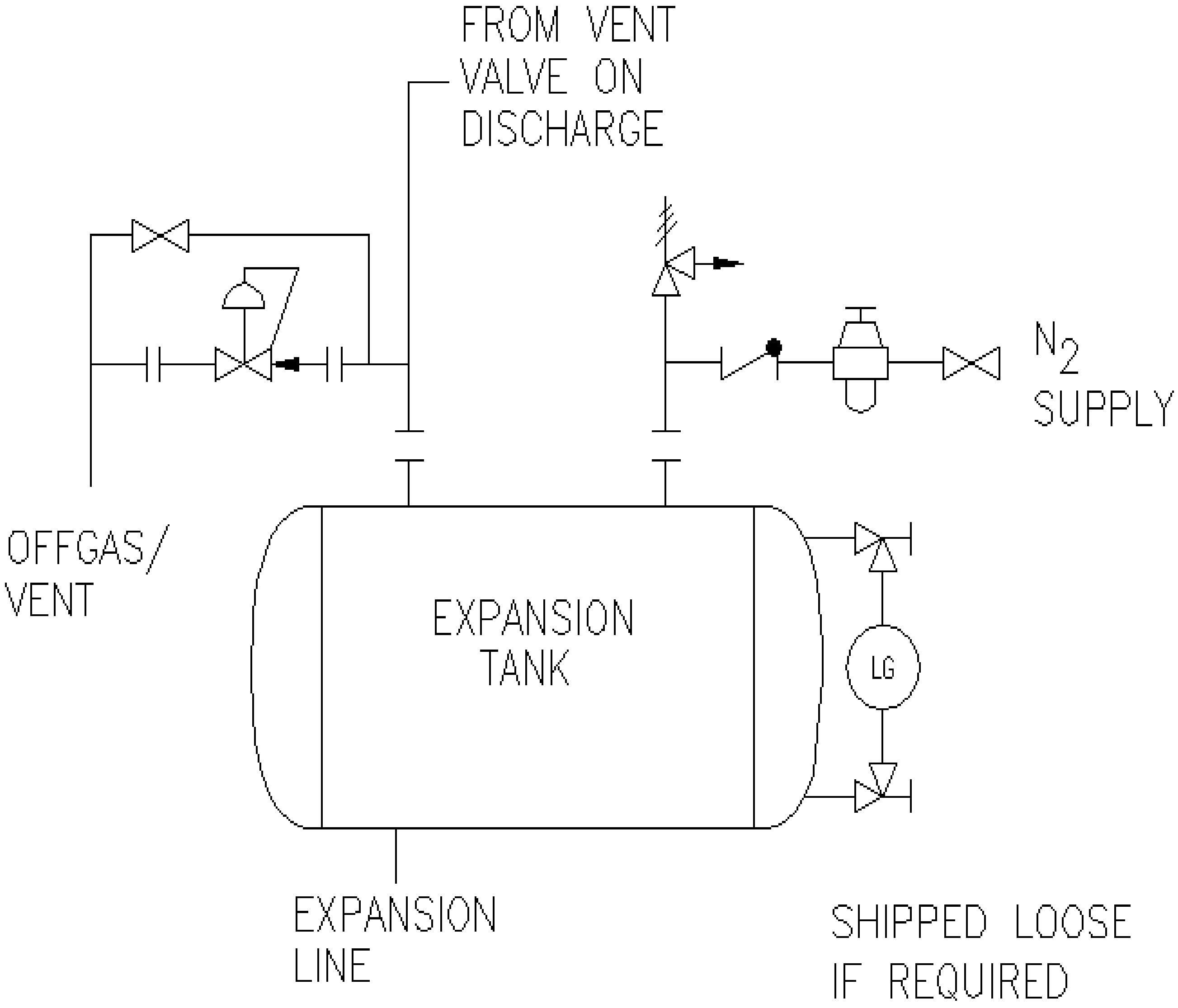


FIGURE 2.0 NITROGEN PURGE OPTION

HOT OIL UNITS

The Temperature Control Unit (TCU) is an engineered package designed to provide precise temperature control of your process equipment (process). It controls the temperature of the process by circulating a heat transfer fluid to and from the process. The TCU will heat or cool (if the cooling option was purchased) the process by adding or removing heat from the heat transfer fluid (fluid).

Extreme care must be used in installing this unit and double checks should be made at every step during installation. Installers and operators of the equipment must be thoroughly familiar with the instructions in this manual before commencing work. If the correct procedures are followed the unit should provide many years of trouble free service.

RECEIVING AND INSPECTION

1 Inspect unit for physical damage.
2 The recipient must file damage claims with carrier.
3 Check the supply voltage on unit data plate. Users supply voltage must be within 10% of voltage noted on data plate.
4 Before hooking up the unit, all pipe connections, flanges, unions and other Fittings including bolts, which hold bonnets to heat exchangers and all electrical connections, must be checked and tightened. Although each machine is operated at the factory before shipment, the constant vibration during shipment can loosen these items, and it is impossible for us to assure that they will be tight after the unit is hooked up. It is easy to check these items before attaching the machine to the load since it will be available from all sides to do this work.
5 Unauthorized alterations to factory supplied equipment voids warranty. Consult factory if modifications are required.

INSTALLATION AND COMMISSIONING

NOTE: Installation, commissioning and maintenance should only be performed by qualified individuals who are versed in local codes and regulations, and experienced with equipment of this type and nature.

CAUTION: Rotating equipment, hot surfaces and sliding valve stems are a potential injury hazard. Use caution when working on or around the equipment and avoid contact.

It can not be stated strongly enough that a closed loop hot oil system must be purged of air and moisture prior to operation. Please follow the steps outlined on the next several pages and use good sense and caution for all procedures. Refer to Figure 1.0 and 2.0 as well as the drawings for the TCU located elsewhere in this manual.

SETTING

The TCU is designed to be place on level flooring to evenly support the machine load. Shimming the unit may be required to correct for non-level field conditions. Excessive distortion of the framing may lead to premature pump failure.

Non-portable units have lagging holes so that the unit can be anchored to the flooring. Anchoring and foundation design is the responsibility of the installing contractor or the owner unless specifically contracted from Budzar Industries, Inc.

ELECTRICAL HOOK-UP

Follow all local and National Electric Codes. First check to see that all switches are in the off position. The electrical installation consists mainly of hooking-up the main supply power. The voltage and frequency of the TCU is indicated on the nameplate of the machine and must be matched within ± 10%. The electrical power taps should be fed to the machine from a fused disconnect switch. Fuses must be sized in accordance with the National Electric Code.

The incoming power is to be connected at the main power connections provided on the TCU. Budzar offers a variety of incoming power connections; non-fused disconnects, fused disconnects, circuit breakers and simple power terminals. A Licensed electrical contractor or electrician who is qualified for industrial equipment installation should handle the power wiring installation. **CAUTION:** NEC requires that a power disconnect, with lockout capability, be within sight of the equipment for maintenance purposes.

EXPANSION TANKS

Budzar offers several expansion tank options, refer to Figures 1.0 and 2.0. If the expansion tank is a vented design it will need to be located at the highest point in the system. This location is required to prevent oil from overfilling the tank and leaking out the vent cap. If the tank was not ordered with remote mounting as an option it may be easy to remove the tank for remote mounting. Contact the Budzar Service Department if questions arise related to expansion tank location.

Even when the nitrogen purging option has been purchased, Budzar still recommends locating the tank at the highest point to simplify venting and moisture purging of the system. Further if piping is higher than the tank and the nitrogen pressure is lost the tank can flood and spill out.

PIPING

Proper piping connections must be made to the TCU. All piping connections are labeled and are shown on the drawings located elsewhere in this manual.

The connections are as follows:

1 Water supply (Cooling water to heat exchangers or pump seal cooling, if applicable)
2 Water Drain or return (Drain out of exchangers or seal cooling, if applicable)
3 Oil circulation connections to the process (Discharge and Return out to load's)
4 Expansion line to tank and discharge vent line to tank (when remote mounting tank)
5 Instrument Air, Nitrogen purge, tank offgas/vent (if applicable)

The successful operation of the Fluid Heat Transfer System is largely dependent upon proper design of the process equipment to be controlled, the sizing and capacity of the TCU and design of the interconnecting piping. Improperly designed piping or process equipment can cause failure of the electric heaters and circulating pumps. Undersized piping or passages in the process can make it impossible to obtain close temperature control. Interconnecting lines between the unit and process should be piped according to appropriate specification. It is essential to provide adequate means to relieve expansion and contraction stresses that occur because of the extreme temperature changes. Customers piping must not place any additional stress or loads on the TCU piping, framing and pump(s). External loads or piping stress can cause misalignment of the pump(s) and motor assembly, which can cause damage, excessive wear or premature failure.

The connecting pipes between the heat transfer machine and the process being controlled must be large enough to:

1 Handle all the heating or cooling necessary to accommodate the maximum load on the process being controlled without causing excessive temperature variation across the process.
2 Permit the machine to operate at or near design conditions to insure close temperature control and to protect the heater and pump.
3 Allow air and moisture to be evacuated from the piping, TCU and process.

As a guideline, the connecting piping or hose should be at least as large as the connection on the Hot Oil Unit. If it is absolutely necessary to reduce the connection size, reduce it by one (1) pipe size only, to keep the restriction to flow at a minimum. Preventing high resistance to flow in the piping system is critical. If rotary unions, check valves or quick disconnects are in the system piping, check these items for ability to handle the proper flow rates. The water feed lines must be free of restrictions that could cause expanding water to create excess pressure, such as a block valve. Service valves can be installed, or may have been supplied by Budzar, in the cooling water lines. The service valves must be open during operation. **CAUTION:** If necessary, install safety pressure relief valves on the cooling water feed lines.

Typical cooling water sources are City Water, Well Water, River or Pond Water. When utilizing of any of these sources, be sure that it is free of contaminates to prevent system and pump seal cooler fouling problems. An ideal source, when system-operating temperatures do not need to go below 95° F, is treated cooling tower water. Chilled water is required to run the unit at colder temperatures.

FLUSHING AND PRESSURE TESTING GUIDELINES

Flush the interconnecting piping to remove all weld slag, scale and other foreign material, which may have accumulated in the piping during installation. Budzar recommends the use of a flushing fluid such as Therminol® FF, MultiTherm® 100 or equal product for the piping loop and the hot oil unit.

If strainers were not purchased as part of the TCU, permanent or temporary strainers should be installed in the interconnecting piping to prevent debris from getting into the pump. Pipe and weld slag or other hard debris will damage the pump seal requiring premature replacement. **Pump seals are not warranted.** During the start-up of the unit the strainers will need to be cleaned frequently to remove accumulated debris. A drop in pump discharge pressure or cavitation of the pump may indicate that the strainer(s) are clogged. Refer to the trouble shooting section for strainer cleaning guidelines.

Pressure test the interconnecting piping according to the specifications to the required test pressure, see the steps below. Budzar recommends using the flushing fluid for the pressure testing of the hot oil unit and piping loop, so that the system will not be contaminated with excess water. **CAUTION: PROTECT ALL INSTRUMENTS, SAFETIES AND PROCESS EQUIPMENT, WHICH COULD BE DAMAGED BY EXCESS PRESSURE.** Even though the unit was pressure tested at the factory and should not require additional testing, flushing the TCU is a good idea.

Pressure test the piping as follows:

1. With the TCU and interconnecting piping filled connect a pressure boost source to a connections on the TCU or piping. A valve should be installed to allow for isolation of the pressure source. An accurate pressure gauge with the test pressure range should be installed to monitor the pressure. An excellent source is a Nitrogen bottle.
2. Allow the Nitrogen to raise the pressure in the piping system to the test pressure.
3. Isolate the source of pressure. Check for leaks and repair as necessary.
4. When the piping is free from leaks hold the pressure in the system for a minimum of one hour.
5. The pressure test must be conducted in a controlled and safe manner to check the integrity of the piping and to check for leaks. This is done to minimize the chance of a failure at operating conditions. A failure during operation may result in the loss of heat transfer fluid, unnecessary down time, product contamination, loss of property, or injury to personnel.

FILLING THE SYSTEM

Make certain that compatible heat transfer oil is being used to meet the system requirements. If any questions arise, contact our Service or Engineering Department for recommended oils.

Fill the system through the fill/drain valve, which should be located below the inlet line on the suction side of the pump. Fill the system at the lowest point in the interconnecting piping when the TCU is installed higher than the process. Fill the piping loop and the hot oil unit and process with thermal fluid from new containers. Filling via a pump will speed the filling process, as will the use of “automatic” air vents, installed at highest points in the piping, these are available from Armstrong, Spirax Sarco and other manufacturers or can be purchased from Budzar. Continue to fill the system while venting the high points until the system is full. **NOTE:** The vent valve on the TCU to the expansion tank must be opened to allow air to vent from the piping. If Budzar did not provide the expansion tank this vent valve must be installed in the field. The manual bypass valve for the expansion tank backpressure regulator, if so equipped, should be open to aid venting and filling. Check to make sure the fill line valve and the expansion line to the underside of the expansion tank are open. Fill the system until level on the expansion tank shows a level of 1/4 the tank capacity.

Now that the unit has oil in it, momentarily engage the start button on the unit and observe the pump rotation. **Make certain that the belt or pump coupling (for long coupled pumps) has been removed before bumping to check rotation, the impeller can unthread itself from the motor shaft. For close coupled pumps the "bumping" must be very brief since the impeller can unthread itself from the motor shaft.** **NOTE:** The alignment of the pump and motor should be check prior to extended operation of the pump. The pumps were aligned prior to shipment but shipping and installation operations may have caused the pump to become misalign. Final alignment is not within the scope of the Budzar supply and must be verified in the field by others. The correct rotation will be either stamped on the pump casing or indicated in the pump section of this manual. If the circulating pump is running backwards, reverse any two of the three-phase power input leads where they enter into the control box. The rotations of the pumps on multi-zone TCU's are tested prior to shipping from the factory. It is advisable to correct for improper phase (rotation) at the main input rather than on the individual pumps. After correct rotation is confirmed start the pump, the pressure gauge should indicate a positive pressure which is a characteristic of the pump and system curves. If no pressure is indicated **stop the pump immediately**, there might be air entrapment starving the pump. If this is the case, the system will not operate until the air is released. Damage to the pump can occur if it is run without oil in the volute so the air must be purged from the pump volute. It may be possible to force the air out by running the fill pump while bleeding air from a piping high point. It may be necessary to loosen the top (2) pump bolts holding the volute together to release the air. Retighten bolts after oil seeps by.

NOTE: The TCU has safeties that prevent the electric heaters from operating if sufficient flow can not be maintained over the heating elements. An example is a pressure switch on the pump discharge, which is wired in the heater control circuit. Optional safeties include a bypass valve installed in the discharge piping and flow measuring devices other than a pressure switch. The bypass valve limits the backpressure in cases where excessive restrictions are encounter that could cause damage to the heater and oil. However, restricted flow to the process can cause erratic control of the process temperature.

AIR AND MOISTURE PURGING

Start the pump to circulate fluid throughout the piping and the process. Once the pump is running the temperature controller, usually mounted in the door of the electrical enclosure, should be set to a low value (50 °F/20 °C) so that heating will not occur. Vent the process equipment and the piping to remove air. **NOTE**: The fill source must be available during this operation since as air is forced out of the piping system additional fluid will be needed to fill the space. **BE CAREFUL THAT THE LEVEL IN THE EXPANSION TANK DOES NOT DROP BELOW THE VISIBLE LEVEL.**

Once the bulk of the air has been expelled the level in the expansion tank may need to be adjusted. Turn off the pump. Drain or add fluid to the hot oil unit until approximately 1/3 to 1/4 of the expansion tank is full or if applicable just above the low-level switch trip point.

Now that the system is completely filled and vented of as much air as possible ramp the setpoint of the hot oil unit up to 230 °F/110 °C in 25 °F steps. **CAUTION: DO NOT EXCEED THE MAXIMUM ALLOWABLE RAMP RATE FOR THE PROCESS EQUIPMENT.** At each step hold the temperature constant and allow the process equipment and interconnecting piping to rise in temperature and check the level in the expansion tank. The manual vent valve on the hot oil unit to the expansion tank should be open to purge air and moisture from the system. If applicable the expansion tank backpressure vent valve manual bypass should also be opened to evacuate air and moisture. If applicable, the 3-way cooling control valve should be modulated through the full stroke several times at every other temperature step to allow for proper venting. Continue venting as in other steps using extreme caution once the temperature has exceeded 110°F/45 °C. This is an important step that may take some time to complete due to the complex nature of the interconnected process piping.

Continue to operate the hot oil unit at 230°F/110 °C to allow moisture, which is in the system to boil out. This may take considerable time since the water must be forced to the expansion tank, through the manual vent valve on the hot oil unit discharge pipe, where it can be expelled from the system through the expansion tank vent. It may be possible to expel water vapor through automatic air vents at the process equipment and at the high points in the interconnecting piping.

CAUTION: Do not overheat the expansion tank since excessive heating of the expansion tank can cause oxidation of the fluid.

Once the system has been vented and boiled out, the nitrogen blanket, if applicable, can be established. Close the manual vent and backpressure bypass valves and pressurize the expansion tank from the nitrogen supply system and verify the pressure settings on the nitrogen regulator and the back pressure regulator. The system is now ready to be brought to maximum operating temperature. Follow the process equipment manufacturer instructions for installation and start up of those pieces of equipment.

TEMPERATURE CONTROLLER

Enclosed in this manual is specific information regarding the temperature controller utilized on this equipment and it contains all information necessary for proper adjustments and service. If additional assistance is required contact our the Budzar Service Department.

TYPICAL PRECAUTIONS

Do not energize the heater until the system is filled with fluid. The liquid level in the expansion tank must be checked continually during the initial start-up procedure. The liquid level should not exceed the 1/4 mark nor drop below the 1/8 mark on the liquid level gauge. If abnormal expansion of fluid occurs, it is either because of air or steam (excess water) still present in the system. Review the air and moisture purging segment and repeat if necessary. If the problem continues shut the pump down and check the air vent valves, if provided, and pump / motor assembly.

OPERATING

Providing that the flushing, filling and purging sequences are complete the unit is now ready to be operated. **CAUTION:** Make certain that the vent valve from the TCU discharge to the expansion tank is closed before raising the unit temperature. Excessive heating of the expansion tank can cause oxidation of the fluid. Start the pump and set the temperature controller initially to operate at 50 °F for approximately fifteen (15) minutes to establish that the system is functioning properly. The first time you start the TCU take amperage readings on the motor(s) and check all the safety controls and compare these to the copy of the test report. If all components are operating as required, begin to heat by setting the temperature controller at ambient plus 100 °F, take amp. readings on heater and compare to the test report. If any problem is found with the Heat Transfer System contact Budzar Industries. If everything is found to operate correctly proceed to heat-up the unit and allow fifteen (15) minutes of operating time at each step of 25 °F before proceeding to the next setpoint change in temperature. Continue to raise the temperature until the system reaches 220 °F. If the pump begins to cavitate it may indicate that water is still trapped in fluid. Excessive water or air in the system can cause the heat transfer fluid to back-up into the expansion tank and thus evacuating the heating chamber. If this happens, return to the purging step. If this problem persists, drain the system and recharge with new moisture free heat transfer fluid. Keep in mind that oil that sits does accumulate moisture.

The TCU may now be operated until the maximum operational setpoint is attained. After the initial start-up sequence day to day start-up should just include turning on the pump and setting the temperature. A system, which has been purged and properly maintained, should start right up and operate without incident. During heat up the only limitation to temperature ramp rate is the process and the available heat in the TCU. **CAUTION:** Some process equipment is susceptible to thermal shock, contact the process equipment manufacturer for ramp rate limitations.

TROUBLESHOOTING

The following points have been noted during previous Installations and appeared to be the most common installation problems. Please read carefully so that you can either rectify or avoid them during the installation of your equipment.

1 Lack of circulation and/or temperature control. Readings that rise and fall over wide spread ranges.

    A Improper piping hook-ups, a condition which will cause an apparent lack of circulation, or lack of control, and can be due to nameplates being located incorrectly or being improperly interpreted. Trace the piping system through the transfer system out to the load and back to make sure that the labels and piping are correct.
    B Caused by lack of circulation due to either vapor binding of the system, restriction in the system or improper piping. Double check all points concerning air venting and pipe sizing.
    C Pump rotation incorrect. Note that a centrifugal pump will develop some flow regardless of its rotational direction. It will, however, develop proper flow only in the right direction. Check pump shafts and motor fans, where rotation can be observed for proper rotation, or use a discharge pressure gauge in conjunction with a suction pressure gauge to determine which direction provides the higher discharge pressure.
    D Wide temperature fluctuation around set point... control band too narrow on controller.

2 Machine will not run properly, motor trips overload or blows fuses, electrical trouble suspected. This, in many cases, is due to the fact that one or more of the four wires compromising a three phase grounded neutral system has a loose connection to either terminals or lugs. Please check each wire following the wire through from source to final termination within the unit power box. **NOTE:** Continuity tests are helpful in finding a loose connection.
3 Premature heater failures... failures can normally be attributed to either over voltage conditions (momentary or consistent), vapor lock in the system or

lack of circulation in the system. When no heat occurs, raise then lower the setpoint on the temperature controller to see if the heater contactor activates. If contactor functions the heater is probably faulty. Heaters generally fail due to:

1. Heater element defective

A Blockage or restriction to flow path
B Units not full of oil and air in system.

4 The unit will not heat up properly even though the heat indicating light is on, heating contactor is known to be closed, and amp. reading is found to be good. This is usually caused by either one of the following two conditions, the temperature controller is calling for heat and cooling at the same time or the solenoid cooling valve being stuck in the open position due to dirt or foreign matter. You can check the temperature controller by this seeing if both the heat and cool lights are on, if this is the case check the controller program copy supplied in this manual. Momentarlly close the cold water supply to the unit and note if it causes the flow of water to stop and the unit to heats-up properly. The cure is to clean the solenoid valve so that it resets properly. Additional checks are strainer blockage, contaminants or blockage in the process such as a mold blockage, uninsulated piping, cool air blowing on unit, heat sinks, etc.

5 When applicable make sure expansion tank is higher than the load. This is necessary when system is shut down as to prevent oil from exiting via the tank.

6 Temperature controls at process-relief valve not seating properly letting fluid bypass the process.

7 Pump seal leaks - poor fluid quality or operating unit above temp. limits.

8 Tank overflow --
  A Too much oil in system
    1. Check level at cold start. Tank should be no more than 1/4 full.
    2. Check total oil in system. Typically oil expands 10% for every 200 °F. rise in temperature
  B Too much moisture in system (overflow occurs around 220-250 °F.
    1. Check cooling tubes or jackets for leaks into oil
    2. Review procedure for filling system

<u>Flow downstream of unit blocked</u>

    1 Check for high discharge pressure readings or open vent valve.
    2 Install By-pass

9 Loss of pressure or cavitation of the pump –
  A May be an indication of a clogged suction strainer. Cool the unit down if possible and stop the pump or stop the pump and allow the unit to cool naturally. Isolate the strainer and remove or clean the strainer screen or basket. Reinstall the screen and open the isolation valves, air will need to be purged. The procedure may need to be repeated several times before all the debris is eliminated. It may be possible to "blowdown" the strainer during hot operations when a strainer blowdown valve was

purchased. **CAUITON: BE CAREFUL WHEN BLOWING DOWN STRAINERS IN HOT SERVICE.**

B Moisture or air entrained in heat transfer fluid. Return to the Air and Moisture Purging section and repeat.

INSULATION (Appendix a)

The system should be started up and allowed to operate at typical temperatures before final insulating steps are completed.

Selection of suitable insulation requires careful consideration because of the high operating temperatures and safety considerations involved. Heat transfer liquids can pose a fire hazard when they contact absorbent insulation materials at elevated temperatures. Laboratory tests have shown that synthetic heat transfer fluids have similar fire hazard characteristics of organic fluids when exposed to absorbent insulation at elevated temperatures. However, in some instances, syntetic heat transfer fluid was shown to present less of a hazard than some organic heat transfer fluids.

Nonabsorbent, closed cell insulation such as cellular glass is the preferred material for systems operating at high temperatures. Closed cell insulation, at a minimum, is recommended for installation at all flanges, valves and connections. Fiberglass insulation may be used provided that it is sealed to prevent saturation from dripping fluid. In addition metal jacketing with high temperature caulking is the minimum recommendation for sealing or install fiberglass insulation only were it is not exposed to dripping fluid.

Additional measures to eliminate liquid leakage into insulation from potential problem areas such as valve packing glands, flange gaskets and instrument connections include:

1 Eliminating the source of the leakage as soon as it occurs. This may require additional and proper tightening of flanged or screwed connections, replacement of leaking gaskets and repacking of valve stems with high temperature packing material.
2 Covering insulation in those areas where leaks are most likely to occur, using a hydraulic setting, oil-resistant cement or nonabsorbent shielding.
3 Establishing a system for regular inspection and maintenance of heat transfer equipment and piping to detect leaks at the earliest opportunity and replace any oil-soaked insulation.

FILTRATION (Appendix b)

Under proper use conditions, the heat transfer fluid generates no solid materials by itself. However, rust, mill scale and other contaminants can be present or can be accidentally introduced into a heat transfer system. Interconnecting piping design should include a filter or at a minimum, flanges and valves for future filter connections.

Budzar offers two basic filter options. A filter can be designed to operate at the highest expected temperature of the system and left on-line continuously. Or, a lower temperature filter can be installed that is by-passed when the system is hot. A lower temperature filter provides greater capacity, fewer leaks and smaller particle size retention at lower initial cost. Generally, filtration down to 10-micron is required to get contaminants and fine particulate out of the liquid.

HEAT TRANSFER SYSTEM CLEANOUT (appendix c)

Cause of System Fouling

Even when proper heat transfer fluids are selected, improper or abnormal operating conditions can cause the heating system to develop fouling on the heat transfer surfaces, which may require a system cleanout.

The most common causes of system fouling are:

- overheating the heat transfer fluid
- contamination by process chemicals or other heat transfer fluids
- oxidation of the heat transfer fluid

Heat transfer fluids are affected by oxidizing conditions. Should extensive oxidation occur from air contacting hot fluid, a carbonaceous residue will form and adhere loosely to the system heating surfaces requiring cleanout of the system. Thermal breakdown of the fluid is less common than oxidation of these fluids, but can create carbonaceous deposits within the system. Contamination from process fluids or other heating media may contribute to fouling of a system. Incompatibility of the fluid chemistries involved may dictate changing to fresh heat transfer fluid. This requires reclamation and or disposal of contaminated heat transfer fluid and refilling the system with new fluid.

Corrective Action

The decision to clean the system to remove troublesome solids that affect pump seal performance and foul the heating surfaces or to replace contaminated heat transfer fluid must be the judgment of the customer. The method of cleaning is dependent upon the degree of solids buildup and surface fouling.

Cleaning Methods

Four (4) methods of "cleaning" a system are offered depending upon the degree of fouling or contamination of the heat transfer fluid.

1 Draining of old fluid and refilling with fresh heat transfer fluid. This method is the easiest and least expensive. Solids in the fluid can be removed by a hot and rapid draining. Addition of new fluid provides a small degree of

cleaning action on slightly fouled heating surfaces. This method can also be effective in converting a TCU to a different brand of heat transfer fluid (assuming heating surfaces are clean). Make certain that the fluids have similar properties including but not limited to; chemistry, heat transfer capability, maximum bulk and film temperature, viscosity and thermal expansion coefficient.

2 Fluid flush method involves flushing the system with a small amount of the heat transfer fluid to be used to fill the system. Isolation of system components is desirable to avoid using large quantities of flushing heat transfer fluid. This method is effective for new systems where surfaces are not heavily fouled.

3 Solvent cleaning - this method is useful to clean or flush a lightly soiled system. Chlorinated solvents are to be avoided with all heat transfer fluid. Typical solvents used are:

- Therminol® FF
- MultiTherm® 100
- Low flammability solvent compatible with the old and new fluid
- kerosene

CAUTION: USE EXTREME CAUTION WHEN FLAMMABLE SOLVENTS ARE USED FOR CLEANING SYSTEMS. FOLLOW NATIONAL FIRE PROTECTION GUIDELINES IN PREPARING THE AREA BEFORE FILLING OR OPERATING TCU DURING CLEANING OPERATIONS.

Caution: solvents used should be completely removed from the system prior to charging with heat transfer fluid.

4 Chemical cleaning - this method is effective in cleaning heavily fouled heating surfaces. The service can be purchased from

- Halliburton

or can be done in house using:

- Oakite cleaning products
- caustic soda and soda ash

Consult the Yellow Pages under chemical cleaning for the local Halliburton representative or cleaning chemicals from Oakite. The recommended Oakite Products cleaning procedure is attached as is the caustic soda, soda ash procedure.

Caution:

- Mechanical agitation by high velocity flow or air injection is necessary to loosen difficult soils

- Cleaning products must be completely removed from the system prior to charging with heat transfer fluid.
- Water, while not detrimental to heat transfer fluid, must be completely removed to preclude startup-pumping problems. Extensive air and moisture purging may be required to bring the TCU and process equipment back online.
- We cannot guarantee that chemical cleaning will remove all surface soils in the heating system. The customer should consult with the representatives of the cleaning service selected.
- The cleaning agents used may affect certain metals in the system such as copper and aluminum.

Chemical Cleaning - Caustic Soda and Soda Ash

1 Fill empty system with cleaning solution containing 5-lb. caustic soda and 5-lb. soda ash per 120 gallons of water.
2 Initiate circulation and heat liquid to 180 ° F.
3 Circulate 24 hours, periodically drain fluid from a low point and replace with clean water. Continue this operation until the fluid in system is clear (about 24 hours).
4 When fluid in system is clear, raise temperature to 215 ° F to 225 °F. stop pump and heater.
5 Quickly drain system, open all vents and allow residual heat to dry system.
6 Assure system is drained. Budzar recommends purging the system with compressed air, which has been dried to 40^{o}F dewpoint, or lower and re-heated to 100 ^{o}F. Follow up the air purge with dry nitrogen. Longer moisture purging times will be required, if the system is not dried out prior to filling, when water based cleaning has been used.
7 Fill with heat transfer fluid selected. Commence with air and moisture purging sequence.
8 Verify that the pump seal(s) are not leaking and replace if necessary. Verify that all of the safeties are working properly.

Contaminated Fluid

Thermally damaged or contaminated heat transfer fluid can often be reclaimed by distillation methods. Fluid contaminated by insoluble particles can be cleaned by filtration. Water can be removed from heat transfer fluid by increasing temperature and flushing water from fluid as steam or can sometimes be removed by settling and separation methods. Consult your local heat transfer fluid Specialist for guidance.

Cleaning Services Contact List:

Companies providing cleaning materials and services can often be found in the Yellow Pages of the phone directory under such headings as Cleaning

Compounds, Cleaning Systems and Chemical Cleaning. Several companies offering nationwide cleaning products and services are listed below:

Dowell Schlumberger
10165 Harwin
Houston, TX 77036
(713) 995-5855

Halliburton Industrial Services, Inc.
P.O. Box 297
Duncan, OK 73536
1-800-932-5326

Main Tech International, Inc.
P.O. Box 1566
LaPorte, TX 77571
(713) 471-6380

Oakite Products, Inc.
50 Valley Road
Berkeley Heights, NJ 07922
(201) 464-6900

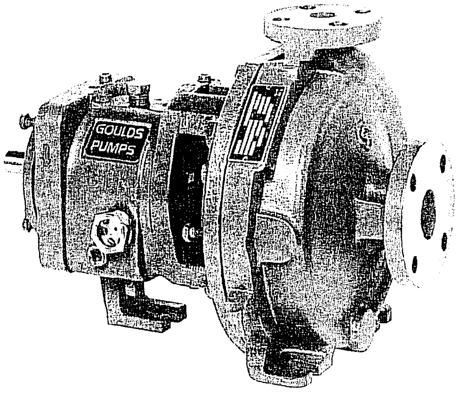
Powerlance International, Inc.
5517 Newport
Houston, TX 77023
(713) 921-4030

RETSCO Industrial Chemical Cleaning Service
12237 FM 529
Houston, TX 77041
(713) 466-0358

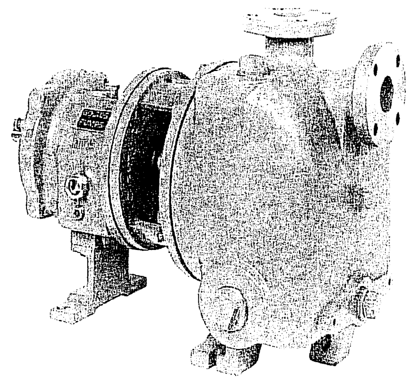
Union Carbide Industrial Services Company (UCISCO)
222 Pennbright
Suite 250
Houston, TX 77090
(713) 872-2100

GOULDS PUMPS

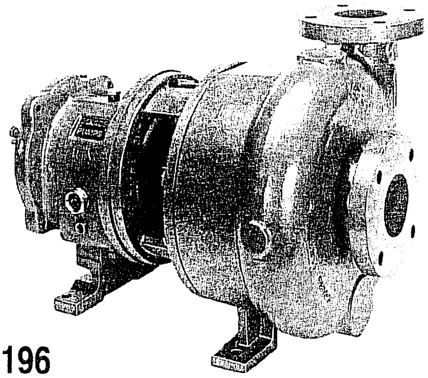
Installation, Operation and Maintenance Instructions



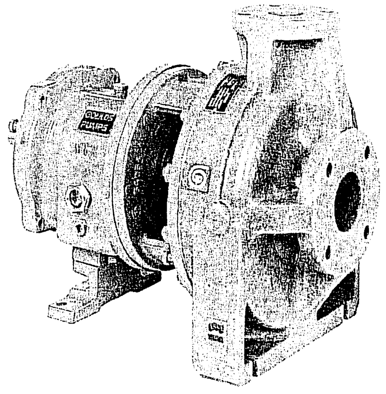
3196



3796



CV 3196



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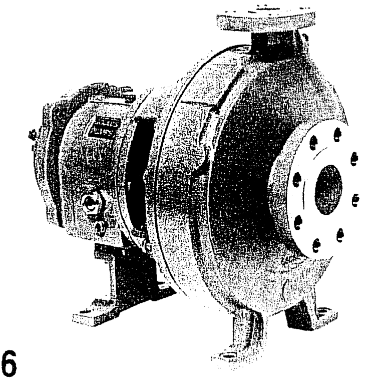
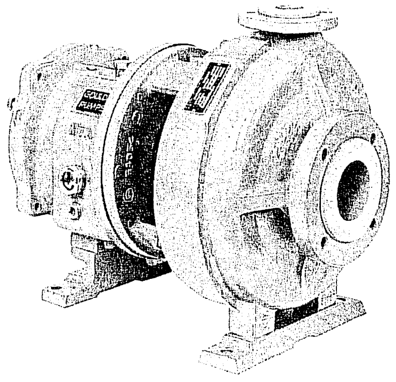


LF 3196



3198

ANSI Family

Pump Safety Tips

Safety Apparel:

- Insulated work gloves when handling hot bearings or using bearing heater
- Heavy work gloves when handling parts with sharp edges, especially impellers
- Safety glasses (with side shields) for eye protection, especially in machine shop areas
- Steel-toed shoes for foot protection when handling parts, heavy tools, etc.
- Other personal protective equipment to protect against hazardous/toxic fluids

Coupling Guards:

- Never operate a pump without a coupling guard properly installed

Flanged Connections:

- Never force piping to make a connection with a pump
- Use only fasteners of the proper size and material
- Ensure there are no missing fasteners
- Beware of corroded or loose fasteners

Operation:

- Do not operate below minimum rated flow, or with suction/discharge valves closed
- Do not open vent or drain valves, or remove plugs while system is pressurized

Maintenance Safety:

- Always lock out power
- Ensure pump is isolated from system and pressure is relieved before disassembling pump, removing plugs, or disconnecting piping
- Use proper lifting and supporting equipment to prevent serious injury
- Observe proper decontamination procedures
- Know and follow company safety regulations

Observe all cautions and warnings highlighted in pump *Installation, Operation and Maintenance Instructions.*

FOREWORD

This manual provides instructions for the Installation, Operation, and Maintenance of the Goulds Models 3196, CV 3196, LF 3196, NM 3196, 3198, and 3796. This manual covers the standard product plus common options that are available. For special options, supplemental instructions are supplied. **This manual must be read and understood before installation and start-up.**

This instruction manual covers six different pump models that all have a common power end. Most assembly, disassembly, and inspection procedures are the same for all the pumps. However, where there are differences, they are called out separately within the manual. The design, materials, and workmanship incorporated in the construction of Goulds pumps makes them capable of giving long, trouble-free service. The life and satisfactory service of any mechanical unit, however, is 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 construction and the correct methods of installing, operating, and maintaining these pumps.

Goulds 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 Goulds parts are used.

.Jse of the equipment on a service other than stated in the order will nullify the warranty, unless written approval is obtained in advance from Goulds Pumps.

Supervision by an authorized Goulds representative is recommended to assure proper installation.

Additional manuals can be obtained by contacting your local Goulds representative or by calling I-800-446-8537.

THIS MANUAL EXPLAINS

- ■ **Proper Installation**
- ■ **Start-up Procedures**
- ■ **Operation Procedures**
- ■ **Routine Maintenance**
- ☐ **Pump Overhaul**
- ☐ **Trouble Shooting**
- ☐ **Ordering Spare or Repair Parts**

TABLE OF CONTENTS

SAFETY

DEFINITIONS

These pumps have 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. Goulds Pumps 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 which require special operator attention:

⚠ WARNING

Operating procedure, practice, etc. which, if not correctly followed, could result in personal injury or loss of life.

⚠ CAUTION

Operating procedure, practice, etc. which, if not followed, could result in damage or destruction of equipment.

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

EXAMPLES

⚠ WARNING

Pump shall never be operated without coupling guard installed correctly.

⚠ CAUTION

Throttling flow from the suction side may cause cavitation and pump damage.

NOTE: Proper alignment is essential for long pump life.

GENERAL PRECAUTIONS

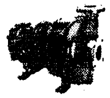
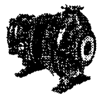
⚠ WARNING

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

- NEVER apply heat to remove impeller. It may explode due to trapped liquid.
- NEVER use heat to disassemble pump 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 power to the driver before performing pump maintenance.
- NEVER operate pump without safety devices installed.
- NEVER operate pump with discharge valve closed.
- NEVER operate pump with suction valve closed.
- DO NOT change conditions of service without approval of an authorized Goulds representative.

GENERAL INFORMATION

PUMP DESCRIPTION

Model	Pump Description	Size Groups	No. of Sizes
 3196 Bare Pump ISO/Photo	The model is based on five power ends and 28 hydraulic pump sizes. The 3196 is a horizontal overhung, open impeller, centrifugal pump that meets the requirements of ANSI B73.1	STX MTX LTX XLT-X X17	5 15 11 5 3
 CV 3196	The model is based on four power ends and seven hydraulic pump sizes. The CV 3196 is a horizontal overhung, recessed impeller, centrifugal pump. It is specifically designed to handle bulky or fiberous solids, air or gas entrained liquids, or shear sensitive liquids.	STX MTX LTX XLT-X	1 4 5 1
 LF 3196	The model is based on three power ends and four hydraulic pump sizes. The LF 3196 is a horizontal overhung, open impeller, centrifugal pump that meets the requirements of ANSI B73.1. It is designed specifically for low flow high head applications.	STX MTX LTX	2 1 2
 NM 3196	The model is based on two power ends and 13 hydraulic pump sizes. The NM 3196 is a horizontal overhung, open impeller, centrifugal pump that meets the requirements of ANSI B73.1. It is made of a fiber reinforced vinylester to handle severe corrosives.	STX MTX	5 8
 3198	The model is based on two power ends and four hydraulic pump sizes. The 3198 is a horizontal overhung, open impeller, centrifugal pump that meets the requirments of ANSI B73.1. It is made of a Teflon® lined ductile iron to handle severe corrosives.	STX MTX	1 3
 3796	The model is based on three power ends and eight hydraulic pump sizes. The 3796 is a horizontal overhung, self priming, open impeller, centrifugal pump.	STX MTX LTX	2 6 6

ANSI Family Parts Commonality

All of Goulds Pumps horizontal ANSI pumps are based on the same power end. All of the metallic units share the same stuffing box covers and seal chambers. The non-metallic units all have unique casings, impellers, and seal chambers. The chart on the following pages demonstrates the parts commonality and the relationship between the model lines.

Model **Casing** **Impeller**

3196

The casing is top centerline discharge and self-venting. The gasket is fully confined. An integral foot support is used for maximum resistance to misalignment and distortion from piping loads. ANSI flat faced serrated flanges are standard. ANSI class 150 raised face serrated, ANSI class 300 flat face serrated, and ANSI class 300 rasied face serrated are available.

The impeller is fully open and threaded to the shaft. The threads are sealed from the pumpage by a Teflon® O-ring.

3796

The casing is centerline discharge and self-venting. It has an integrally cast priming chamber that allows the pump to evacuate air to prime itself. The gasket is fully confined. An integral foot support is used for maximum resistance to misalignment and distortion from piping loads. ANSI class 150 flat face serrated, and class 300 raised face serrated flanges also available as an option. The casing comes with a provision to accept an immersion heater to keep the liquid in the priming chamber from freezing in outdoor applications.

CV 3196

The casing is tangential discharge and available with optional connections for venting, flushing, and solids cleanout. The gasket is fully confined. An integral foot support is used for maximum resistance to misalignment and distortion from piping loads. ANSI class 150 flat face serrated flanges are standard on all sizes.

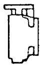
The impeller is fully open and recessed from the casing. It has curved vanes and is threaded to the shaft. The threads are sealed from the pumpage by a Teflon® O-ring.

LF 3196

The casing is top centerline discharge and self-venting. The gasket is fully confined. An integral foot support is used for maximum resistance to misalignment and distortion from piping loads. ANSI class 150 raised face serrated flanges are standard on 4, 8, and 10" sizes. ANSI class 300 raised face serrated flanges are standard on the 13" size and optional on 4, 8, and 10" sizes.

The impeller is fully open and has radial vanes and balance holes. The impeller is threaded to the shaft and sealed from the pumpage by a Teflon® O-ring.

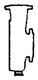
NM 3196



The casing is top centerline discharge and self venting. It is constructed from a fiber reinforced vinylester that is ribbed for strength. It is sealed using a Viton® O-ring as standard. An integral foot support is used for maximum resistance to misalignment and distortion from piping loads. ANSI class 150 flat face flanges are standard.

The impeller is fully open and threaded to the shaft. It is a fiber reinforced vinylester over a Hastelloy C insert that provides support and rigidity to the impeller while securing it to the shaft. The threads are sealed from the pumpage by a Teflon® O-ring.

3198

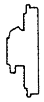


The casing is top centerline discharge and self-venting. The ductile iron casing is lined with PFA Teflon® for corrosion resistance and is offered with ANSI class 150 raised face flanges. The casing gasket is a Teflon® envelope with a compressible filler that provides a positive seal with low bolt torque.

The impeller is fully open and threaded to the shaft. It is constructed of a PFA Teflon® covered steel insert. The insert provides support and rigidity to the impeller while securing it to the shaft. The threads are sealed from the pumpage by a Teflon® O-ring

Cover/Chamber

Power Ends



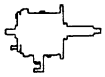
The 3196, CV 3196, LF 3196, and 3796 are available with a stuffing box cover designed for packing and BigBore™ or TaperBore™ *PLUS* seal chambers for improved performance of mechanical seals.

An optional dynamic seal is available which uses a repeller to pump liquid out of the stuffing box while the pump operates. A static seal prevents leakage when the pump is shutdown.

The NM 3196 is supplied with a fiber reinforced vinylester backplate to accommodate a clamped outside single seal. The backplate is also available with an internal bypass flush. An optional bolt on seal chamber is available for conventional back-to-back double seals.

The 3198 is supplied with a PFA Teflon® lined backplate to accommodate a clamped outside single seal. Also available for the backplate is a bolt-on metallic seal chamber for conventional back-to-back double seals. An optional PFA Teflon® lined standard bore stuffing box cover is available for conventional single clamped seat inside or outside seals. For cartridge seals, an ETFE Tefzel® lined BigBore™ seal chamber is available.

Frame Adapter - The ductile iron frame adapter has a machined rabbet fit to the seal chamber/ stuffing box cover and a precision dowel pin fit to the bearing frame. The 3198 frame adapter has the same features but different dimensions to accommodate the pump's Teflon® lining.



Power End - The oil level is viewed through a sight glass. Optional oil cooling is provided by a finned tube. Flood oil lubrication is standard. The power end is sealed with non-metallic labyrinth seals. No machining is required to convert from oil to grease or oil mist lubrication. Regreasable bearings and oil mist lubrication are optional.

Shaft - The shaft is available with or without a sleeve. When supplied with a Teflon® sleeve, the 3198 shaft is knurled under the sleeve to provide a positive drive for the sleeve.

Bearings - The inboard bearing carries only radial loads. 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, except for the LTX which uses a pair of single row angular contact ball bearings mounted back-to-back.

NAMEPLATE INFORMATION

Every pump has two Goulds nameplates that provide information about the pump. The tags are located on the casing and bearing frame.

Pump Casing Tag - provides information about the pump's hydraulic characteristics. Note the format of the pump size: Discharge x Suction - Nominal maximum Impeller Diameter in inches. (Example: 2x2-8) (Figs. 1 & 2).

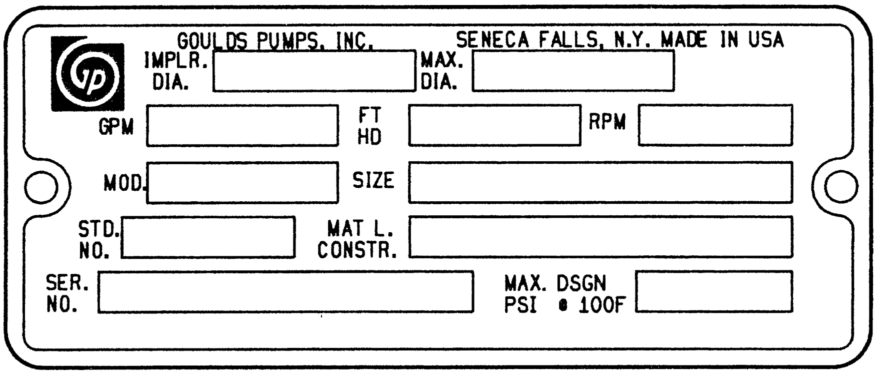


Fig. 1 (English)

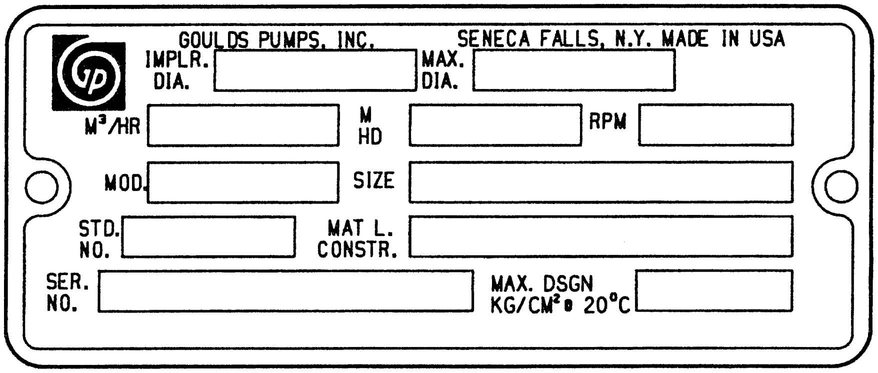


Fig. 2 (Metric)

Bearing Frame Tag - provides information on the lubrication system used (Fig. 3).

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 casing tag. Item numbers can be found in this manual.

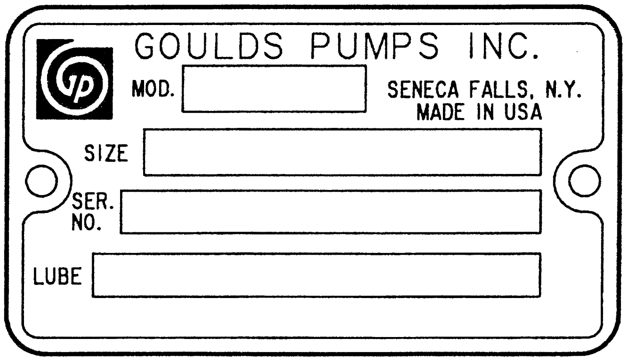


Fig. 3

RECEIVING THE PUMP

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

STORAGE REQUIREMENTS

Short Term: (Less than 6 months) Goulds normal packaging procedure is designed to protect the pump during shipping. Upon receipt, 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.

NOTE: Long term storage treatment can be purchased with the initial pump order or can be applied to pumps already in the field that were not treated at the factory. This service can be supplied by contacting your local Goulds sales representative.

HANDLING

WARNING

Pump and components are heavy. Failure to properly lift and support equipment could result in serious physical injury or damage to pumps. Steel toed shoes must be worn at all times.

Use care when moving pumps. Lifting equipment must be able to adequately support the entire assembly. Hoist bare pump using a suitable sling, under the suction flange and bearing frame. Baseplate mounted units are moved with slings under the pump casing and driver. Refer to Figs. 4-7 for examples of proper lifting techniques.

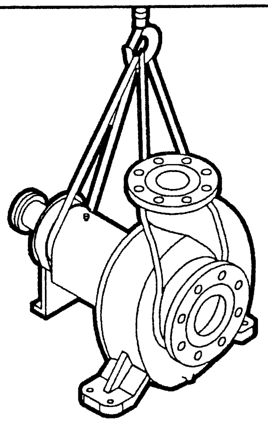


Fig. 4

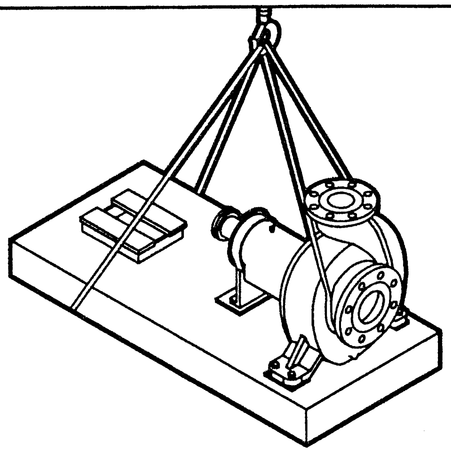


Fig. 5

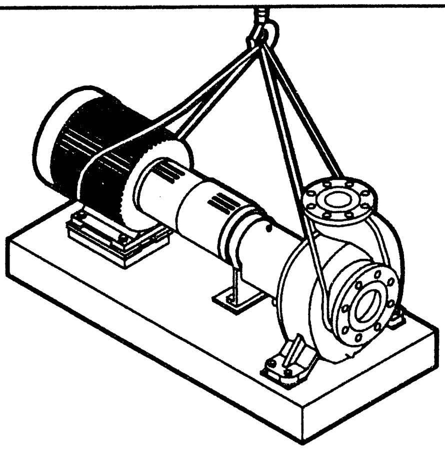


Fig. 6

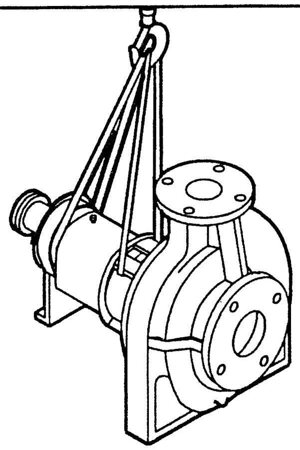


Fig. 7

NOTE: When lifting the NM 3196 or metallic units with integral suction flanges that do not have a way to secure the strap on the suction flange, the strap shown in Figures 4-6 around the suction flange should be secured around the frame adapter (Fig. 7).

INSTALLATION

BASEPLATE INSPECTION

1. Remove all equipment.
2. Completely clean the underside of baseplate. It is sometimes necessary to coat the underside of the baseplate with an epoxy primer. This may have been purchased as an option.
3. Remove the rust preventative solution from the machined pads with an appropriate solution.

SITE/FOUNDATION

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

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.

The location and size of the foundation bolts are shown on the outline assembly drawing, provided with the pump data package.

Foundation bolts commonly used are sleeve type (Fig. 8) and J type (Fig. 9). Both designs permit movement for final bolt adjustment.

1. Inspect foundation for dust, dirt, oil, chips, water, etc. and remove any contaminants. Do not use oil-based cleaners as grout will not bond to it.

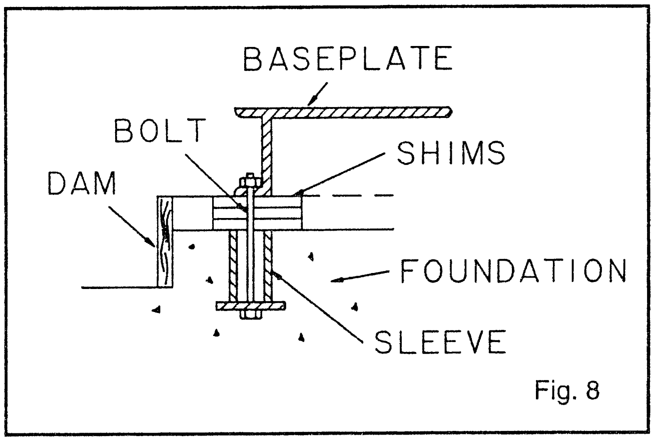


Fig. 8

2. Prepare the foundation in accordance with the grout manufacturer's recommendations.

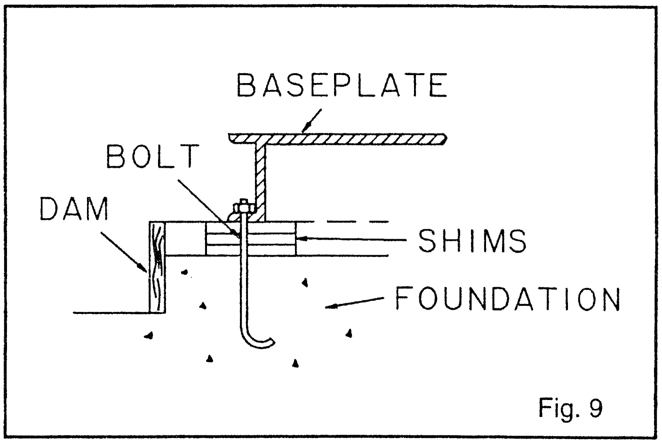


Fig. 9

LEVEL BASEPLATE

CAST IRON/PERMABASE™/FAB. STEEL

1. Place two sets of wedges or shims on the foundation, one set on each side of every foundation bolt. The wedges should extend .75 in. (20mm) to 1.5 in. (40mm) above foundation, to allow for adequate grouting. This will provide even support for the baseplate once it is grouted.
2. 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 packing or rags to prevent grout from entering.
3. Carefully lower baseplate onto foundation bolts.
4. Level baseplate to within 1/8" (3.2mm) over length of the baseplate and to within .088 in. (1.5mm) over the width of the base by adjusting wedges.
5. A level should be placed across the pump mounting pads and the motor mounting pads.
6. Hand tighten the bolts.

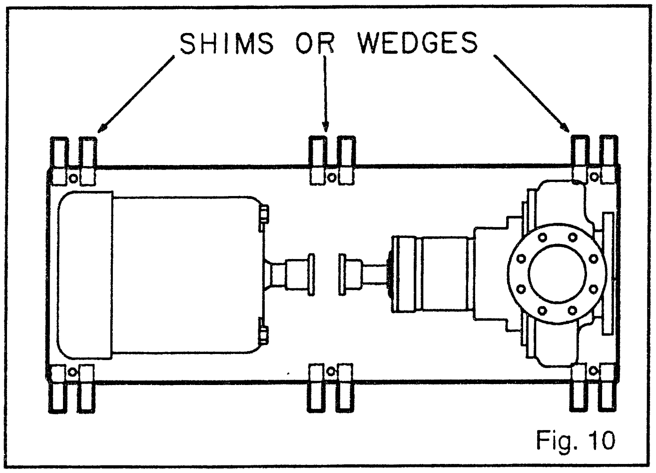


Fig. 10

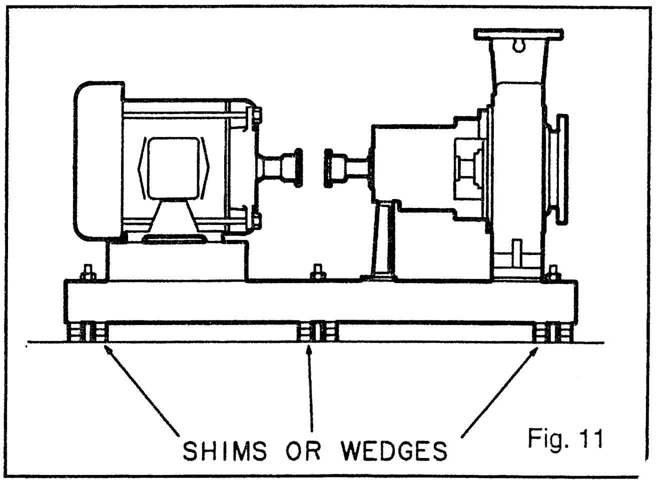


Fig. 11

FEATURE FAB. STEEL / API STYLE

(BASEPLATES PROVIDED WITH VERTICAL LEVELING ADJUSTERS)

Coat the jack screws with an anti-seizing compound to allow for easy removal after the grout has been cured.

2. Cut round circular plates from bar stock to set the jack screws on. The edges of the plates should be chamfered to reduce stress concentrations.
3. Set the baseplate on the foundation and use the four corner jack screws to raise the baseplate off the foundation 0.75" to 1.5". The two center jack screws should not be touching the foundation.

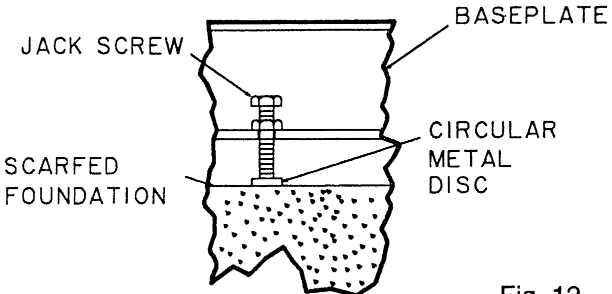


Fig. 12

4. Place two machinist levels on the motor pads, one lengthwise on a single motor pad, and another across the ends of both motor pads (Fig. 13).

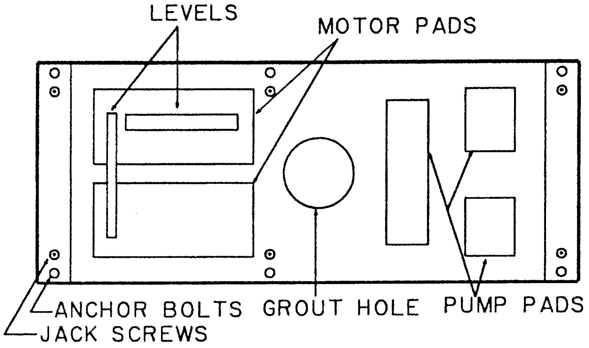


Fig. 13

NOTE: When using a machinist level, it is important that the surface being leveled is free of all contaminants, such as dust, to ensure an accurate reading.

5. Level the motor pads as close to zero as possible, in both directions, by adjusting the four jack screws.
6. Next, turn down the center jack screws so that they are resting on their metal discs on the foundation.
7. Place the two levels on the pump pads, one lengthwise on a single pump pad, and another across the middle of both pump pads (Fig. 14).

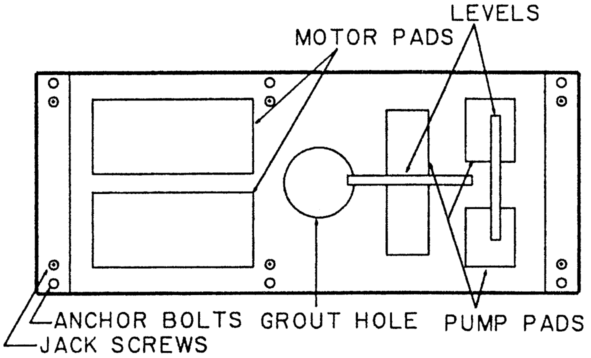


Fig. 14

8. Level the pump pads as close to zero as possible, in both directions, by adjusting the jack screws.
9. Install the anchor bolts until they are hand tight.
10. Return the levels to the motor pads and check the level measurements.
11. Adjust the jack screws and anchor bolts, if necessary, until all level measurements are within the design requirements of 0.002 in./ft.
12. When taking readings, center the level over the pad being measured.

NOTE: The Baseplate Leveling Worksheet provided may be used when taking readings.

Stilt Mounted

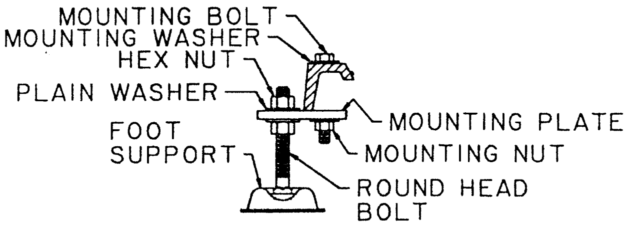


Fig. 15

1. Raise or support the baseplate above the foundation or floor.
2. Determine the desired baseplate height above the floor, referenced to the stilt mounting flange.

3. Set the bottom adjusting nuts and jamnuts on each stilt to the desired height.
4. Insert a washer between the bottom adjusting nut and the baseplate.
5. Install each stilt, holding it in place with another washer and the top adjusting nut. Finish by installing the top jam nut.
6. Once all four stilts have been installed, lower the unit making sure each stilt bolt head settles into its floor cup.
7. Level the baseplate while making final height adjustments. Adjust the baseplate height by loosening the top jam nut and adjusting nut. Change the height by moving the lower adjusting nut. When the baseplate is level, tighten the top adjusting nuts and then snug the lower and upper jam nuts.

NOTE: Suction and discharge piping must be individually supported. The stilt mounted baseplate is not designed to support any static pipe loads.

Spring Mounted

1. Raise or support the baseplate above the foundation or floor. Be sure to allow enough room under the baseplate to install the spring assemblies.
2. Set the bottom adjusting nuts on each spring stud to the desired height.
3. Insert a washer between the bottom adjusting nut and the spring follower. Install a spring and another follower. Install this subassembly from the bottom of the baseplate.
4. Install the upper half of the spring assembly consisting of a follower, a spring, another follower, and a flat washer. Now install the top adjusting nut and jam nut. Tighten finger tight.
5. Repeat steps 1 thru 4 for all the spring assemblies.
6. Once all the springs have been installed, lower th unit on to the foundation pads.

NOTE: The foundation pads are supplied by the customer. They are to be 16-20 micro-inch surface finish 316 stainless steel plate.

7. Level the baseplate while making final height adjustments. Adjust the baseplate height by loosening the top jam nut and adjusting nut. Change the height by moving the lower adjusting nut. When the baseplate is level, tighten the top adjusting nuts just enough to make sure the top springs are not loose in their followers and then snug the lower and upper jam nuts.

NOTE: Suction and discharge piping must be individually supported. The spring mounted baseplates are designed to support piping loads developed by thermal expansion only.

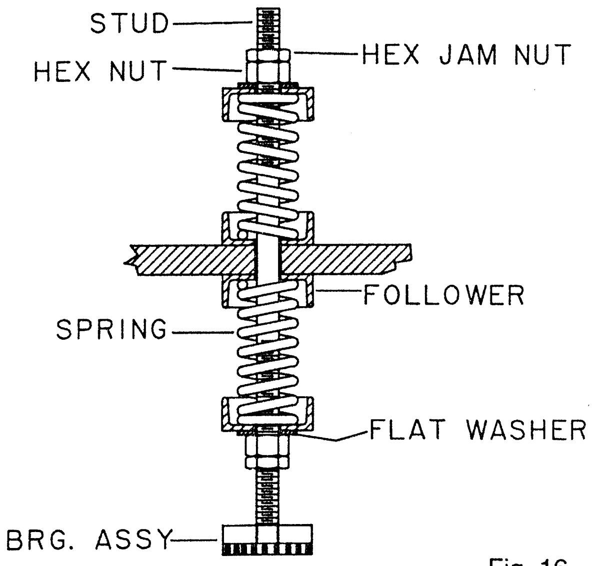
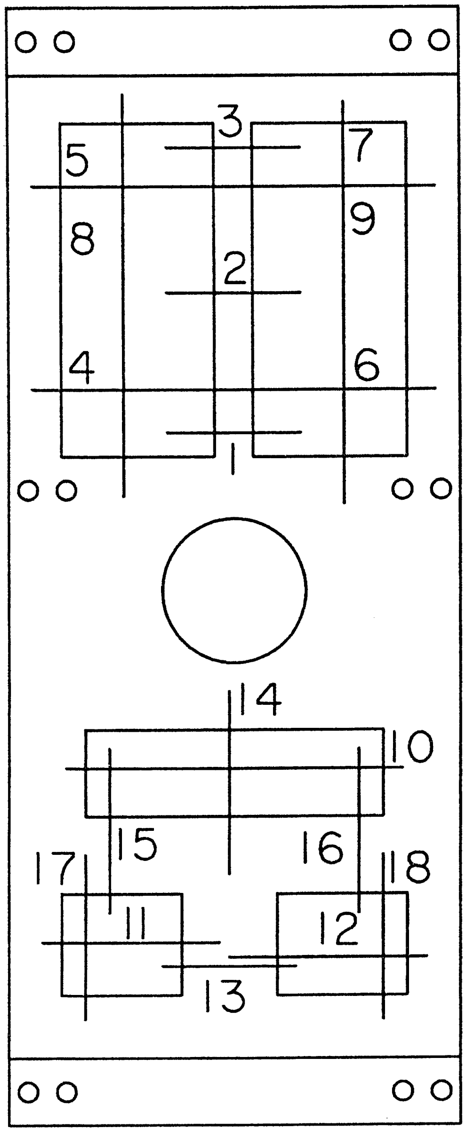


Fig. 16

BASEPLATE LEVELING WORKSHEET



LEVEL MEASUREMENTS

1) ____________________
2) ____________________
3) ____________________
4) ____________________
5) ____________________
6) ____________________
7) ____________________
8) ____________________
9) ____________________
10) ____________________
11) ____________________
12) ____________________
13) ____________________
14) ____________________
15) ____________________
16) ____________________
17) ____________________
18) ____________________

ALIGNMENT

WARNING

Before beginning any alignment procedure ,make sure driver power is locked out. Failure to lock out driver power will result in serious physical injury.

To remove guard, refer to coupling guard assembly/ disassembly instructions.

The points at which alignment is checked and adjusted are:

- **Initial Alignment** is done prior to operation when the pump and the driver are at ambient temperature.
- **Final Alignment** is done after operation when the pump and driver are at operating temperature.

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

NOTE: Proper 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 the procedures in *Appendix III*.

ALIGNMENT CHECKS

Initial Alignment (Cold Alignment)

- *Before Grouting Baseplate* - To ensure alignment can be obtained.
- *After Grouting Baseplate* - To ensure no changes have occurred during grouting process.
- *After Connecting Piping* - To ensure pipe strains haven't altered alignment. If changes have occurred, alter piping to remove pipe strains on pump flanges.

Final Alignment (Hot Alignment)

- *After First Run* - To obtain correct alignment when both pump and driver are at operating temperature. Thereafter, alignment should be checked periodically in accordance with plant operating procedures.

NOTE: Alignment check must be made if process temperature changes, piping changes and or pump service is performed.

ALIGNMENT CRITERIA

Good alignment is achieved when the dial indicator readings as specified in the alignment procedure are:

- .002 in. (.05 mm) Total Indicated Reading (T.I.R.) or less when the pump and driver are at operating temperature (Final Alignment)
- .0005 in. per inch of dial indicator separation for the reverse dial indicator or laser method when the pump and driver are at operating temperature (Final Alignment)

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

Table 1
Cold Setting of Parallel Vertical Alignment

Pumpage Temperature	Set Driver Shaft, Inches (mm)					
	3196	CV 3196	LF 3196	NM 3196	3198	3796
50° F (10° C)	.002 (.05) low	.002 (.05) low	.002 (.05) low	.002 (.05) low	.002 (.05) low	.002 (.05) low
150° F F (65° C)	.001 (.03) high	.001(.03) high	.001(.03) high	.001(.03) high	.001(.03) high	.001(.03) high
250° F (120° C)	.005 (.12) high	.005 (.12) high	.005 (.12) high	.005 (.12) high	.005 (.12) high	.005 (.12) high
350° F (175° C)	.009 (.23) high	.009 (.23) high	.009 (.23) high	N/A	.009 (.23) high	.009 (.23) high
450° F (218° C)	.013 (.33) high	.013 (.33) high	.013 (.33) high	N/A	N/A	.013 (.33) high
550° F (228° C)	.017 (.43) high	.017 (.43) high	.017 (.43) high	N/A	N/A	.017 (.43) high
650° F (343° C)	.021 (.53) high	.021 (.53) high	.021 (.53) high	N/A	N/A	N/A
700° F (371° C)	.023 (.58) high	.023 (.58) high	.023 (.58) high	N/A	N/A	N/A

ALIGNMENT TROUBLESHOOTING

Table 2

Problem	Probable Cause	Remedy
Cannot obtain horizontal (Side-to-Side) alignment, angular or parallel	Driver feet bolt bound.	Loosen pump hold down bolts and slide pump and driver until horizontal alignment is achieved.
	Baseplate not leveled properly, probably twisted.	Determine which corner(s) of the baseplate are high or low and remove or add shims at the appropriate corner(s) and realign.

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 dam around foundation. Thoroughly wet foundation (Fig. 17).
3. Pour grout through grout hole in baseplate, up to level of dam. Remove air bubbles from grout as it is poured by puddling, using a vibrator, or pumping the grout into place. Non-shrink grout is recommended.

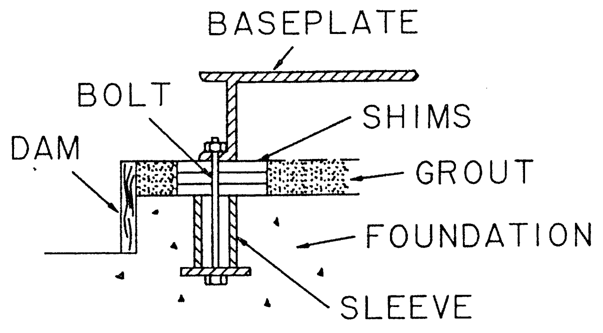


Fig. 17

4. Allow grout to set.
5. Fill remainder of baseplate with grout. Remove air as before (Fig. 18).

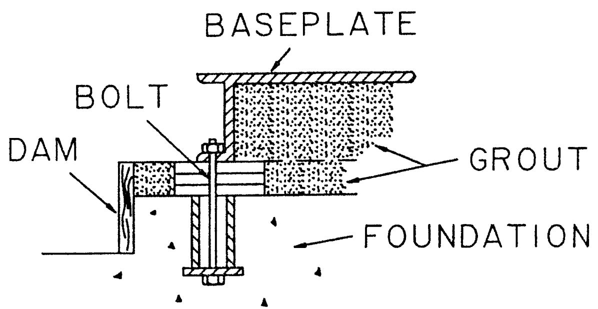


Fig. 18

6. Allow grout to set at least 48 hours.
7. Tighten foundation bolts.

ALIGNMENT CHECK

Re-check alignment before continuing, using methods previously described.

GENERAL

Guidelines for piping are given in the "Hydraulic Institute Standards" available from: Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ 07054-3802 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 be supported independently of, and line up naturally with, the pump flanges.
2. Piping runs should be as short as possible to minimize friction losses.
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, if used, be properly installed in suction and/or discharge lines when handling liquids at elevated temperatures, so linear expansion of piping will not draw pump out of alignment.

INCORRECT

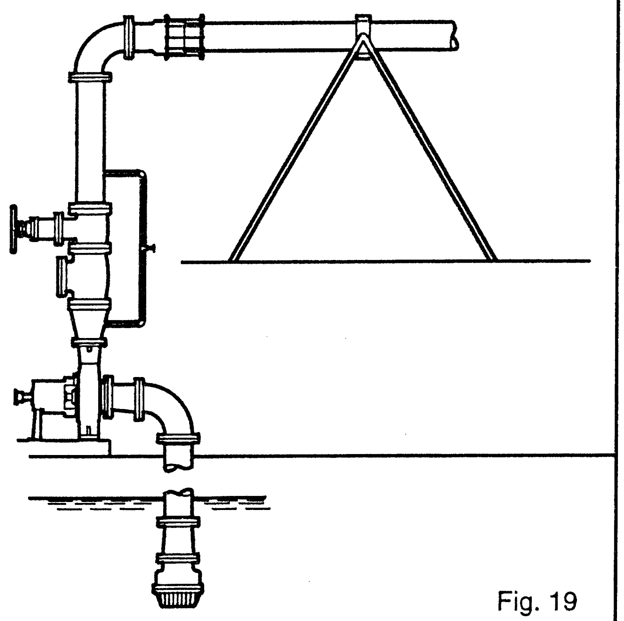


Fig. 19

CORRECT

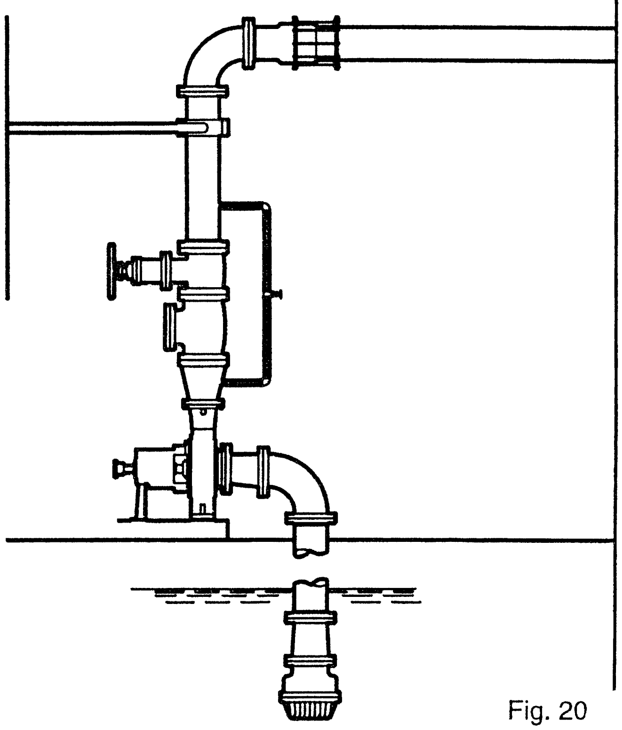


Fig. 20

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 pipe parts, valves and fittings, and pump branches prior to assembly.

SUCTION PIPING

⚠ WARNING

NPSH$_A$ must always exceed NPSH$_R$ as shown on Goulds 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 two pipe diameters of straight pipe between the elbow and suction inlet. Where used, elbows should be long radius (Fig. 21).

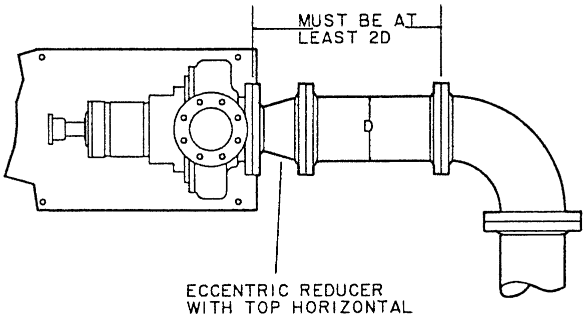


Fig. 21

INCORRECT

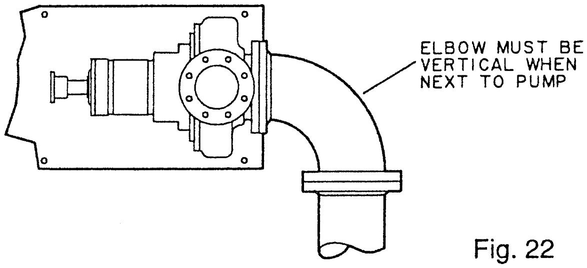


Fig. 22

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 of smaller diameter than the pump suction.**
3. Reducers should be eccentric at the pump suction flange with sloping side down (Figs. 23, 24, 25).

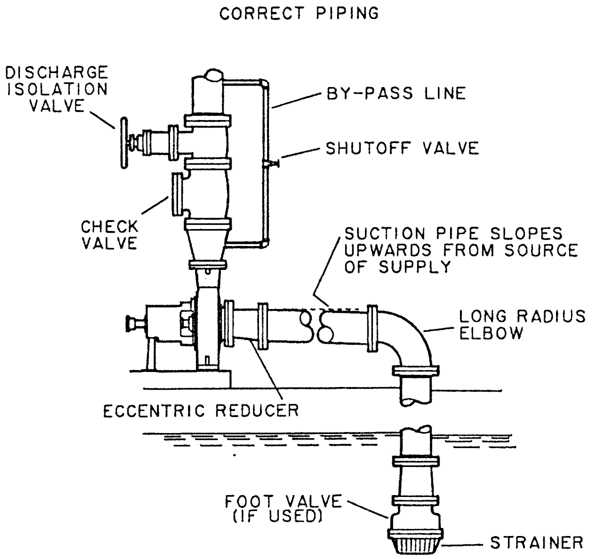


Fig. 23

CAUTION

Pump must never be throttled on suction side.

4. Suction strainers, when used, must have a net "free area" of at least three times the suction pipe area.
5. Separate suction lines are recommended when more than one pump is operating from the same source of supply.

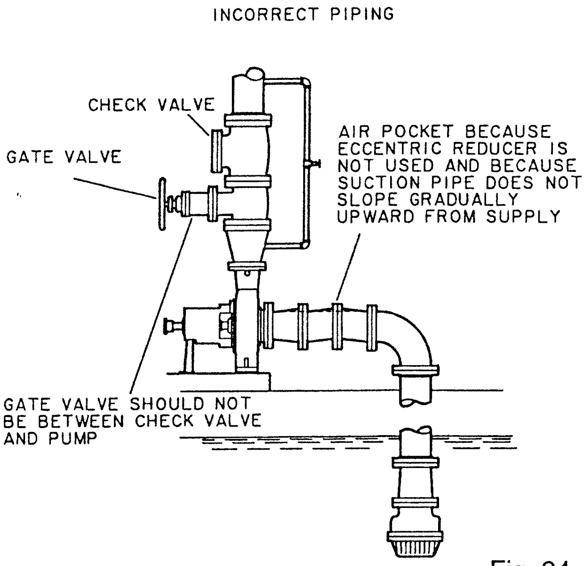


Fig. 24

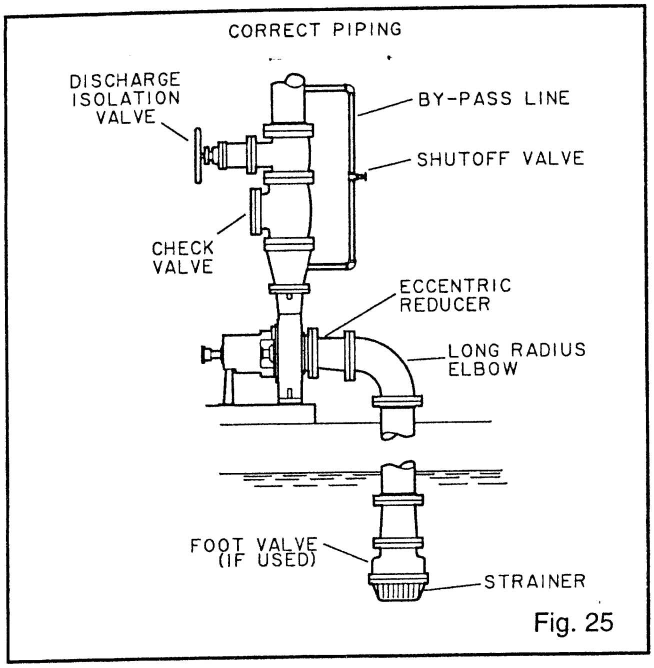


Fig. 25

Suction Lift Conditions

1. Suction pipe must be free from air pockets.
2. Suction piping must slope upwards to pump.
3. All joints must be air tight.
4. A means of priming the pump must be provided, such as a foot valve, except for the 3796 self priming pump.

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 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.

DISCHARGE PIPING

1. 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, and for inspection and maintenance of pump. The check valve prevents pump or seal damage due to reverse flow through the pump when the driver is turned off.
2. Increasers, if used, should be placed between pump and check valves.
3. Cushioning devices should be used to protect the pump from surges and water hammer if quick-closing valves are installed in system.

FINAL PIPING CHECK

After connecting the piping to 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 previously to determine absence of pipe strain. If pipe strain exists, correct piping.

OPERATION

PREPARATION FOR START-UP

CHECKING ROTATION

⚠ CAUTION

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

1. Lock out power to driver.

⚠ WARNING

Lock out driver power to prevent accidental start-up and physical injury.

2. Make sure coupling hubs are securely fastened to shafts.

NOTE: Pump is shipped with coupling spacer removed.

3. Unlock driver power.
4. Make sure everyone is clear. Jog driver just long enough to determine direction of rotation. Rotation must correspond to arrow on bearing housing.
5. Lock out power to driver.

CHECK IMPELLER CLEARANCE

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 front clearance at the factory to predetermined limits which are consistent with service conditions.

The maximum impeller setting should not be set more than .005 inch (0.13mm) above values in *Table 3* or significant performance degradation will result.

Also, for pumpage temperatures above 200° F (93° C) the cold (ambient) setting must be increased per *Table 3*. This is necessary to prevent the impeller from contacting the casing due to differential expansion from the higher operating temperatures. See *Section 5, Preventive Maintenance,* for impeller adjustment procedure.

Table 3

Impeller Clearances

Cold Temperature Clearances for Various Service Temperatures, inches (mm)

Service Temperature	3196			LF 3196 3796	CV 3196[1]	NM 3196		3198
	STX	MTX/LTX	XLTX/X17	STX MTX/LTX	STX MTX/LTX XLTX	STX	MTX/LTX	STX, MTX/LTX
-20 - 150° F (-29-66° C)	.005 (.13)	.008 (.20)	.015 (.38)	.015 (.38)	.060 (1.52)	.005 (.13)	.008 (.20)	.015 (.38)
Up to 175° F (80° C)	.005 (.13)	.008 (.20)	.015 (.38)	.015 (.38)	.060 (1.52)	.005 (.13)	.008 (.20)	.020 (.51)
Up to 200° F (93° C)	.005 (.13)	.008 (.20)	.015 (.38)	.015 (.38)	.060 (1.52)	.005 (.13)	.008 (.20)	.024 (.61)
Up to 225° F (93° C)	.006 (.16)	.009 (.23)	.016 (.40)	.016 (.40)	.060 (1.52)	N/A	N/A	.028 (.71)
Up to 250 ° F (121° C)	.007 (.18)	.010 (.26)	.017 (.43)	.017 (.43)	.060 (1.52)	N/A	N/A	.032 (.81)
Up to 275° F (93° C)	.008 (.21)	.011 (.28)	.018 (.46)	.018 (.46)	.060 (1.52)	N/A	N/A	.036 (.91)
Up to 300° F (149° C)	.009 (.23)	.012 (.30)	.019 (.48)	.019 (.48)	.060 (1.52)	N/A	N/A	.040 (1.02)
Up to 350° F (177° C)	.011 (.28)	.014 (.36)	.021 (.53)	.021 (.53)	.060 (1.52)	N/A	N/A	N/A
Up to 400° F (204° C)	.013 (.33)	.016 (.41)	.023 (.58	.023 (.58)	.060 (1.52)	N/A	N/A	N/A
Over 400° F (204° C)	.015 (.38)	.018 (.46)	.025 (.64)	.025 (.64)	.060 (1.52)	N/A	N/A	N/A

[1] Clearance is set from the back of the impeller to the stuffing box cover/seal chamber/backplate.

COUPLE PUMP AND DRIVER

⚠ WARNING

Lock out driver power to prevent accidental rotation and physical injury.

1. Install and lubricate coupling per manufacturer's instructions.
2. Install coupling guard (Fig. 26). Refer to Coupling Guard Installation and Disassembly Section *Appendix II.*

⚠ WARNING

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

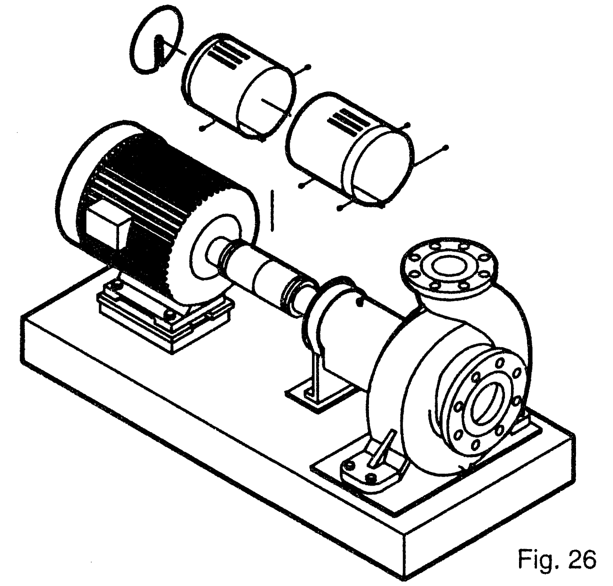


Fig. 26

LUBRICATING BEARINGS

⚠ CAUTION

Pumps are shipped without oil.

Oil Lubrication: Fill bearing frame with oil, through filler connection (located on top of bearing frame refer to Fig. 34), until oil level reaches the middle of the sight-glass. A high quality turbine type oil with rust and oxidation inhibitors should be used. See *Table 5* for recommendations.

Pure Oil Mist Lubrication: Oil mist is an optional feature for the 3196. Follow oil mist generator manufacturer's instructions. The inlet connections are located on the top of the bearing frame, connection points are covered under lubrication. (Refer to *Appendix I* on converting lubrication.)

Grease Lubrication: Pumps are shipped **with** grease. See *Table 6* for grease requirements.

Greased For Life Bearings: These bearings are filled with grease and sealed by the bearing manufacturer.

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

See *Preventive Maintenance* section for lubrication recommendations.

⚠ CAUTION

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

SHAFT SEALING

Cartridge Mechanical Seals:

1. Slide the cartridge seal onto the shaft or sleeve until it contacts the inboard labyrinth oil seal.
2. Assemble the seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
3. Slide the cartridge seal into the seal chamber and secure using the four studs and nuts.
4. Continue the pump reassembly per the instructions in *Section 6 - Disassembly & Reassembly.*
5. Set the impeller clearance per the instructions in *Section 4 - Operation.*

   Tighten the set screws in the seal locking ring to secure the seal to the shaft.

7. Remove the centering clips from the seal.

Conventional Inside Component Mechanical Seal:

1. Assemble the seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
2. Apply blueing to the shaft/sleeve at the face of the seal chamber.
3. Continue the complete reassembly of the pump, less the mechanical seal.
4. Set the impeller clearance per the instructions in *Section 4 - Operation.*
5. Scribe a line on the blued shaft/sleeve at the face of the seal chamber.
6. Remove the casing, impeller, and seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
7. Slide the gland (with the stationary seat and gland gasket installed) onto the shaft until it contacts the inboard labyrinth oil seal.
8. Install the mechanical seal rotary unit per the manufacturer's instructions using the scribed line and the seal reference dimension.
9. Reassemble the seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
10. Slide the gland on the seal chamber studs and secure with the gland nuts. Be sure to tighten the nuts evenly such that the gland is seated on the seal chamber pilot and is perpendicular to the shaft.
11. Complete the reassembly of the pump per the instructions in *Section 6 - Dissassembly & Reassembly.*

Conventional Outside Component Mechanical Seal:

1. Assemble the seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
2. Apply blueing to the shaft/sleeve at the face of the seal chamber.
3. Continue the complete reassembly of the pump, less the mechanical seal.
4. Set the impeller clearance per the instructions in *Section 4 - Operation.*
5. Scribe a line on the blued shaft/sleeve at the face of the seal chamber.

6. Remove the casing, impeller, and seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
7. Install the mechanical seal rotary unit per the manufacturer's instructions using the scribed line and the seal reference dimension. Be sure to secure the rotary unit in place using the set screws in the locking ring.
8. Install the gland (with the stationary seat and gland gaskets installed) on the seal chamber.
9. Reassemble the seal chamber per the instructions in *Section 6 - Disassembly & Reassembly.*
10. Complete the reassembly of the pump per the instructions in *Section 6 - Disassembly & Reassembly.*

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

a. **Product Flushing** - In this arrangement, the pumpage is piped from the casing (and cooled in an external heat exchanger, when required) then injected into seal gland.

b. **External Flush** - A clean, cool compatible liquid is injected from an outside source directly into the seal gland. The flushing liquid must be at a pressure of 5-15 psi (0.35-1.01 kg/cm^2) greater than the seal chamber pressure. Injection rate should be ½-2 GPM (2-8 LPM).

c. Other methods may be used which make use of multiple gland connections and/or seal chamber connections. Refer to the documentation supplied with the pump, mechanical seal reference drawing, and piping diagrams.

Packed Stuffing Box Option: Models 3196, CV 3196, LF 3196, and 3796 pumps are shipped without packing, lantern ring or split gland installed. These are included with the box of fittings shipped with the pump and must be installed before start-up.

Installation of Packing:

1. Carefully clean stuffing box bore.
2. Twist the packing just enough to get it around the shaft (Figs. 27, 28).
3. Insert packing, staggering the joints in each ring by 90°.
4. The stuffing box arrangement in order of installation is: 2 packing rings, lantern ring (two-piece), then 3 packing rings.

CAUTION

Follow instructions to ensure the lantern ring is located at the flushing connection (Fig. 29). Otherwise, no flush will be obtained.

5. Install the gland halves and evenly hand tighten the nuts.

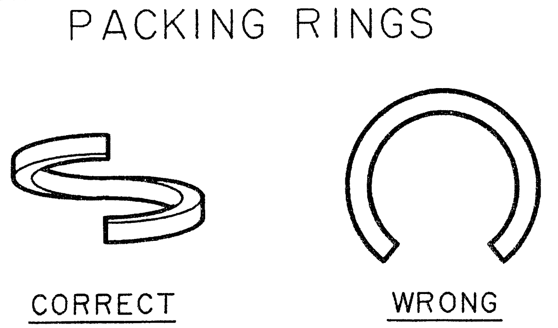


Fig. 27

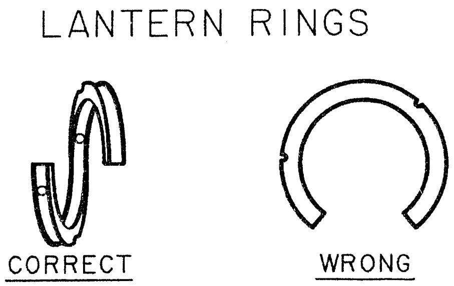


Fig. 28

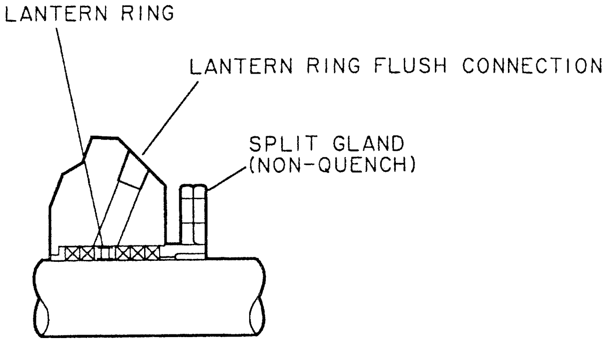


Fig. 29

Connection of Sealing Liquid: If the stuffing box pressure is above atmospheric pressure and the pumpage is clean, normal gland leakage of 40-60 drops per minute is usually sufficient to lubricate and cool the packing and sealing liquid is not required.

NOTE: Otherwise, a product flush can be used if a clean pumpage exists.

An external sealing liquid is required when:

1. Abrasive particles in the pumpage could score shaft sleeve.
2. Stuffing box pressure is below atmospheric pressure due to the pump running with a suction lift, or when the suction source is under a vacuum. Under these conditions, packing will not be cooled and lubricated and air will be drawn into pump.

If an outside source of clean compatible liquid is required, the pressure should be 15 psi (1.0 kg/cm^2) above the suction pressure. The piping should be connected to the lantern ring connection with a 40-60 drops-per-minute leak rate.

> ***NOTE: Most packing requires lubrication. Failure to lubricate packing may shorten the life of the packing and pump.***

Dynamic Seal Option: The 3196, CV 3196, and LF 3196 dynamic seal consists of two seals: a repeller that prevents leakage during pump operation and a secondary seal that prevents leakage when the unit is not operating. The repeller acts as a pump to prevent liquid from entering the stuffing box during pump operation. The repeller does not require a flush except for services which allow a build-up of solids on the repeller. A flush connection can be provided for this purpose. A drain connection can also be supplied to drain the repeller chamber if a danger of freezing exists.

Secondary Seals: The secondary seal prevents leakage during pump shut down. This seal is either graphite packing or an elastomeric face or lip seal.

1. **Graphite Packing** - This packing will provide adequate life running dry but will provide longer performance if it is lubricated with either clean water or grease. When clean water is used, remember that the repeller reduces both the quantity and pressure of seal water required. If the suction head is less than the repeller capability, the stuffing box pressure is the same as atmospheric. Seal water pressure must be high enough to overcome static head when the pump is not operating to keep pumpage out of the packing. Flow must be sufficient to cool the packing. If grease is used as the lubricant, spring-loaded grease lubricators should be used to maintain a constant supply.
2. **Elastomeric Face or Lip Seal** - The elastomeric face seal consists of an elastomer rotary fitted to the shaft, and a ceramic stationary seat fitted in the gland. To set the seal, remove the gland nuts and slide the gland back on the sleeve. Pull the rotary back on the sleeve until it is about 1 inch beyond the stuffing box face. Push the gland back onto the studs, pushing the rotary back along the sleeve. Tighten the gland nuts. This ensures contact, no other adjustments are needed. The lip seal is pressed into the gland and no adjustment is required. Both seals are designed to run dry, so no flush is required.

PRIMING PUMP (3196, CV 3196, LF 3196, 3198, NM 3196)

Never start the pump until it has been properly primed. Several different methods of priming can be used, depending upon type of installation and service involved.

Suction Supply Above Pump

1. Slowly open the suction valve (Fig. 30).
2. Open air vents on the suction and discharge piping until water flows out.
3. Close the vent valves.

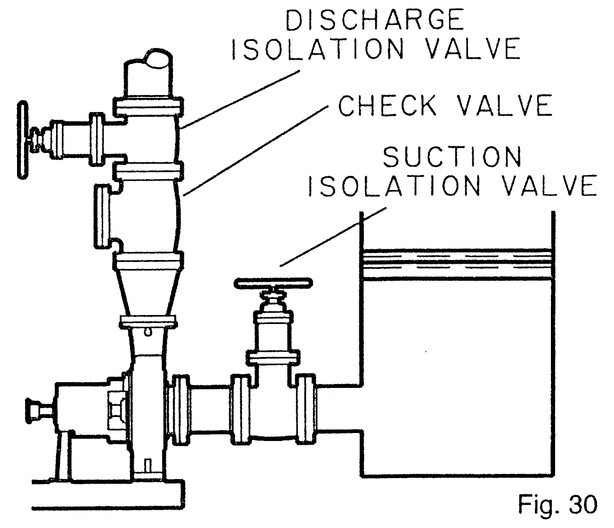


Fig. 30

Suction Supply Below Pump (except 3796)

A foot valve and outside source of liquid may be used to prime the pump. Outside source of liquid can come from a priming pump, pressurized discharge line, or other outside supply (Fig. 31 and 32).

NOTE: Model 3796 is a self-priming pump and does not require the use of a foot valve in the suction line. Refer to the pump's performance curve to determine the time required for priming.

1. Close discharge valve and open air vents in casing.
2. Open valve in outside supply line until only liquid escapes from vent valves.
3. Close the vent valves and then the outside supply line.

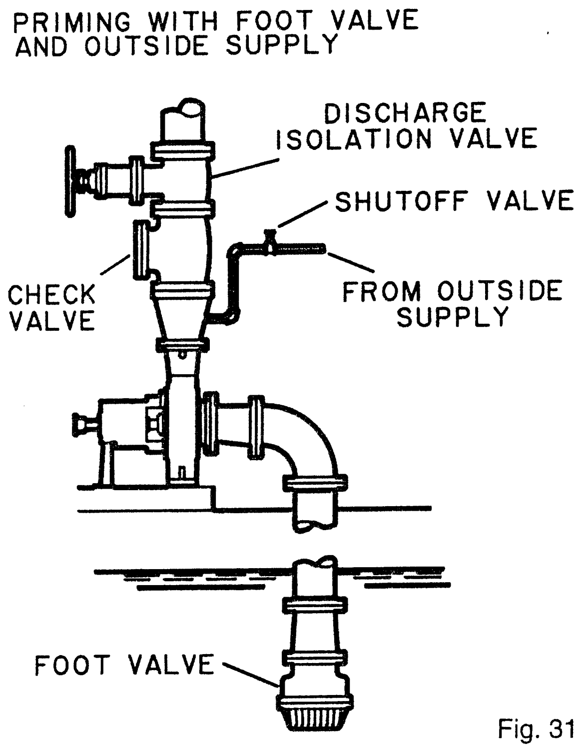


Fig. 31

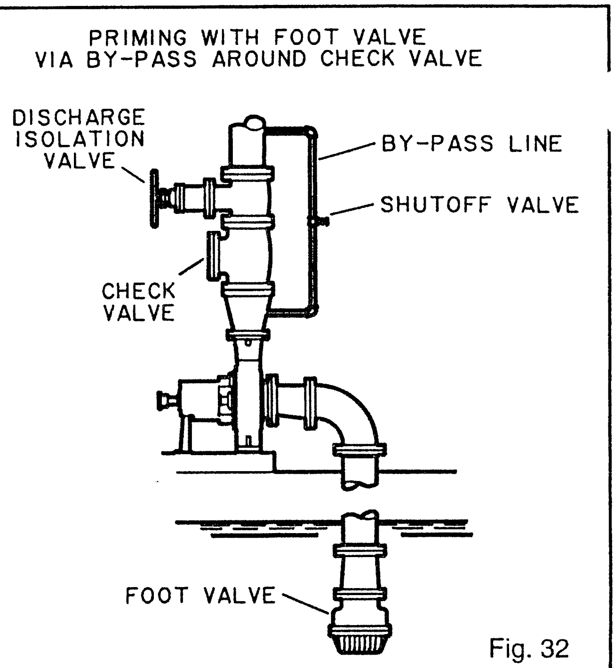


Fig. 32

Suction Supply Below Pump - 3796

NOTE: The 3796 is a self-priming pump and does not require manual priming prior to start-up (except for the initial charge). However, in a pressurized system, the pump requires an air vent or a permanent bypass line in the discharge piping to vent the evacuated air.

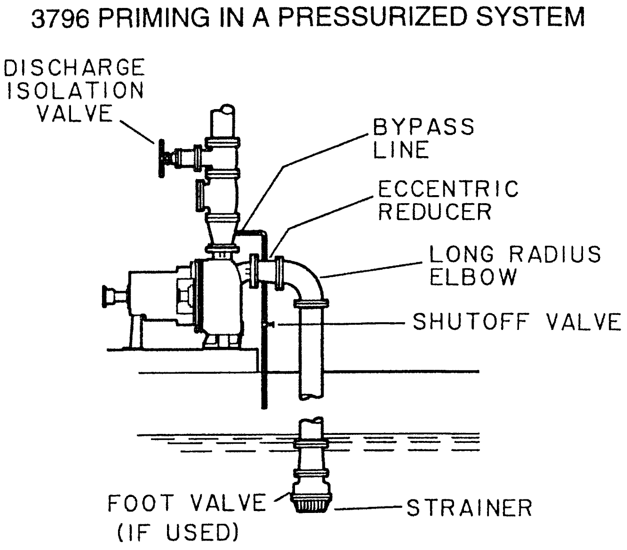


Fig. 33

Other Methods of Priming:

1. Priming by Ejector.
2. Priming by Automatic Priming Pump.

STARTING PUMP

1. Make sure suction valve and any recirculation 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.

OPERATION

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.

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.

Damage occurs from:

1. Increased vibration levels - Affects bearings, stuffing box (or seal chamber), and mechanical seal.
2. Increased radial thrusts - Stresses on shaft and bearings.
3. Heat build up - Vaporization causing rotating parts to score or seize.
4. Cavitation - Damage to internal surfaces of pump.

OPERATING UNDER FREEZING CONDITIONS

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

SHUTDOWN

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

⚠ WARNING

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

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 while unit is still hot per alignment procedure in the *Installation* Section.
3. Reinstall coupling guard. Refer to coupling guard instruction in *Appendix II.*

PREVENTIVE MAINTENANCE

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.

MAINTENANCE SCHEDULE

ROUTINE MAINTENANCE

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

ROUTINE INSPECTIONS

- Check level and condition of oil through sight glass on bearing frame.
- Check for unusual noise, vibration and bearing temperatures.
- Inspect pump and piping for leaks.
- Check seal chamber/stuffing box leakage.
  - *Mechanical Seal*: Should be no leakage.
  - *Packing*: Excessive leakage requires adjustment or possible packing replacement. Refer to *Section 4 - Operation* for packing gland adjustment.

3 MONTH INSPECTIONS

- Check the foundation and the hold-down bolts for tightness.
- If the pump has been left idle, check the packing. Replace if required.
- Oil should be changed at least every 3 months (2000 hours) or more often if there are any adverse atmospheric conditions or other conditions which might contaminate or break down the oil. If it is cloudy or contaminated as seen by inspection through the sight glass, it should be changed immediately.
- Check the shaft alignment. Realign if required.

ANNUAL INSPECTIONS

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

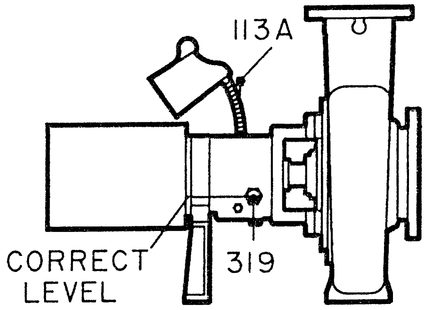
MAINTENANCE OF BEARINGS

OIL LUBRICATED BEARINGS

⚠ WARNING

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

Remove fill plug (113A) and add oil until level is at the center of the sight glass (319). Replace fill plug (Fig. 34) (See *Table 4).*



OIL LUBRICATED BEARINGS

Fig. 34

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	Qts.	Oz.	ml
STX	1.5	16	400
MTX	1.3	42	1250
LTX	4.5	48	1400
XLT-X and X17	3	96	3000

A high quality turbine oil with rust and oxidation inhibitors should be used. For the majority of operational conditions, bearing temperatures 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 (See *Table 5).* For higher operating temperatures, pumpage above 350°F (177°C), synthetic lubrication is recommended.

Table 5
Lubricating Oil Requirements

	Pumpage temperature below 350°F (177°C)	Pumpage temperature above 350°F (177°C)
ISO Grade	**VG 68**	**VG 100**
Approx. SSU at 100°F (38°C)	300	470
DIN 51517	C68	C100
Kinem. viscosity at 100°F (40°C) mm^2/sec	68	100

Some acceptable lubricants are:

Exxon	Teresstic EP 68
Mobil	Mobil DTE 26 300 SSU @ 100°F (38°C)
Sunoco	Sunvis 968
Royal Purple	SYNFILM ISO VG 68 Synthetic Lube

GREASE LUBRICATED BEARINGS

Grease lubricated bearings are pre-lubricated at the factory. Most pumps have Sunoco 2EP grease. High temperature units (pumpage temperature greater than 350° F) use Mobil SCH32. Regrease bearings every 2000 operating hours or 3 months.

Regrease Procedure:

NOTE: When regreasing, there is danger of impurities entering the bearing housing. The grease container, the greasing device, and fittings must be clean.

1. Wipe dirt from grease fittings.
2. Remove 2 grease relief plugs (113) from bottom of frame.
3. Fill both grease cavities through fittings with recommended grease until fresh grease comes out of the relief holes. Reinstall grease relief plugs (113).
4. Ensure frame seals are seated in bearing housing and, if not, press in place with drains located at the bottom.

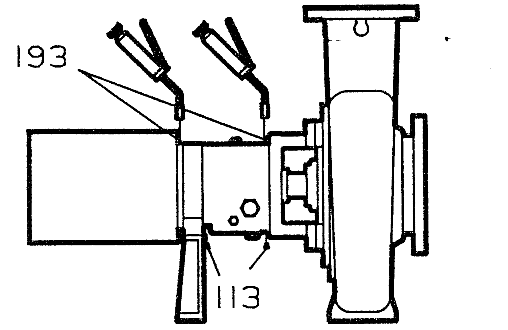


Fig. 35

NOTE: The bearing temperature usually rises after regreasing due to an excess supply of grease. Temperatures will return to normal after pump has run and purged the excess from the bearings, usually two to four hours.

For most operating conditions a lithium based mineral oil grease of NLGI consistency No. 2 is recommended. This grease is acceptable for bearing temperatures of 5°F to 230°F (-15°C to 110°C). Bearing temperatures are generally about 20°F (18°C) higher than bearing housing outer surface temperature.

Table 6 Lubricating Grease Requirements

	Pumpage temperature below 350°F (177°C)	Pumpage temperature above 350°F (177°C)
NLGI consistency	2	3
Mobil	Mobilux EP2	SCH32
Exxon	Unirex N2	Unirex N3
Sunoco	Mutipurpose 2EP	
SKF	LGMT 2	LGMT 3

⚠ CAUTION

Never mix greases of different consistency (NLGI 1 or 3 with NLGI 2) or different thickener. For example never mix a lithium base grease with a polyurea base grease.

Pumpage temperatures above 350°F (177°C) should be lubricated by a high temperature grease. Mineral oil greases should have oxidation stabilizers and a consistency of NLGI 3.

NOTE: If it is necessary to change grease type or consistency, the bearings must be removed and the old grease removed.

5

MAINTENANCE OF SHAFT SEALS

MECHANICAL SEALS

When mechanical seals are furnished, 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.

The life of a mechanical seal depends on various factors such as cleanliness of the liquid handled and its lubricating properties. Due to the diversity 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 mechanical seal fails.

PACKED STUFFING BOX (3196, CV 3196, LF 3196, 3796)

⚠ WARNING

Lock out driver power to prevent accidental start-up and physical injury.

The stuffing box is not packed at the factory and must be packed properly before operation of the pump. The packing is furnished in a box of fittings which accompany the pump. The packing used must be suitable for the pumpage. Make sure the stuffing box 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, three packing rings, followed by the split gland (Fig. 29). Insert single packing rings by twisting as shown in Fig. 27. Press each ring to ensure proper compression in the stuffing box. Stagger joints 90°. Refer to Figs. 26, 27.

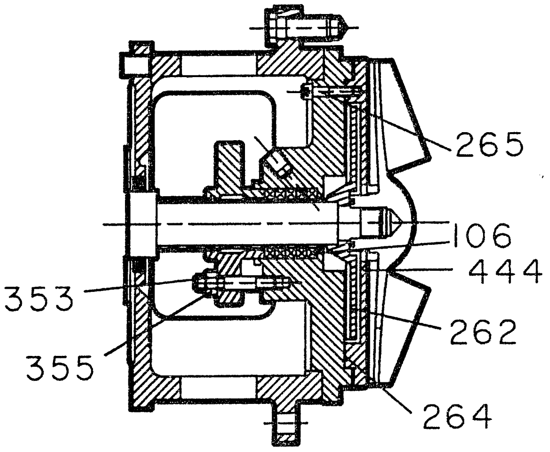
Lightly and evenly tighten the gland. Excessive tightening will result in premature failure of the packing and shaft sleeve. After packing it must be possible to rotate shaft by hand. Final adjustment of packing gland is made after pump is started.

DYNAMIC SEAL (3196, CV 3196, LF 3196)

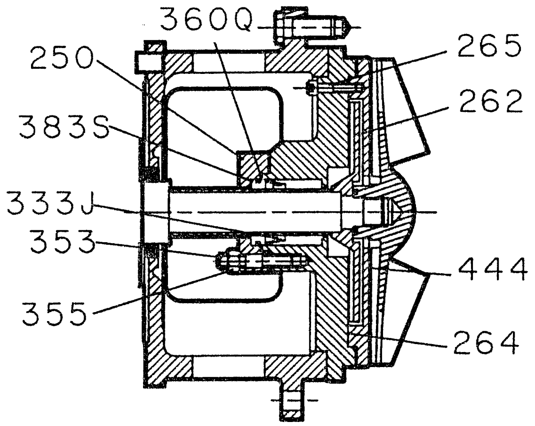
Dynamic Seal Components

Repeller **-** The dynamic repeller effectively prevents leakage of pumpage through the stuffing box when the pump is *operating* under published acceptable conditions. Dynamic seal parts do not wear substantially to affect operation unless the service is particularly abrasive or corrosive. Refer to *Disassembly and Reassembly* Section for maintenance, disassembly, and repair.

Static Seal **-** A static seal is used to prevent leakage when the pump is *shut down.* This is either a lip seal, elastomeric face seal, or graphite packing. The lip and elastomeric face seal require no maintenance other than replacement when leakage becomes excessive. The packing should be installed as stuffing box packing. It is a special type designed to run dry, so it does not require an external flush.



Dynamic Seal with Packing Fig. 36



Dynamic Seal with Chekseal™ Fig. 37

IMPELLER CLEARANCE SETTING

WARNING

Lock out driver power to prevent accidental startup and physical injury.

A change in pump performance may be noted over time by a drop in head or flow or an increase in power required. Performance can usually be renewed by adjusting the impeller clearance. Two techniques are given to set the impeller clearance, the dial indicator method and the feeler gauge method.

DIAL INDICATOR METHOD (all but CV)

1. Remove coupling guard. Refer to coupling guard instructions *Appendix II.*
2. Remove coupling.
3. Set indicator so that button contacts either the shaft end or against face of coupling (Fig. 38).
4. Loosen jam nuts (423) on jack bolts (370D) and back bolts out about two turns.

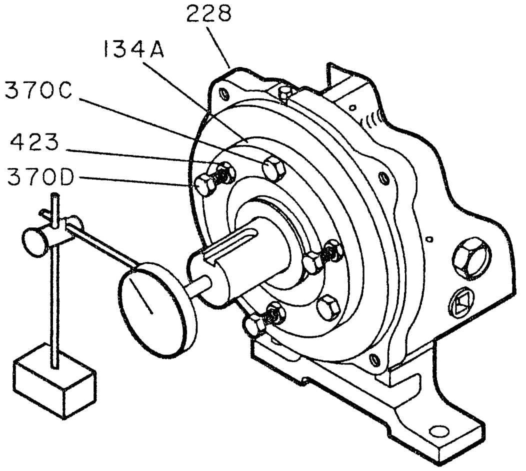


Fig. 38

5. Tighten each locking bolt (370C) evenly, drawing the bearing housing (134A) towards the bearing frame (228) until impeller contacts the casing. Turn the shaft to ensure contact is made.

6. Set indicator to zero and back locking bolt (370C) out about one turn.

   Thread jack bolts (370D) in until they evenly contact the bearing frame. Tighten the jack bolts evenly (about one flat at a time) backing the bearing housing (134A) away from the bearing frame until the indicator shows the proper clearance per *Table 3.*

8. Evenly tighten locking bolts (370C), then jack bolts (370D) keeping indicator reading at proper setting.
9. Check shaft for free turning.
10. Replace coupling guard.

DIAL INDICATOR METHOD (CV 3196)

1. Remove coupling guard. Refer to coupling guard instructions *Appendix II.*
2. Remove coupling.
3. Set indicator so that button contacts either the shaft end or against the face of coupling (Fig. 38).
4. Loosen each locking bolt (370C) several turns.
5. Loosen jam nuts (423) on jack bolts (370D) and turn bolts in several turns until impeller contacts the stuffing box cover or seal chamber. Turn shaft to ensure contact is made.
6. Set dial indicator at zero.
7. Back off the jacking bolts (370D) several turns and tighten the locking bolts (370C) to move the impeller away from the stuffing box cover or seal chamber until the dial indicator shows that a .060" clearance has been obtained.
8. Turn in the jacking bolts (370D) and tighten the jam nuts (423) evenly.
9. Check shaft for free turning.
10. Replace coupling.
11. Replace coupling guard.

FEELER GAUGE METHOD (all but CV)

1. Remove coupling guard. Refer to coupling guard instructions in *Appendix II.*
2. Loosen jam nuts (423) on jack bolts (371A) and back bolts out about two turns (Fig. 39).
3. Tighten locking bolts (370C) evenly, drawing bearing housing (134A) towards frame (228) until impeller contacts the casing. Turn shaft to ensure contact is made.
4. Using a feeler gauge, set the gap between the three locking bolts (370C) and bearing housing (134A) per impeller clearances in *Table 3.*
5. Evenly back out bearing housing (134A) using the three jack bolts (370D) until it contacts the locking bolts (370C). Evenly tighten jam nuts (423B).
6. Check shaft for free turning.
7. Replace coupling guard.

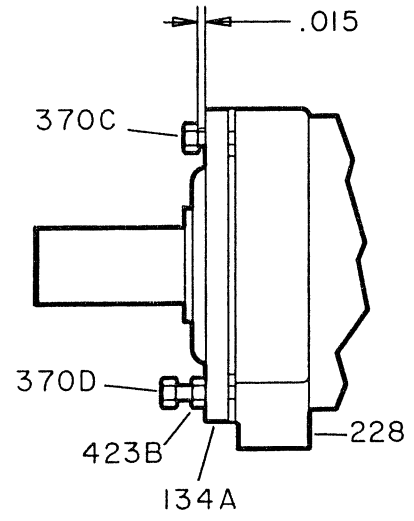


Fig. 39

FEELER GAUGE METHOD (CV)

1. Remove coupling guard. Refer to coupling guard instruction in *Appendix II.*
2. Remove coupling.
3. Loosen each locking bolt (370C) several turns.
4. Loosen jam nuts (423) on jack bolts and turn bolts in several turns until impeller contacts the stuffing box cover or seal chamber. Turn shaft to ensure contact is made.
5. Measure the gap between the bearing housing and the bearing frame with feeler gauges. Reduce this measurement by .060" and place the resultant feeler gauges between the bearing housing and the bearing frame as shown in Fig. 39.
6. Back off the jacking bolts (370D) several turns tighten the locking bolts (370C) to move the impeller away from the stuffing box cover or seal chamber until the bearing housing snugs up the feeler gagues between the bearing housing and the bearing frame.
7. Turn in the jacking bolts (370D) and tighten the jam nuts (423) evenly.
8. Check shaft for free turning.
9. Replace coupling.
10. Replace coupling guard.

Table 3
Impeller Clearances

Cold Temperature Clearances for Various Service Temperatures, inches (mm)

Service Temperature	3196			LF 3196 3796	CV 3196[1]	NM 3196		3198
	STX	MTX/LTX	XLTX/X17	STX MTX/LTX	STX MTX/LTX XLTX	STX	MTX/LTX	STX, MTX/LTX
-20 - 150° F (-29-66° C)	.005 (.13)	.008 (.20)	.015 (.38)	.015 (.38)	.060 (1.52)	.005 (.13)	.008 (.20)	.015 (.3
Up to 175° F (80° C)	.005 (.13)	.008 (.20)	.015 (.38)	.015 (.38)	.060 (1.52)	.005 (.13)	.008 (.20)	.020 (.5
Up to 200° F (93° C)	.005 (.13)	.008 (.20)	.015 (.38)	.015 (.38)	.060 (1.52)	.005 (.13)	.008 (.20)	.024 (.61)
Up to 225° F (93° C)	.006 (.16)	.009 (.23)	.016 (.40)	.016 (.40)	.060 (1.52)	N/A	N/A	.028 (.71)
Up to 22 ° F (121° C)	.007 (.18)	.010 (.26)	.017 (.43)	.017 (.43)	.060 (1.52)	N/A	N/A	.032 (.81)
Up to 275° F (93° C)	.008 (.21)	.011 (.28)	.018 (.46)	.018 (.46)	.060 (1.52)	N/A	N/A	.036 (.91)
Up to 300° F (149° C)	.009 (.23)	.012 (.30)	.019 (.48)	.019 (.48)	.060 (1.52)	N/A	N/A	.040 (1.02)
Up to 350° F (177° C)	.011 (.28)	.014 (.36)	.021 (.53)	.021 (.53)	.060 (1.52)	N/A	N/A	N/A
Up to 400° F (204° C)	.013 (.33)	.016 (.41)	.023 (.58	.023 (.58)	.060 (1.52)	N/A	N/A	N/A
Over 400° F (204° C)	.015 (.38)	.018 (.46)	.025 (.64)	.025 (.64)	.060 (1.52)	N/A	N/A	N/A

[1] Clearance is set from the back of the impeller to the stuffing box cover/seal chamber/backplate.

TROUBLESHOOTING

Problem	Probable Cause	Remedy
No liquid delivered.	Pump not primed.	Reprime 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.
	Wrong direction of rotation.	Change rotation to concur with direction indicated by arrow on bearing housing or pump casing.
	Foot valve or suction pipe opening not submerged enough.	Consult factory for proper depth. Use baffle to eliminate vortices.
	Suction lift too high.	Shorten suction pipe.
No liquid delivered (3796)	Vent line not connected.	Pipe in vent line to expell air.
Pump not producing rated flow or head.	Air leak thru gasket.	Replace gasket.
	Air leak thru stuffing box	Replace or readjust packing/mechanical seal.
	Impeller partly clogged.	Back flush pump to clean impeller.
	Excessive impeller-to-casing clearance.	Adjust impeller clearance.
	Insufficient suction head.	Ensure that suction line shutoff valve is fully open and line is unobstructed.
	Worn or broken impeller.	Inspect and replace if necessary.
Pump starts then stops pumping.	Improperly primed pump.	Reprime pump.
	Air or vapor pockets in suction line.	Rearrange piping to elilminate air pockets.
	Air leak in suction line.	Repair (plug) leak.
Bearings run hot.	Improper alignment.	Re-align pump and driver.
	Improper lubrication.	Check lubricant for suitability and level.
	Lube cooling.	Check cooling system.
Pump is noisy or vibrates.	Improper pump/driver alignment.	Align shafts.
	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.	Locate and correct system problem.
Excessive leakage from stuffing box.	Packing gland improperly adjusted.	Tighten gland nuts.
	Stuffing box improperly packed.	Check packing and repack box.
	Worn mechanical seal parts.	Replace worn parts.
	Overheating mechanical seal.	Check lubrication and cooling lines.
	Shaft sleeve scored.	Remachine or replace as required.
Motor requires excessive power.	Head lower than rating. Pumps too much liquid.	Consult factory. Install throttle valve, trim impeller diameter.
	Liquid heavier than expected.	Check specific gravity and viscosity.
	Stuffing packing too tight.	Readjust packing. Replace if worn.
	Rotating parts bind.	Check internal wearing parts for proper clearances.

DISASSEMBLY & REASSEMBLY

REQUIRED TOOLS

- Wrenches
- Screwdriver
- Lifting Sling
- Rubber Mallet
- Induction Bearing Heater
- Bearing Puller
- Brass Drift Punch
- Snap-Ring Pliers
- Torque Wrench with Sockets
- Allen Wrenches
- Dial Indicator
- Micrometer
- Cleaning Agents
- Cleaning Agents
- Feeler Gauges
- Hydraulic Press
- Leveling Blocks

DISASSEMBLY

⚠ WARNING

Pump components can be heavy. Proper methods of lifting must be employed to avoid physical injury and/or equipment damage. Steel toed shoes must be worn at all times.

⚠ WARNING

The pump may handle hazardous and/or toxic fluids. Proper personal protective equipment should be worn. Precautions must be taken to prevent physical injury. Pumpage must be handled and disposed of in conformance with applicable environmental regulations.

NOTE: Before disassembling the pump for overhaul, ensure all replacement parts are available.

⚠ WARNING

Lock out power supply to driver motor to prevent accidental startup and physical injury.

1. Shut off all valves controlling flow to and from pump.

⚠ WARNING

Operator must be aware of pumpage and safety precautions to prevent physical injury.

2. Drain liquid from piping, flush pump if necessary.
3. Disconnect all auxiliary piping and tubing.
4. Remove coupling guard. Refer to Coupling Guard Installation and Disassembly Section in *Appendix II.*
5. Disconnect Coupling.

NOTE: See Appendix V for C-Face adapter disassembly instructions, if required.

6. Remove coupling guard pump endplate.

7. If oil lubricated, drain oil from bearing frame by removing bearing frame drain plug (408A). Replace plug after oil is drained. Remove oil reservoir, if equipped (Fig. 40).

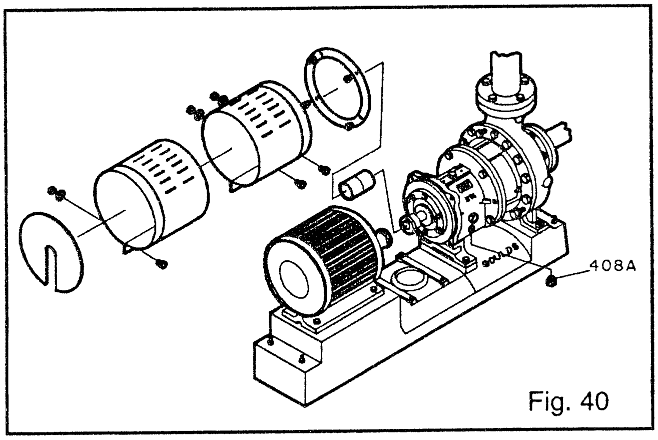


Fig. 40

NOTE: Oil analysis should be part of a preventive maintenance program and is helpful to determine cause of a failure. Save oil in a clean container for inspection.

8. *All, except with C-Face adapter:* Place sling from hoist through frame adapter (108) or frame (228A) for STX (Fig. 41).

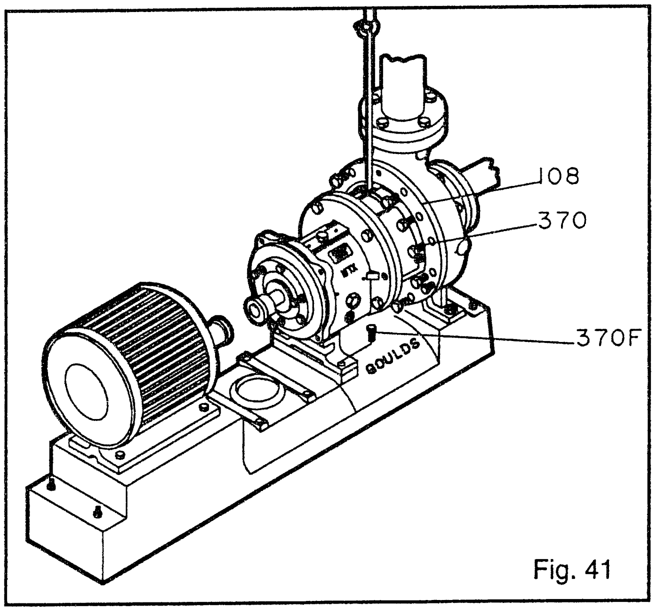


Fig. 41

C-Face adapter: Place one sling from hoist through frame adapter (108) or frame (228A) for STX and a second sling from hoist through the C-Face adapter (Fig. 42).

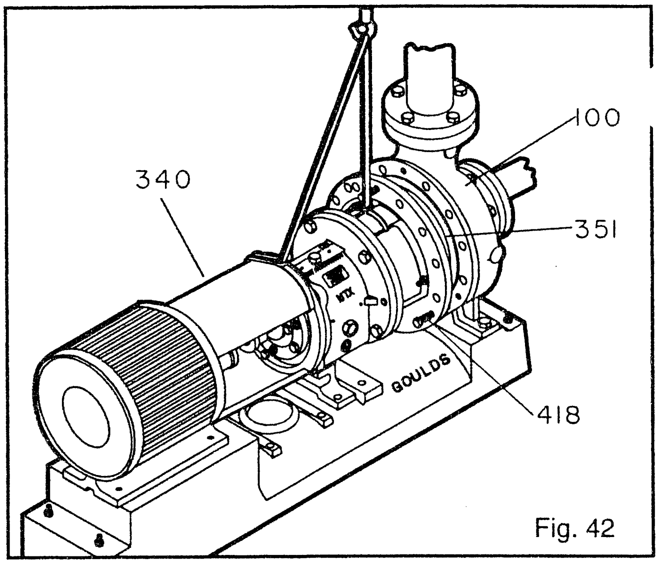


Fig. 42

9. Remove bearing frame foot hold down bolts (370F).

10. Remove casing bolts (370).

⚠ WARNING

Never apply heat to remove parts. Use of heat may cause an explosion due to trapped fluid, resulting in severe physical injury and property damage.

11. Remove back pull-out assembly from casing (100). Tighten jack screws (418) evenly to remove back pull-out assembly (Fig. 43).

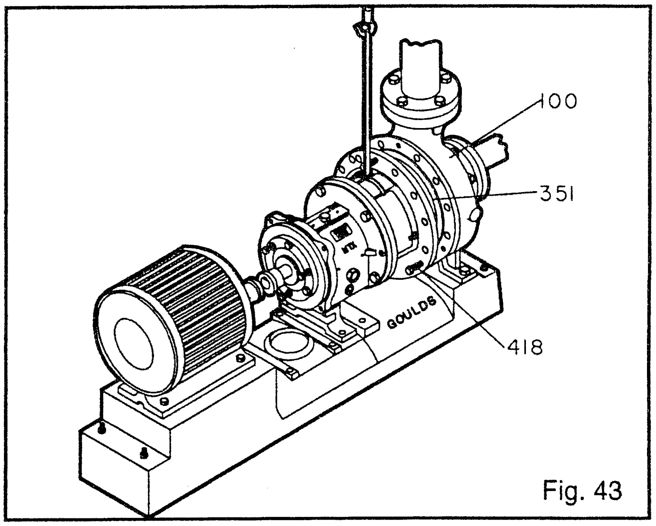


Fig. 43

NOTE: Penetrating oil can be used if adapter to casing joint is excessively corroded.

NOTE: Remove and then mark shims from under frame foot. Save for reassembly.

⚠ WARNING

Never remove the back pull-out assembly unassisted, physical injury can occur.

12. Remove casing gasket (351) and discard. (Replace with new gasket during reassembly.)

13. Remove jack screws (418).

NOTE: Casing gasket (351) may partially adhere to casing due to binders and adhesives in the gasket material. Clean all gasket surfaces.

14. Move back pull-out assembly to clean work bench.

15. Support frame adapter (108) securely to workbench.

16. Remove coupling hub (Fig. 44).

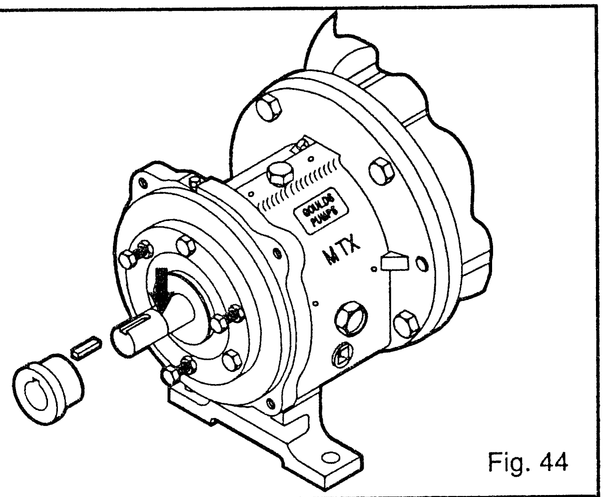


Fig. 44

NOTE: Blue and scribe shaft for relocating coupling hub during reassembly.

REMOVAL OF IMPELLER

WARNING

Never apply heat to remove an impeller. The use of heat may cause an explosion due to trapped fluid, resulting in severe physical injury and property damage.

WARNING

Wear heavy work gloves when handling impellers (101) as sharp edges may cause physical injury.

STX, MTX, & LTX

1. Slide Goulds shaft wrench (A05107A or A01676A) over the shaft (122) and key.

2. Rotate the impeller clockwise (viewed from the impeller end of the shaft), raising the wrench off of the work surface.

3. Quickly turn the impeller counterclockwise (viewed from the impeller end of the shaft), impacting the wrench handle on the workbench or a solid block until the impeller loosens (Fig. 45).

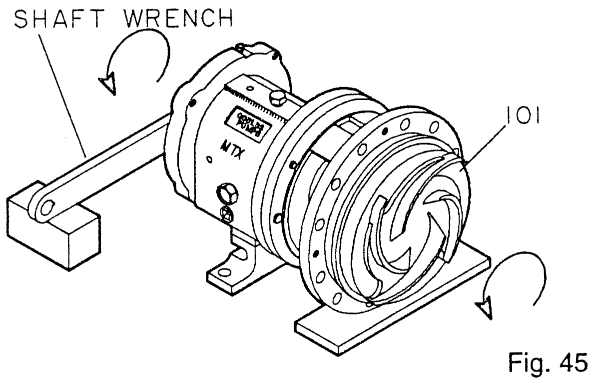
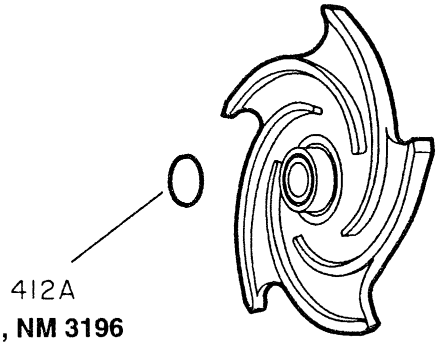


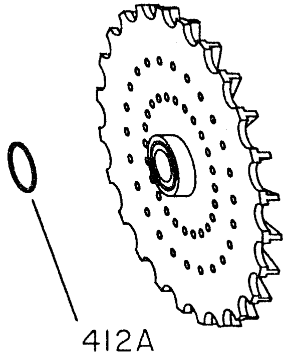
Fig. 45

4. Remove impeller O-ring (412A) and discard (Fig. 46, 47, 48). Replace with a new o-ring during reassembly.



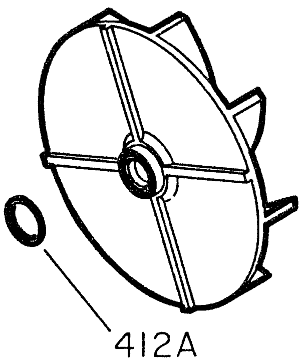
3196, NM 3196
3198, 3796

Fig. 46



LF 3196

Fig. 47

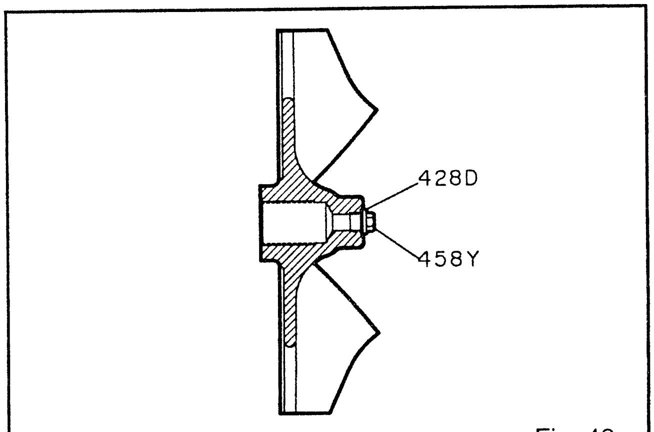


CV 3196

Fig. 48

XLT-X & X17

1. Remove impeller plug (458Y) from the front of the impeller (101) and discard the Teflon® gasket (428D) (Fig. 49).



3196 XLT-X and X-17 Fig. 49

2. Spray penetrating oil through the plug hole into the cavity at the end of the shaft. Wait 15 minutes. Rotate the shaft several times while waiting to distribute the oil.
3. Slide Goulds shaft wrench (A05107A) over the shaft (122) and key.
4. Rotate the impeller clockwise (viewed from the impeller end of the shaft), raising the wrench off of the work surface.
5. Quickly turn the impeller counterclockwise (viewed from the impeller end of the shaft), impacting the wrench handle on the workbench or a solid block until the impeller loosens (Fig. 45).
6. If the impeller cannot be loosened after several attempts, place a socket wrench over the cast nut on the impeller hub and turn the impeller counterclockwise (viewed from the impeller end of the shaft). Be sure the impeller wrench is resting on the workbench or a solid block and the power end is secure on the work surface.
7. Remove impeller O-ring (412A) and discard (Fig. 46, 47, 48). Replace with a new o-ring during reassembly.

NOTE: It is recommended that the frame foot (241) be clamped to the workbench when using this method to remove the impeller.

NOTE FOR ALL MODELS: If the impeller cannot be removed by the previous methods, cut the shaft between the gland and the frame, remove the impeller, stuffing box cover, gland, sleeve and shaft end as a unit. Do not use heat.

REMOVAL OF SEAL CHAMBER COVER (MECHANICAL SEAL) - 3196, CV 3196, LF 3196, 3796

1. Remove gland stud nuts (355).
2. Remove seal chamber stud nuts (370H).
3. Remove seal chamber (184). (Fig. 50)

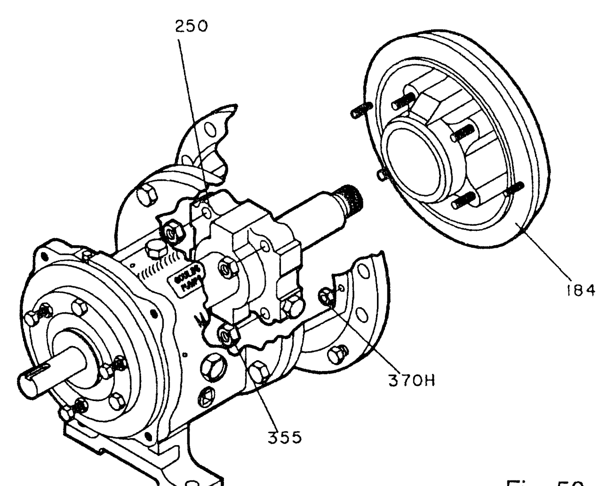


Fig. 50

4. Remove shaft sleeve (126), if used.

NOTE: Mechanical seal is attached to sleeve (126). Rotary portion of seal needs to be removed from sleeve by loosening set screws and sliding it off the sleeve. Refer to mechanical seal instructions.

5. Remove gland (107) with stationary seat and O-ring (360Q) (Fig. 51).

NOTE: Be careful not to damage the stationary portion of the mechanical seal. It is seated in the gland bore.

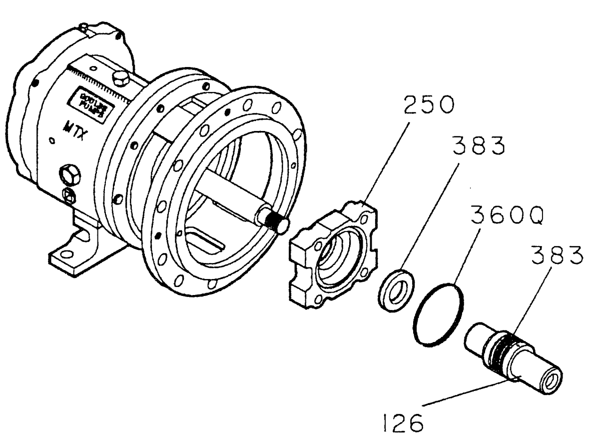


Fig. 51

REMOVAL OF SEAL CHAMBER COVER AND/OR BACKPLATE - NM 3196 & 3198

Remove the gland or seal chamber stud nuts (355).

2. Remove the backplate and stud nuts (370H).

3. Remove the backplate (184) (Fig. 52).

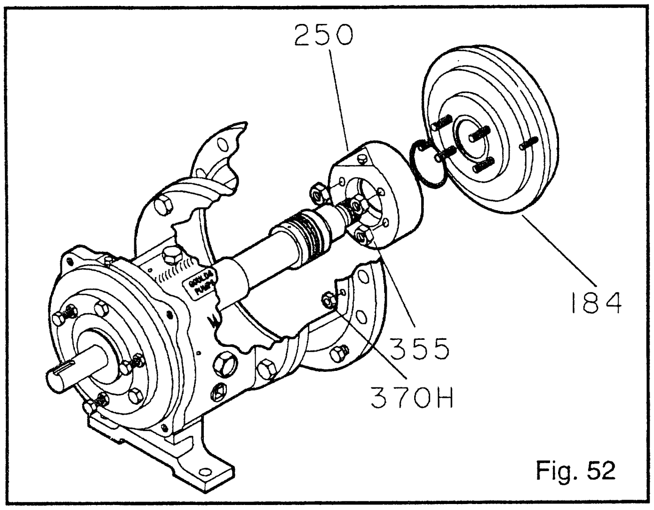


Fig. 52

4. Remove the shaft sleeve (126).

NOTE: The mechanical seal is attached to the sleeve (126). The rotary portion of the seal needs to be removed from the sleeve by loosening the set screws and sliding off the sleeve. Refer to the mechanical seal instructions.

NOTE: The Teflon® sleeve on the 3198 must be cut off the shaft to be removed. First remove the mechanical seal from the sleeve. Now, the sleeve can be removed by slicing the sleeve lengthwise with a sharp knife.

5. Remove the stationary seat and the gland or seal chamber with the gland gaskets (Figs. 53 & 54).

NOTE: Be careful not to damage the stationary portion of the mechanical seal. It is either clamped between the backplate and the gland or seated in the seal chamber bore.

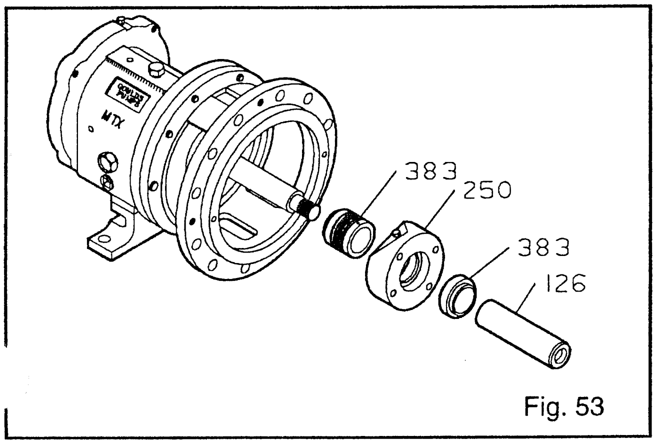


Fig. 53

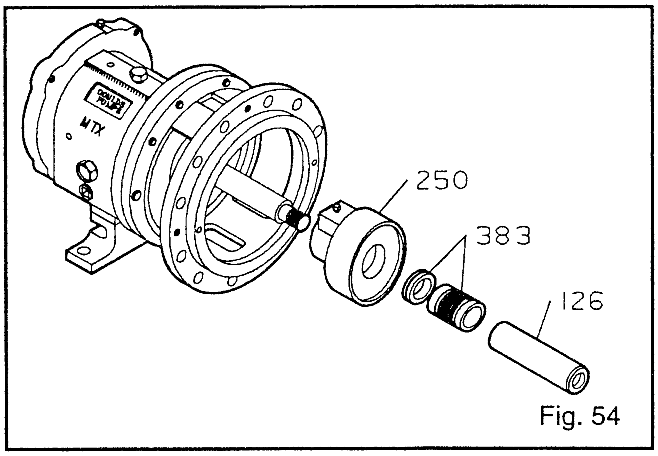


Fig. 54

REMOVAL OF STUFFING BOX COVER (PACKED BOX) - 3196, CV 3196, LF 3196, & 3796

1. Remove gland stud nuts (355), and gland(107).

2. Remove stuffing box cover stud nuts (370H).

3. Remove stuffing box cover (184). (Fig. 55).

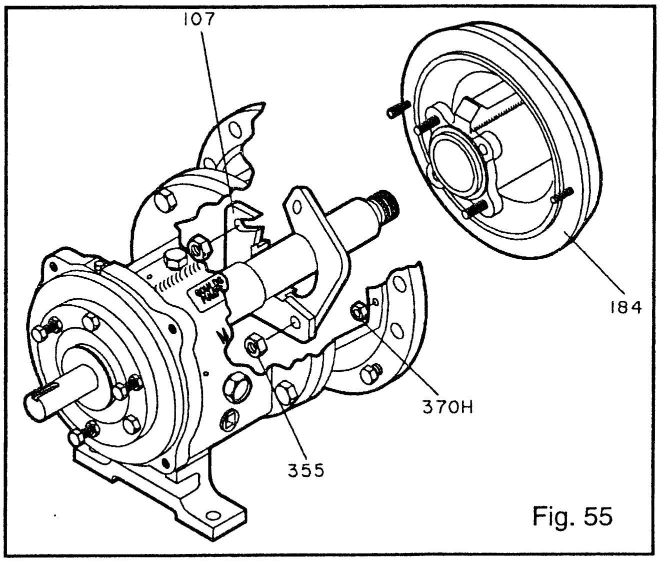


Fig. 55

4. Remove shaft sleeve (126) (Fig. 56).

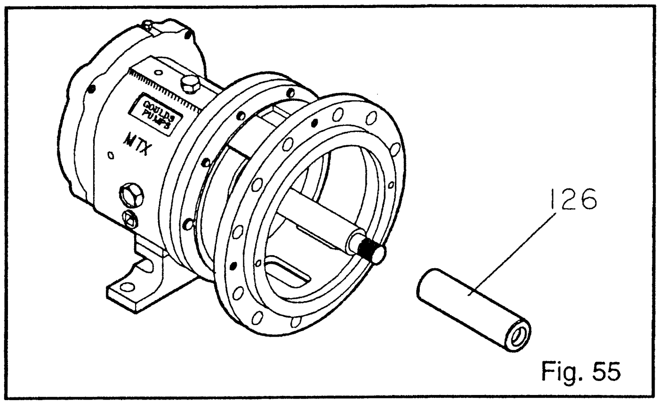


Fig. 55

5. Remove packing (106) and lantern ring (105) from stuffing box cover (184) (Fig. 57).

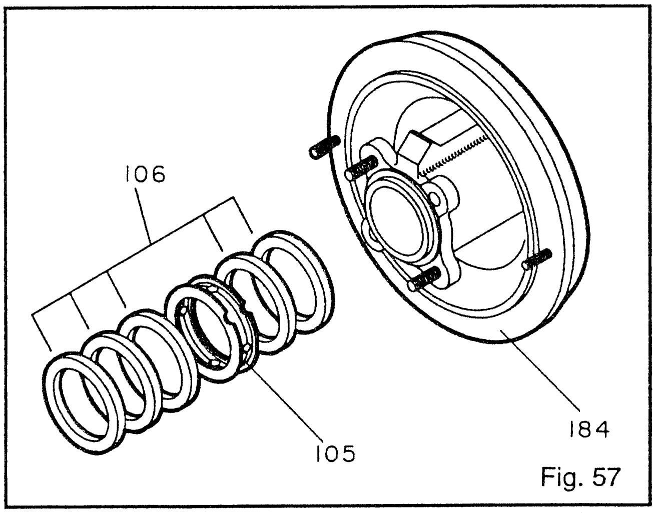


Fig. 57

REMOVAL OF DYNAMIC SEAL - 3196, CV 3196, LF 3196

1. Remove stud nuts (370H).
2. Remove dynamic seal assembly (Fig. 58).

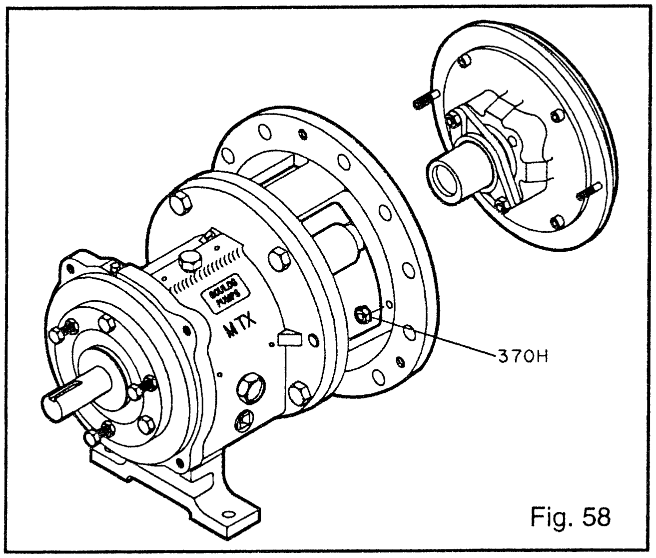


Fig. 58

3. Remove socket head cap screws (265) (Fig. 59).
4. Remove stuffing box cover (184) and gasket (264).
5. Remove repeller (262) from backplate (444).

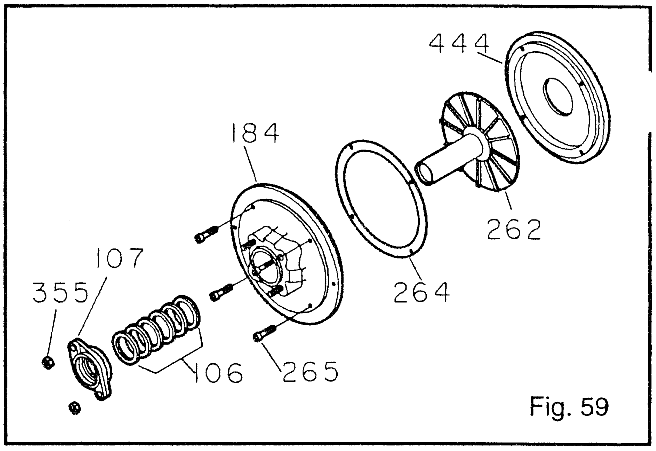


Fig. 59

REMOVE FRAME ADAPTER - MTX, LTX, XLT-X, X17

1. Remove dowel pins (469B), and bolts (370B).
2. Remove frame adapter (108) (Fig. 60).
3. Remove and discard gasket (360D). Replace with new gasket during reassembly.

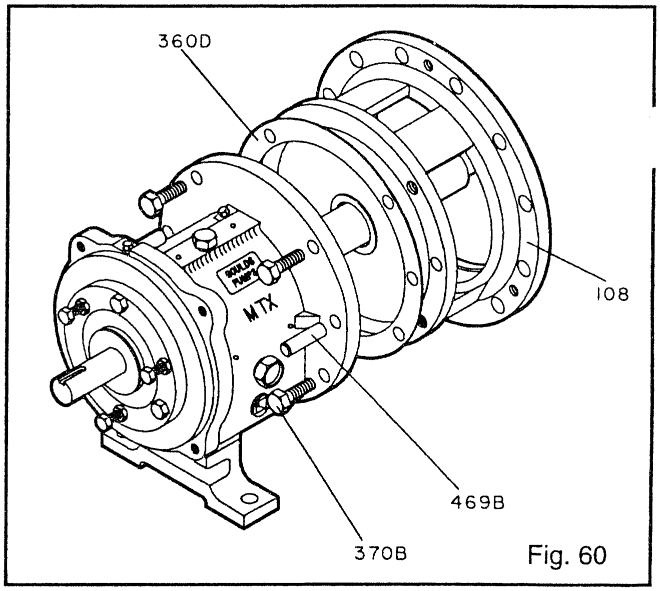


Fig. 60

NOTE: The 3198 frame adapter is not interchangeable with any other model's adapter.

REMOVE INBOARD LABYRINTH OIL SEAL (333A)

1. It is an O-ring fit into the bearing frame (228A) for STX, frame adapter (108) for MTX, LTX, XLT-X and X17. Remove O-rings (497H), (497J) if necessary (Fig. 61).

NOTE: Labyrinth oil seal O-rings (497H, J) are part of 3196 maintenance kits or can be obtained separately.

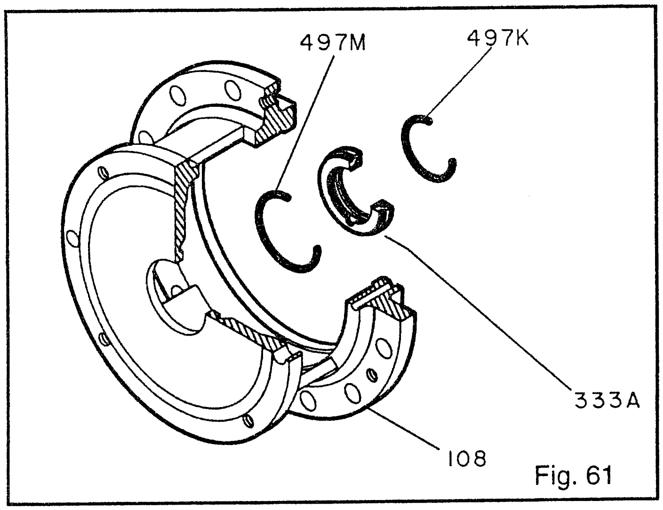


Fig. 61

DISASSEMBLY OF POWER END - STX, MTX

1. Remove clamp screws (370C). Back off jam nuts (423). Tighten jack screws (370D) evenly, this will start bearing housing (134) out of bearing frame (228A) (Fig. 62).
2. Remove the shaft assembly from the bearing frame (228A).

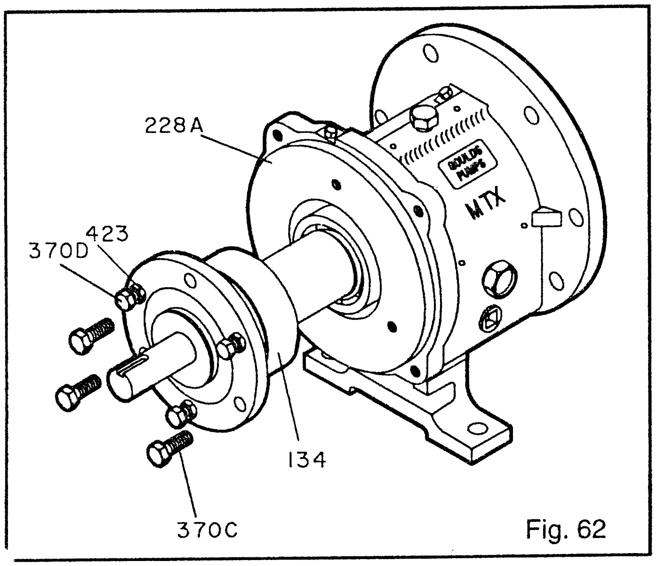


Fig. 62

3. Remove jack screws (370D) with nuts (423) (Fig. 63).
4. Remove bearing housing O-ring (496).
5. Remove outboard bearing retaining snap ring (361A).

NOTE: Snap ring cannot be removed from the shaft until bearings are removed.

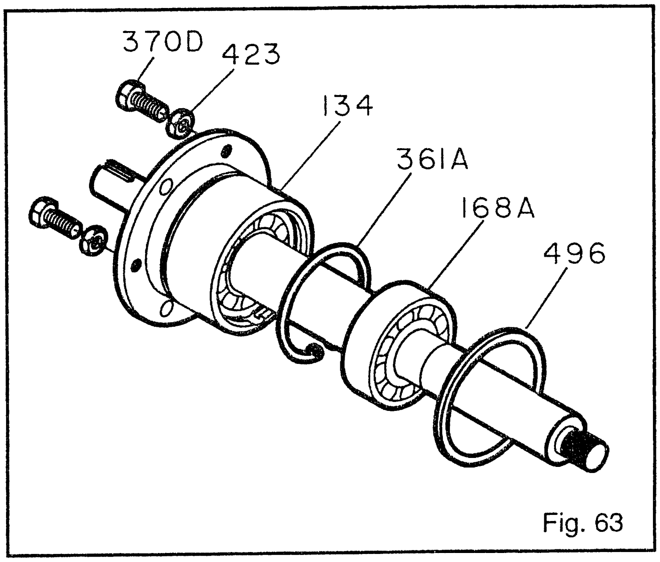


Fig. 63

6. Remove bearing housing (134) from shaft (122) with bearings (112A, 168A) (Fig. 64).

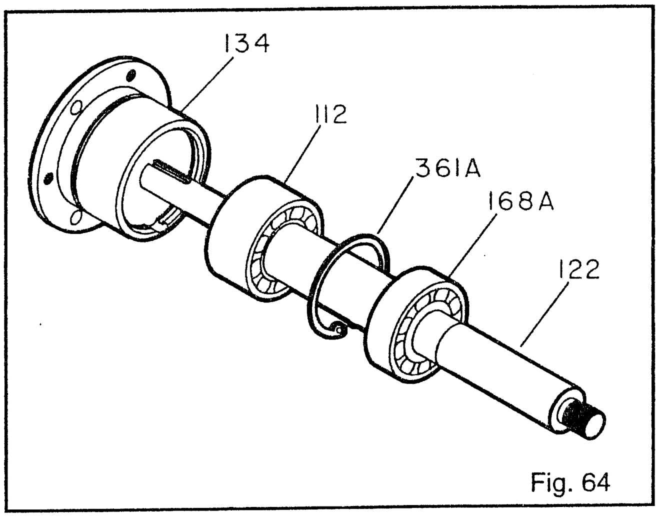


Fig. 64

7. Remove outboard labyrinth seal (332A) from bearing housing (134). Remove O-rings (497F), (497G) if necessary (Fig. 65).

NOTE: Labyrinth oil seal O-rings (497F, G) are part of 3196 maintenance kits or can be obtained separately.

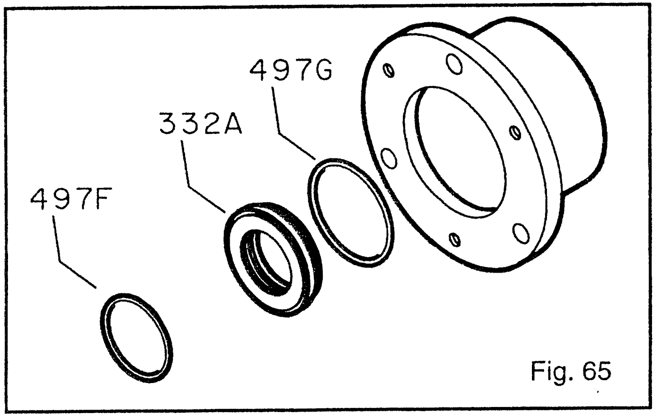


Fig. 65

8. Remove bearing locknut (136) and bearing lock washer (382) (Fig. 66).
9. Remove inboard bearing (168A).
10. Remove outboard bearing (112A).

NOTE: When pressing bearings off shaft, use force on inner race only.

NOTE: Save bearings for inspection.

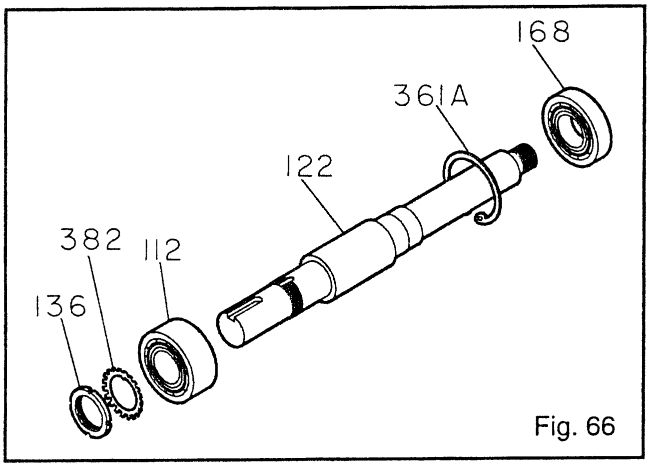


Fig. 66

DISASSEMBLY OF POWER END - LTX

1. Remove clamp screws (370C). Back off jam nuts (423). Tighten jack screws (370D) evenly, this wil start bearing housing (134) out of bearing frame (228A) (Fig. 67).
2. Remove shaft assembly from bearing frame (228A).

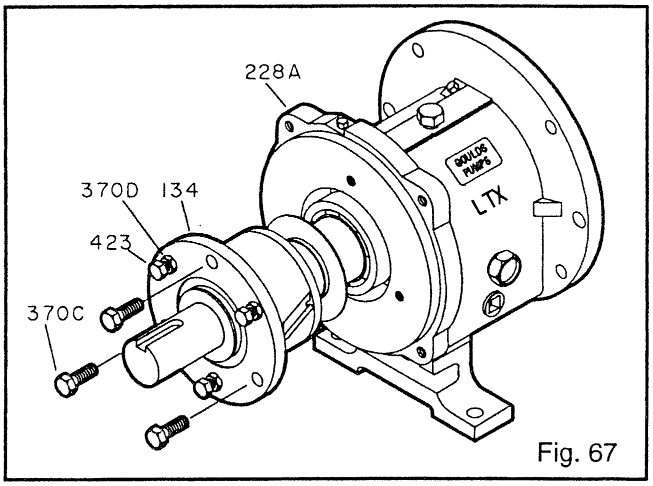


Fig. 67

3. Remove jack screws (370D) with nuts (423) (Fig. 68).
4. Remove clamp ring screws (236A). Separate clamp ring (253B) from bearing housing (134).

NOTE: Clamp ring cannot be removed from the shaft until bearings are removed.

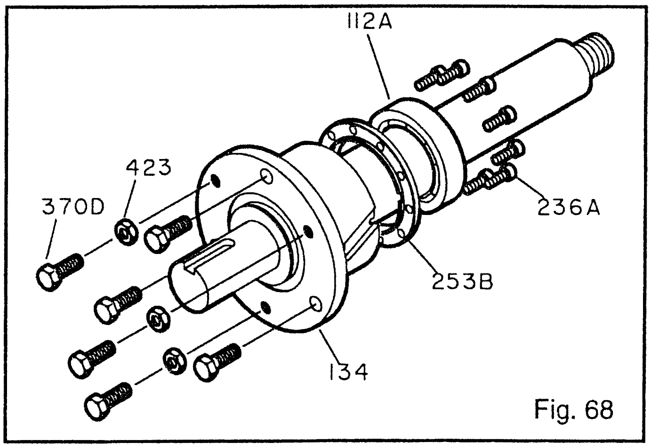


Fig. 68

5. Remove bearing housing (134) from shaft (122) with bearings (112A, 168A) (Fig. 69).

6. Remove bearing housing O-ring (496).

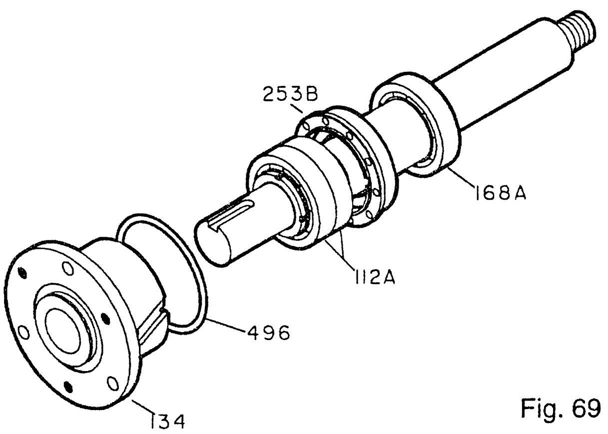


Fig. 69

7. Remove inboard bearing (168A) (Fig. 70).

8. Remove bearing locknut (136) and bearing lockwasher (382).

9. Remove outboard bearings (112A). Remove clamp ring (253B).

NOTE: When pressing bearings off shaft, use force on inner race only.

NOTE: Save bearings for inspection. Do not reuse bearings.

NOTE: Do not remove oil flinger (248A) unless it is damaged.

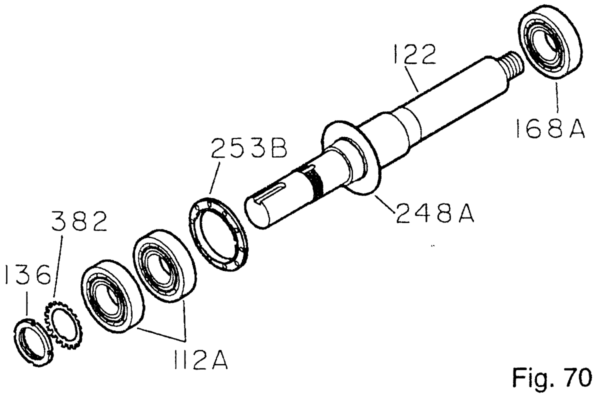


Fig. 70

10. Remove outboard labyrinth seal (332A) from bearing housing (134). Remove O-rings (497F), (497G) if necessary (Fig. 71).

NOTE: Labyrinth oil seal O-rings (497F, G) are part of 3196 maintenance kits or can be obtained separately.

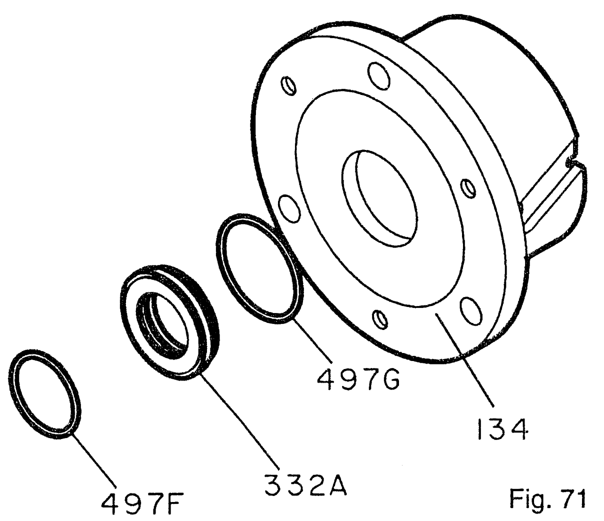


Fig. 71

DISASSEMBLY OF THE POWER END - XLT-X, X17

1. Remove bearing frame to frame foot bolts (370F) and frame foot (241) (Fig. 72).

2. Remove clamp screws (370C). Back off jam nuts (423). Tighten jack screws (370D) evenly, this will start bearing housing (134) out of bearing frame (228A).

3. Remove shaft assembly from bearing frame (228A).

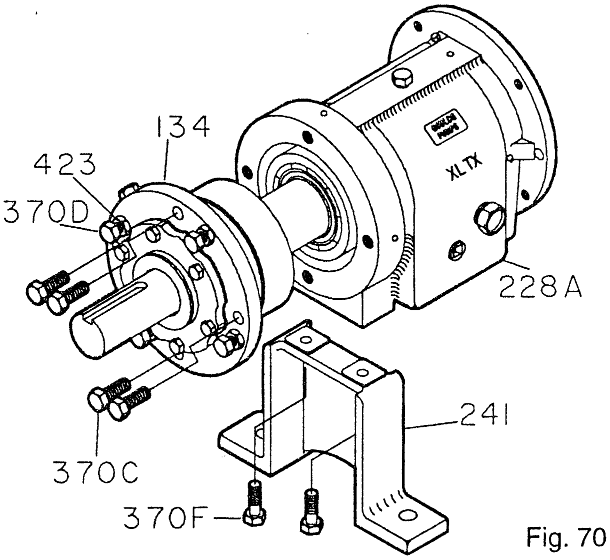


Fig. 70

4. Remove jack screws (370D) with nuts (423) (Fig. 73).
5. Remove bearing housing O-ring (496).
6. Remove inboard bearing (168A).

NOTE: When pressing bearings off shaft, use force on inner race only.

NOTE: Save bearings for inspection.

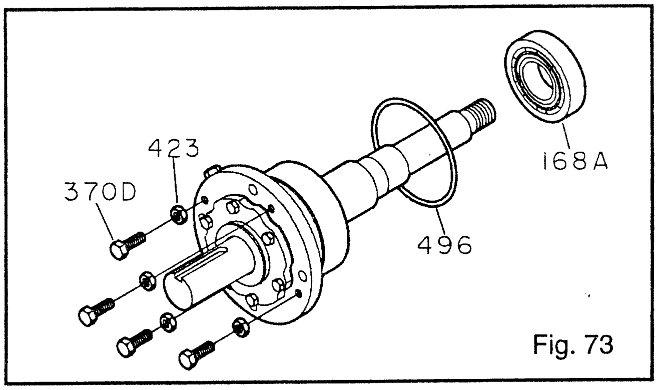


Fig. 73

7. Remove bolts (371C), bearing end cover (109A) and gasket (360C) (Fig. 74).
8. Remove outboard labyrinth seal (332A) from end cover (109A). Remove O-rings (497F), (497G) if necessary.

NOTE: Labyrinth oil seal O-rings (497F, G) are part of 3196 maintenance kits or can be obtained separately.

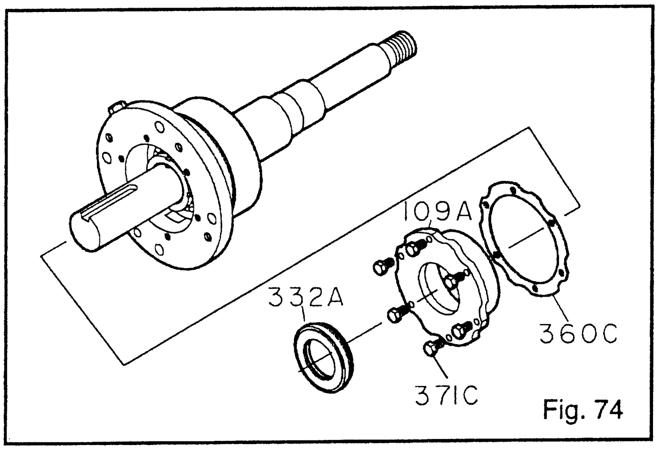


Fig. 74

9. Remove bearing housing (134) from shaft (122) with bearing (112A) (Fig. 75).

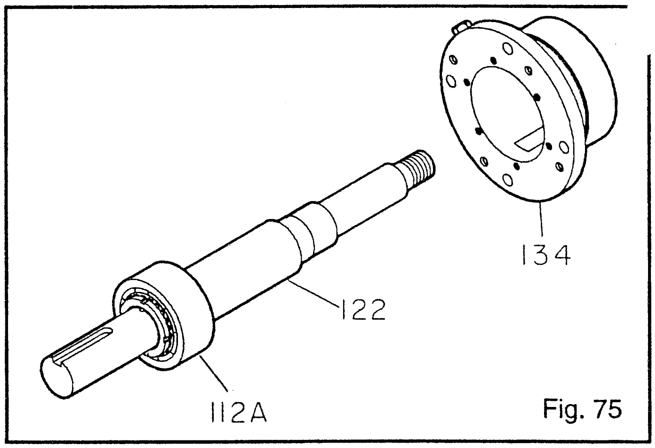


Fig. 75

10. Remove bearing locknut (136) and bearing lockwasher (382) (Fig. 76).
11. Remove outboard bearing (112A).

NOTE: When pressing bearings off shaft, use force on inner race only.

NOTE: Save bearings for inspection.

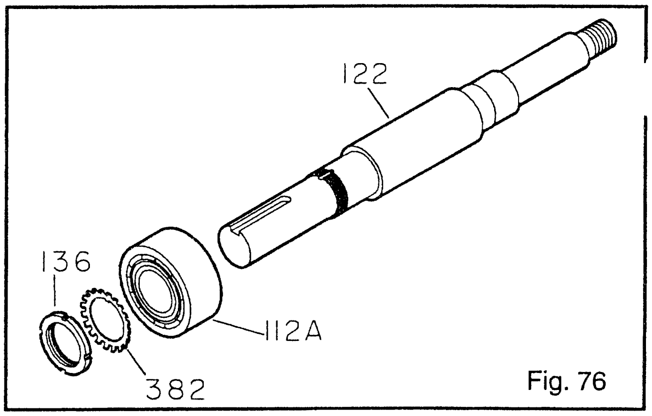


Fig. 76

DISASSEMBLY OF POWER END - STX, MTX with Duplex Bearings

Remove clamp screws (370C). Back off jam nuts (423). Tighten jack screws (370D) evenly, this will start bearing housing (134) out of bearing frame (228A) (Fig. 77).

2. Remove shaft assembly from bearing frame (228A).

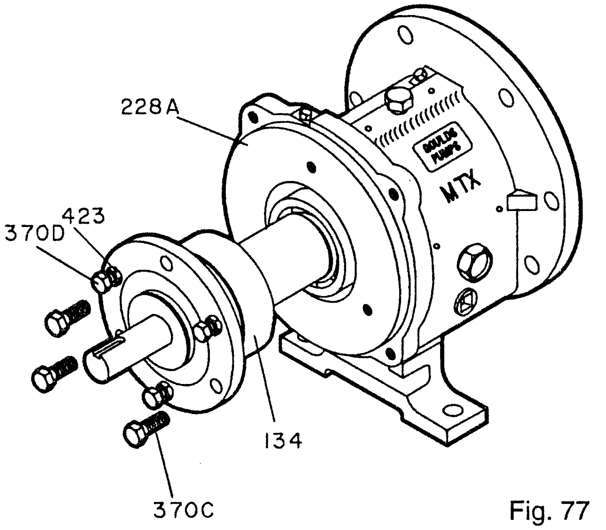


Fig. 77

3. Remove jack screws (370D) with nuts (423) (Fig. 78).

Remove bearing housing O-ring (496).

5. Remove clamp ring screws (236A). Separate clamp ring (253B) from bearing housing (134).

NOTE: Clamp ring cannot be removed from the shaft until bearings are removed.

6. Remove bearing housing (134) from shaft (122) with bearings (112A, 168A) (Fig. 79).

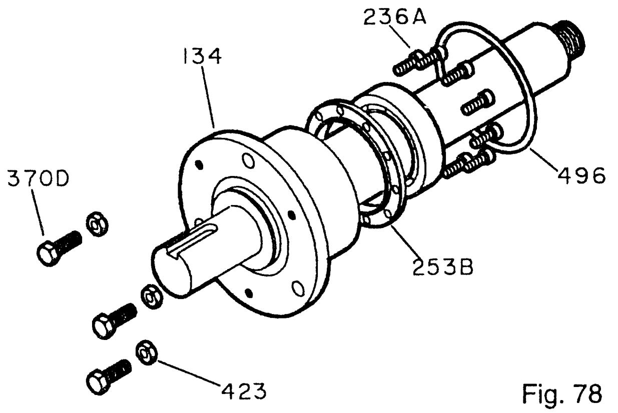


Fig. 78

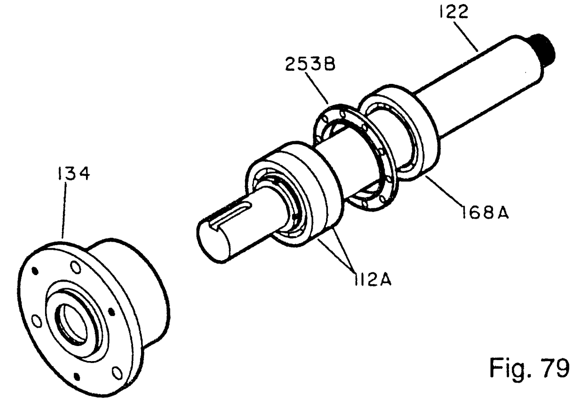


Fig. 79

7. Remove inboard bearing (168A) (Fig. 80).

8. Remove bearing locknut (136) and bearing lockwasher (382).

9. Remove outboard bearings (112A).

NOTE: When pressing bearings off shaft, use force on inner race only.

NOTE: Save bearings for inspection.

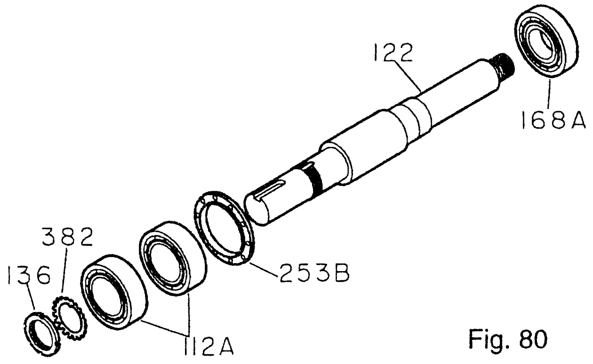


Fig. 80

10. Remove outboard labyrinth seal (332A) from bearing housing (134). Remove O-rings (497F), (497G) if necessary (Fig. 81).

NOTE: Labyrinth oil seal O-rings (497F, G) are part of 3196 maintenance kits or can be obtained separately.

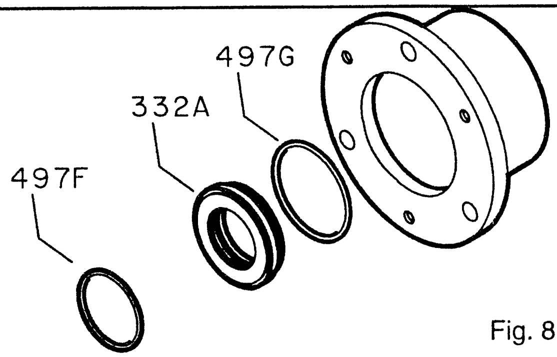


Fig. 81

DISASSEMBLY OF POWER END - XLT-X, X17 With Duplex Bearings

1. Remove bearing frame to frame foot bolts (370F) and frame foot (241) (Fig. 82).
2. Remove clamp screws (370C). Back off jam nuts (423). Tighten jack screws (370D) evenly, this will start bearing housing (134) out of bearing frame (228A).
3. Remove shaft assembly from bearing frame (228A).

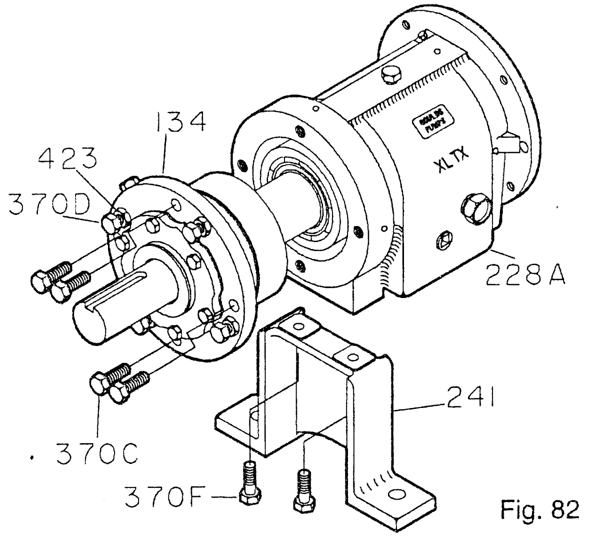


Fig. 82

4. Remove jack screws (370D) with nuts (423) (Fig. 83).
5. Remove bearing housing O-ring (496).
6. Remove inboard bearing (168A).

NOTE: When pressing bearings off shaft, use force on inner race only.

NOTE: Save bearings for inspection.

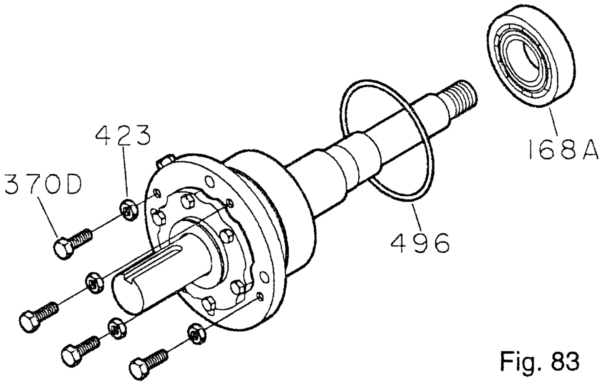


Fig. 83

7. Remove bolts (371C), end cover (109A) and gasket (360C) (Fig. 84).
8. Remove outboard labyrinth seal (332A) from end co (109A). Remove O-rings (497F), (497G) if necessary.

NOTE: Labyrinth oil seal O-rings (497F, G) are part of 3196 maintenance kits or can be obtained separately.

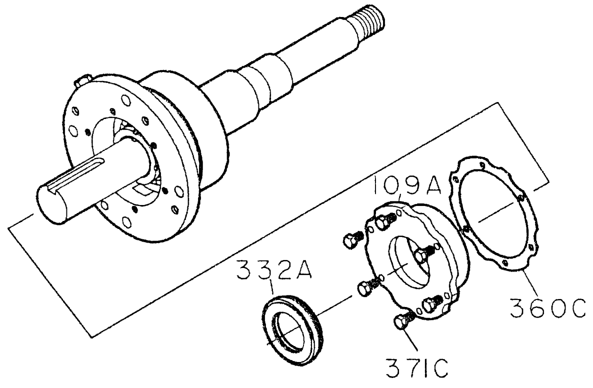


Fig. 84

9. Remove bearing housing (134) from shaft (122) with bearings (112A) (Fig. 85).

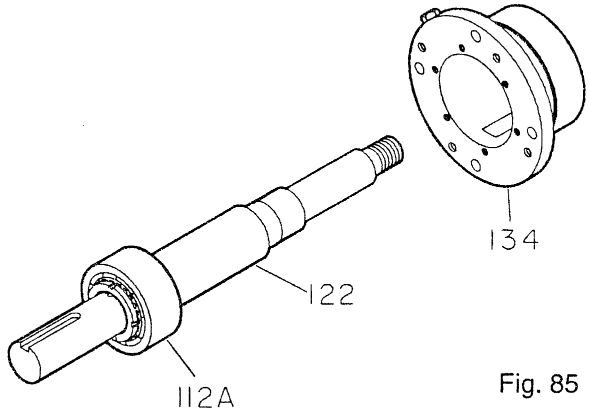


Fig. 85

10. Remove bearing locknut (136) and bearing lockwasher (382) (Fig. 86).
11. Remove outboard bearing (112A).

NOTE: When pressing bearings off the shaft, use force on the inner race only.

NOTE: Save bearings for inspection.

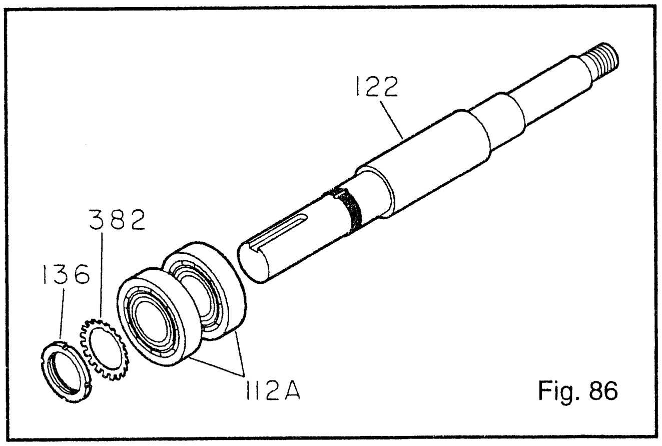


Fig. 86

ALL MODELS

DISASSEMBLY OF BEARING FRAME

1. Remove oil fill plug (113A), oil drain plug (408A), sight glass (319), sight oiler plug (408J), four (4) oil mist/grease connection plugs (408H), and oil cooler inlet and outlet plugs (408L, 408M) from bearing frame (228A).
2. MTX, LTX: Remove bearing frame foot-to-frame bolts (370F), and frame foot (241).

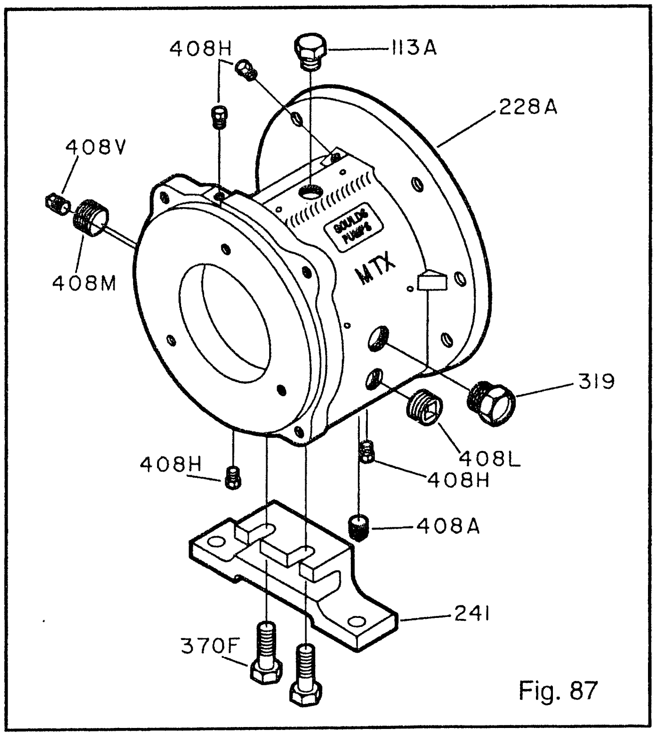


Fig. 87

INSPECTIONS

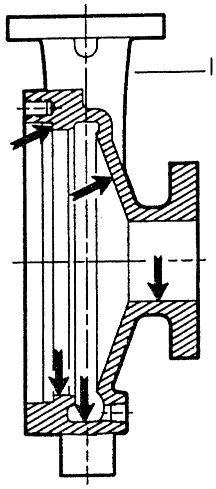
The pump parts must be inspected to the following criteria before they are reassembled to insure the pump will run properly. Any part not meeting the required criteria should be replaced.

> ***NOTE: Clean parts in solvent to remove oil, grease or dirt. Protect machined surfaces against damage during cleaning.***

Casing

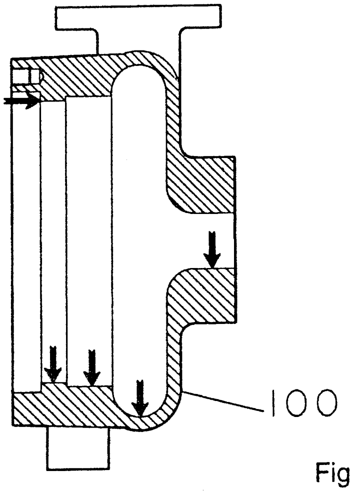
The casing (100) should be inspected for cracks and excessive wear or pitting. It should be repaired or replaced if it exceeds the following criteria (Figs. 88, 89 & 90).

1. Localized wear or grooving greater than 1/8 in. (3.2 mm) deep.
2. Pitting greater than 1/8 in. (3.2 mm) deep.
3. Inspect case gasket seat surface for irregularities.



3196, LF 3196,
NM 3196, 3198

Fig. 88



CV 3196

Fig. 89

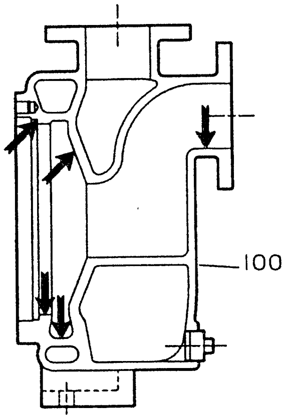


Fig. 90

Impeller

1. Inspect impeller (101) vanes for damage. Replace if grooved deeper that 1/16 in. (1.6 mm) or if worn evenly more than 1/32 in. (0.8 mm). (Area "a" in Fig. 91).
2. Inspect pumpout vanes for damage. Replace if worn more than 1/32 in. (0.8 mm). (Area "b" in Fig. 91).
3. Inspect leading and trailing edges of the vanes for cracks, pitting, and erosion or corrosion damage. (Area "c" in Fig. 91.).

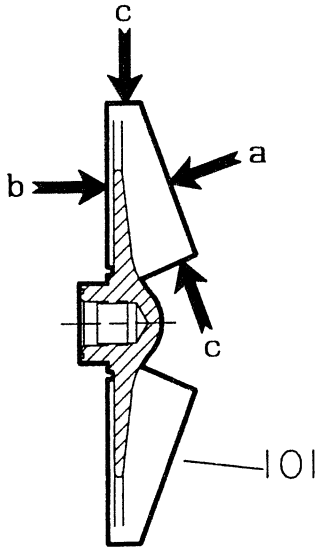
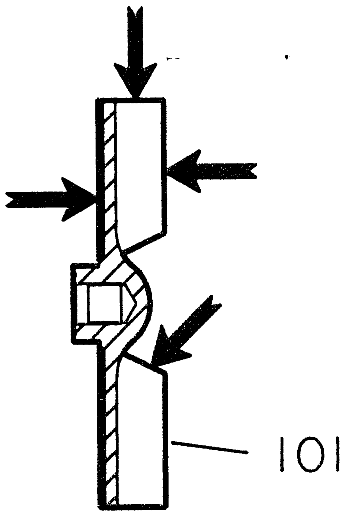


Fig. 91



CV 3196

Fig. 92

NOTE: For CV 3196 impeller, the face of the impeller is cast, not machined. The face runout need not be checked.

Frame Adapter

1. Check frame adapter (108) for cracks or excessive corrosion damage. Replace if any of these conditions exist (Fig. 93).
2. Make sure gasket surface is clean.

NOTE: The 3198 frame adapter is not interchangeable with any other model's adapter.

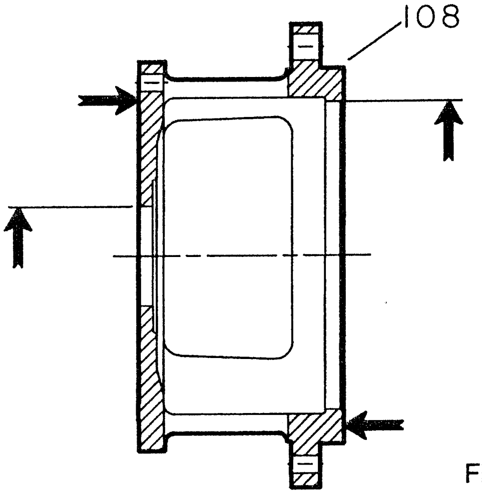


Fig. 93

Shaft and Sleeve - All Except 3198

1. Check bearing fits. If any are outside the tolerance in *Table 8*, replace the shaft (122) (Fig. 94).
2. Check shaft straightness. Replace shaft if runout exceeds values in *Table 12*.
3. Check shaft and sleeve (126) surface for grooves, pitting. Replace if any are found (Fig. 95).

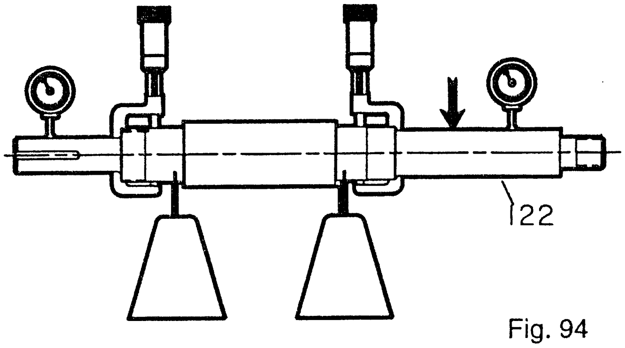


Fig. 94

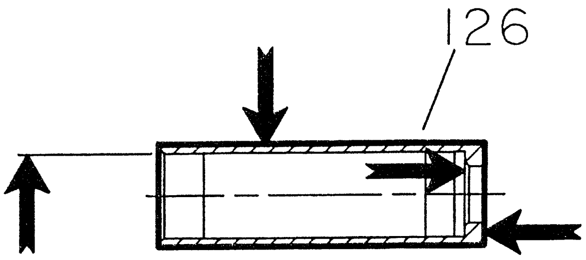


Fig. 95

Shaft and Sleeve - 3198

The 3198 is offered with a metallic sleeve which uses the standard 3196 (ANSI products) shaft. It is also offered with a Teflon® sleeve. The use of the Teflon® sleeve requires a special shaft and a different inboard labyrinth oil seal. The inspection procedures are the same as those listed above for the balance of the products.

Bearing Frame

1. Visually inspect bearing frame (228) and frame foot (241) for cracks. Check frame inside surfaces for rust, scale or debris. Remove all loose and foreign material (Figs. 96, 97).
2. Make sure all lubrication passages are clear.
3. If frame has been exposed to pumpage, inspect for corrosion or pitting.
4. Inspect inboard bearing bore according to the Alignment Troubleshooting table found in the *Installation* section.

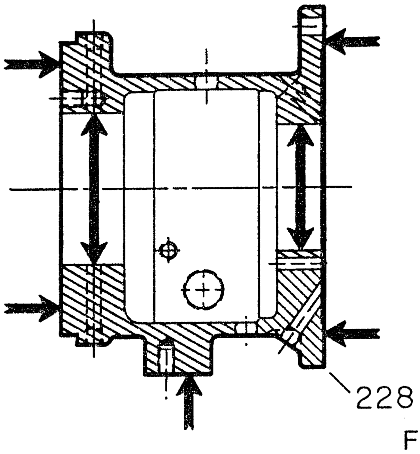


Fig. 96

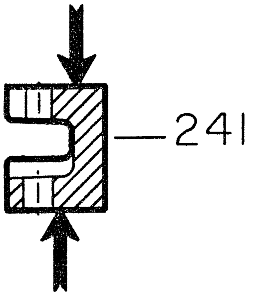


Fig. 97

C-Face Adapter

For C-Face adapter inspections, See *Appendix V.*

Dynamic Seal Repeller
(3196, CV 3196, LF 3196 only)

1. Inspect dynamic seal repeller (262) vanes for damage. Replace if grooved deeper than 1/16 in. (1.6 mm) or if worn evenly more than 1/32 in. (0.8 mm) (Fig. 98).
2. Inspect sleeve surface for grooves, pitting or other damage. Replace if damaged.

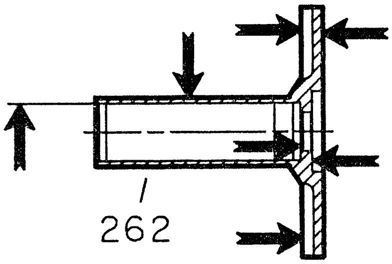
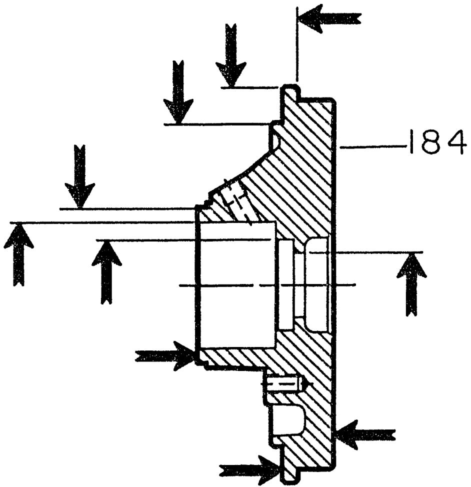


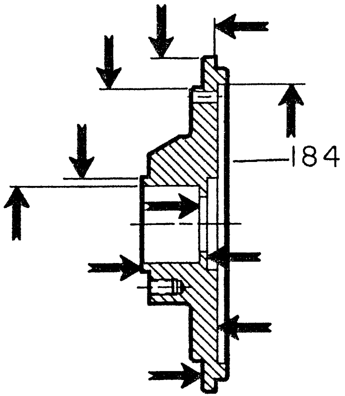
Fig. 98

Seal Chamber/Stuffing Box Cover and Dynamic Seal Backplate

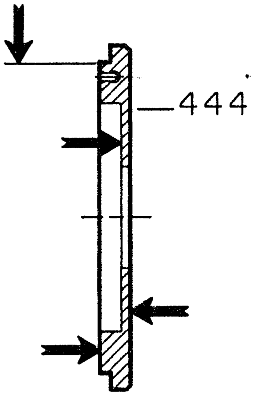
1. Make sure seal chamber/stuffing box cover (184) and dynamic seal backplate (444) gasket surface is clean at adapter face (Figs. 99 - 107).
2. Replace if there is any pitting or wear greater than 1/8 in. (3.2 mm) deep.



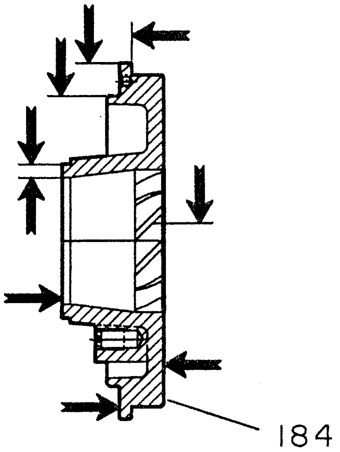
BigBore™ Chamber Fig. 99



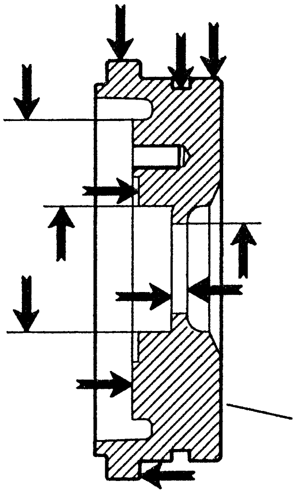
Stuffing Box Cover Fig. 100



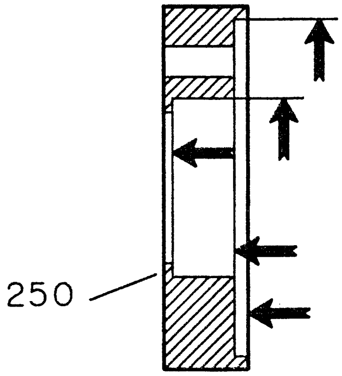
Dynamic Seal Backplate Fig. 101



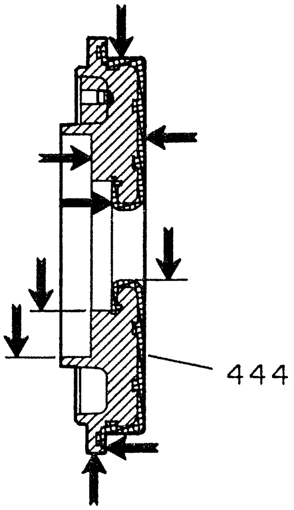
TaperBore™ *PLUS* Fig. 102



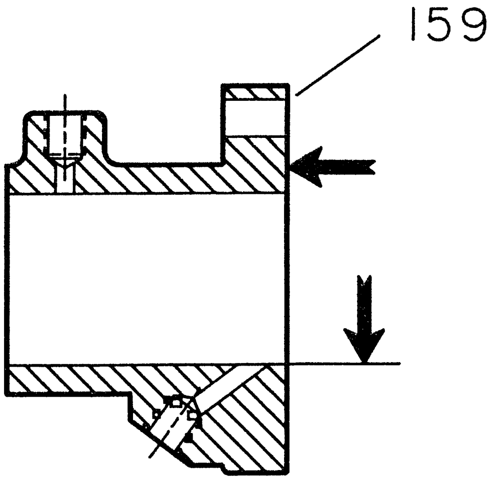
NM 3196 Backplate Fig. 103



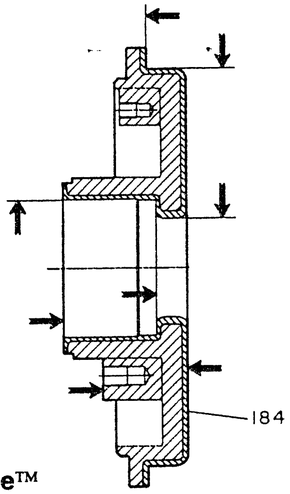
NM 3196 Seal Chamber Fig. 104



3198 Backplate Fig. 105



3198 Seal Chamber Fig. 106



3198 BigBore™ Fig. 107

Bearings

1. Ball bearings (112A, 168A) should be inspected for contamination and damage. The condition of the bearings will provide useful information on operating conditions in the bearing frame. Lubricant condition and residue should be noted, oil analysis is often helpful. Bearing damage should be investigated to determine cause. If cause is not normal wear, it should be corrected before pump is returned to service.

DO NOT RE-USE BEARINGS.

Bearing Housing

1. Inspect bearing housing (134) bore according to *Table 8*. Replace if dimensions exceed *Table 8* values.

2. Visually inspect for cracks and pits.

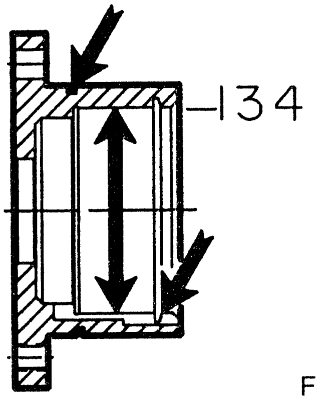
   STX, MTX - Snap ring groove must not be cracked (Fig. 108).

   LTX - Grooves and holes must be clear (Fig. 109).

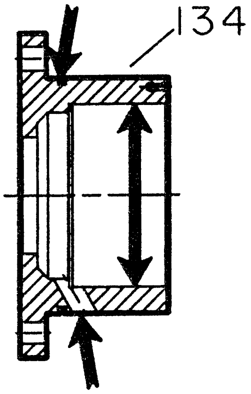
   XLT-X, X17 - Gasket surface must be clean (Fig. 110).

Labyrinth Seals

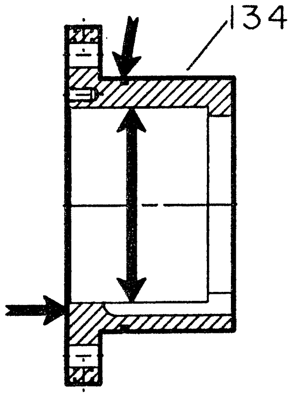
1. Labyrinth seal (332A, 333A) O-rings should be inspected for cuts and cracks. Replace as needed.



STX/MTX Fig. 108



LTX Fig. 109



XLTX/X17 Fig. 110

Table 8
Bearing Fits & Tolerances

According to ABEC I standard

	STX in. (mm)	MTX in. (mm)	LTX in. (mm)	XLT-X, X-17 in. (mm)
Shaft O.D. Inboard	1.3785 (35.013) 1.3781 (35.002)	1.7722 (45.013) 1.7718 (45.002)	2.1660 (55.015) 2.1655 (55.002)	2.5597 (65.015) 2.5592 (65.002)
Clearance	0.0010 (0.025) tight 0.0001 (0.002) tight	0.0010 (0.025) tight 0.0001 (0.002) tight	0.0012 (0.030) tight 0.0001 (0.002) tight	0.0012 (0.030) tight 0.0001 (0.002) tight
Bearing I.D. Inboard	1.3780 (35.000) 1.3775 (34.988)	1.7717 (45.000) 1.7712 (44.988)	2.1654 (55.000) 2.1648 (54.985)	2.5591 (65.000) 2.5585 (64.985)
Frame I.D. Inboard	2.8346 (72.000) 2.8353 (72.019)	3.9370 (100.000) 3.9379 (100.022)	4.7244 (120.000) 4.7253 (120.022)	5.5118 (140.000) 5.5128 (140.025)
Clearance	0.0012 (0.032) loose 0.0000 (0.000) loose	0.0015 (0.037) loose 0.0000 (0.000) loose	0.0015 (0.037) loose 0.0000 (0.000) loose	0.0017 (0.043) loose 0.0000 (0.000) loose
Bearing O.D. Inboard	2.8346 (72.000) 2.8341 (71.987)	3.9370 (100.000) 3.9364 (99.985)	4.7244 (120.000) 4.7238 (119.985)	5.5118 (140.000) 5.5111 (139.982)
Shaft O.D. Outboard	1.1815 (30.011) 1.1812 (30.002)	1.7722 (45.013) 1.7718 (45.002)	1.9690 (50.013) 1.9686 (50.002)	2.5597 (65.015) 2.5592 (65.002)
Clearance	0.0008 (0.021) tight 0.0001 (0.002) tight	0.0010 (0.025) tight 0.0001 (0.002) tight	0.0010 (0.025) tight 0.0001 (0.002) tight	0.0012 (0.030) tight 0.0001 (0.002) tight
Bearing I.D. Outboard	1.1811 (30.000) 1.1807 (29.990)	1.7717 (45.000) 1.7712 (44.988)	1.9685 (50.000) 1.9680 (49.988)	2.5591 (65.000) 2.5585 (64.985)
Housing I.D. Outboard	2.8346 (72.000) 2.8353 (72.019)	3.9370 (100.000) 3.9379 (100.022)	4.3307 (110.000) 4.3316 (110.022)	5.5118 (140.000) 5.5128 (140.025)
Clearance	0.0012 (0.032) loose 0.0000 (0.000) loose	0.0015 (0.037) loose 0.0000 (0.000) loose	0.0015 (0.037) loose 0.0000 (0.000) loose	0.0017 (0.043) loose 0.0000 (0.000) loose
Bearing O.D. Outboard	2.8346 (72.000) 2.8341 (71.987)	3.9370 (100.000) 3.9364 (99.985)	4.3307 (110.000) 4.3301 (109.985)	5.5118 (140.000) 5.5111 (139.982)

REASSEMBLY

Refer to *Table 9* for torque values while reassembling pump.

Table 9
Bolt Torque, Ft-Lbs (N•m)

Location	Frame	3196, CV 3196, LF 3196, 3796		NM 3196		3198	
		Lube	Dry	Lube	Dry	Lube	Dry
Casing Bolts (370) or Casing Nuts (425)	6" STX	30 (40)	45 (60)	27 (36)	40 (53)	N/A	N/A
	8" STX	20 (27)	30 (40)	20 (27)	30 (40)	35 (47)	53 (71)
	MTX, LTX	30 (40)	45 (60)	27 (36)	40 (53)	35 (47)	53 (71)
	XLT-X, X17	30 (40)	45 (60)	N/A	N/A	N/A	N/A
Frame-to-Adapter	All	20 (27)	30 (40)	20 (27)	30 (40)	20 (27)	30 (40)
Bearing Clamp Ring Bolts (236A) Duplex Bearing Only	STX, MTX	10* (1.1)	17* (1.9)	10* (1.1)	17* (1.9)	10* (1.1)	17* (1.9)
	LTX	55* (6.2)	83* (9.4)	55* (6.2)	83* (9.4)	55* (6.2)	83* (9.4)
Bearing End Cover Bolts (371C)	XLT-X, X17	9 (12)	12 (16)	N/A	N/A	N/A	N/A
Dynamic Seal Capscrews (265)	STX, MTX, LTX	55* (6.2)	83* (9.4)	N/A	N/A	N/A/	NVA
	XLT-X, X17	9 (12)	12 (16)	N/A	N/A	N/A	N/A

* Values are in inch-lbs (Nm)

Refer to *Table 10* for shaft end play while reassembling pump.

Table 10
Shaft End Play

	STX in. (mm)	MTX in. (mm)	LTX in. (mm)	XLT-X in. (mm)
Double Row	.0011 (.028) .0019 (.047)	.0013 (.033) .0021 (.054)	not applicable	.0014 (.036) .0023 (.058)
Duplex	.0007 (.018) .0010 (.026)	.0009 (.022) .0012 (.030)	.0010 (.026) .0015 (.038)	.0010 (.026) .0015 (.038)

Table 11
Bearing Type

Frame	Inboard	Outboard	
		Double Row	Duplex
STX	6207	5306A / C3	7306 BECBM
MTX	6309	5309A / C3	7309 BECBM
LTX	6311	not applicable	7310 BECBM
XLT-X, X17	6313	5313A / C3	7313 BECBY

Table 12
Shaft Runout Tolerances

	Sleeve Fit in. (mm)	Coupling Fit in. (mm)
With Sleeve	.001 (.026)	.001 (.026)
Less Sleeve	.002 (.051)	.001 (.026)

NOTE: Bearing type is based on SKF/MRC designation.

Assembly of Rotating Element and Bearing Frame

STX, MTX

NOTE: Make sure that threads are clean and apply thread sealant to pipe threads and fittings.

1. Install oil fill plug (113A), oil drain plug (408A), sight window (319), sight oiler plug (408J), four oil mist connection plugs (408H) or grease fittings (193) and relief plugs (113), and oil cooler inlet and outlet plugs (408L, 408M) in bearing frame (228) (Fig. 111).
2. Attach bearing frame foot (241) with bolts (370F). Hand tighten.

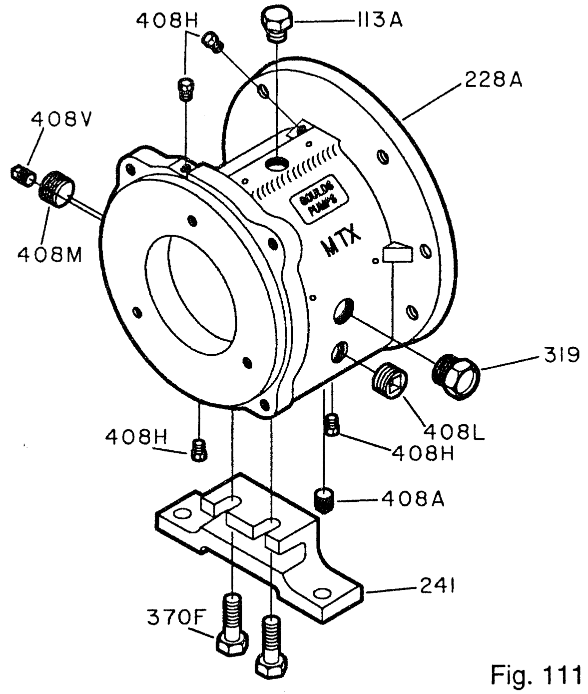


Fig. 111

3. Install outboard bearing (112A) on shaft (122) (Fig. 112).

NOTE: Regreaseable bearing has a single shield. The outboard bearing is installed with shield toward impeller.

NOTE: There are several methods used to install bearings. The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

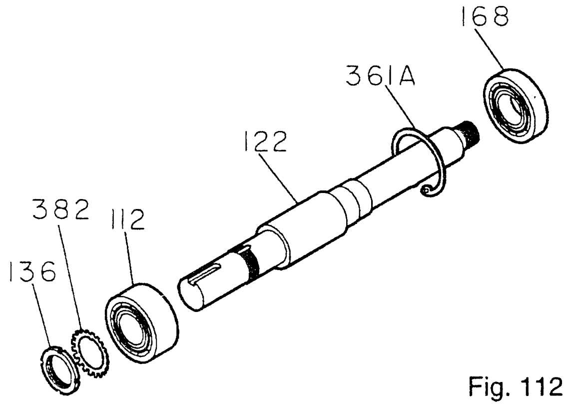


Fig. 112

4. Place lockwasher (382) on shaft (122). Place tang of lockwasher in keyway of shaft.

5. Thread locknut (136) onto shaft (122). Tighten locknut until snug. Bend any tang of lockwasher into a slot of locknut.

NOTE: Tighten locknut if necessary to align the closest tab of lockwasher with slot on locknut.

6. Place bearing retaining ring (361A) over shaft (122), flat side facing bearing.

7. Install inboard bearing (168A) on shaft (122).

NOTE: Regreaseable bearing has a single shield. The inboard bearing is installed with shield away from impeller.

NOTE: There are several methods used to install bearings. The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

NOTE: Coat internal surfaces of bearings with lubricant to be used in service.

8. Install new O-ring (496) (Fig. 113).

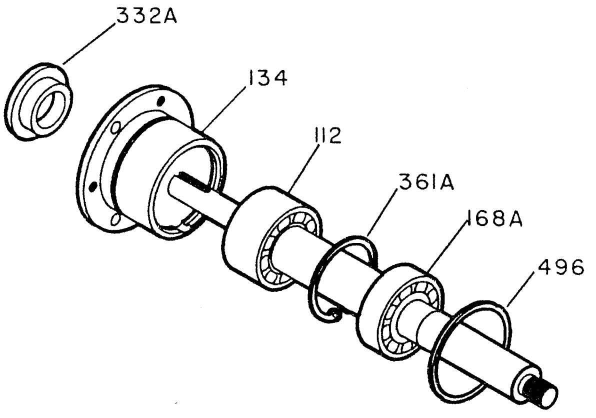


Fig. 113

9. Coat outside of outboard bearing (112A) and bearing housing (134) bore with oil.

10. Install bearing housing (134) onto shaft/bearing assembly.

NOTE: Do not force assembly together.

11. Insert retaining ring (361A) into groove in housing (134) bore. Check shaft for free turning.

NOTE: The space between the ends of retainin ring should be located in the oil return groove so as not to obstruct oil flow.

12. Install outboard labyrinth oil seal (332A) into bearing housing (134). It is an O-ring fit. Position the labyrinth seal drain slots at the bottom (6 o'clock) position.

NOTE: See Appendix IV for detailed labyrinth seal installation instructions.

NOTE: Make sure the keyway edges are free of burrs.

NOTE: Cover the keyway lengthwise with a piece of electrical tape prior to installing the labyrinth seal. This will protect the O-rings.

13. Coat outside of bearing housing (134) with oil (Fig. 114).

14. Coat all internal surfaces of bearing frame (228A) with oil.

15. Install shaft assembly into frame (228A). Check shaft for free turning.

16. Install clamping bolts (370C) into bearing housing (134). Hand tighten.

17. Install jacking bolts (370D) with locking nuts (423) into housing (134). Hand tighten.

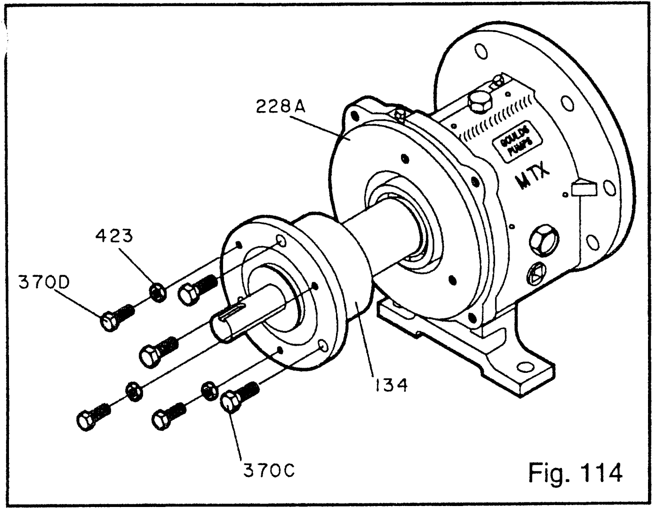


Fig. 114

LTX

NOTE: Make sure that threads are clean and apply thread sealant to pipe threads and fittings.

1. Install the oil fill plug (113A), oil drain plug (408A), sight window (319), sight oiler plug (408J), four oil mist connection plugs (408H) or grease fittings (193) and grease relief plugs (113), and oil cooler inlet and outlet plugs (408L, 408M) in bearing frame (228) (Fig. 115).
2. Attach bearing frame foot (241) with bolts (370F). Hand tighten.

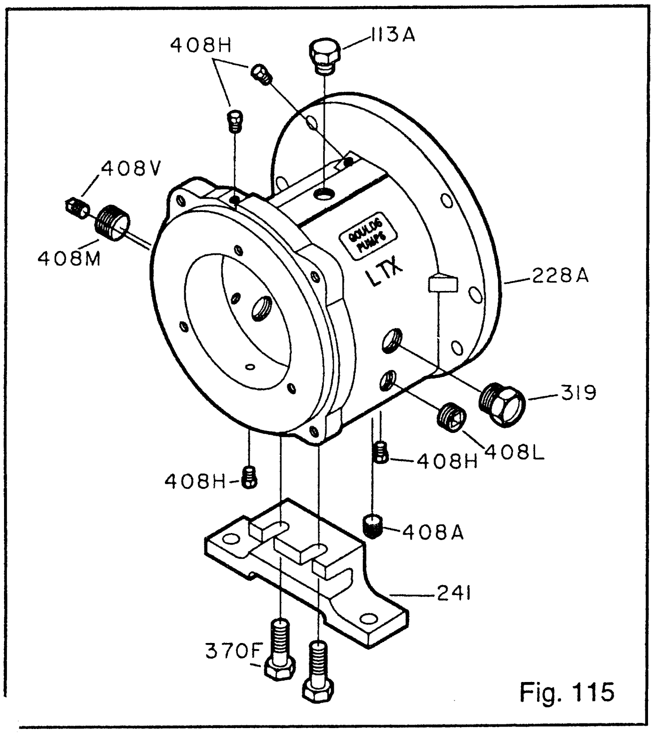


Fig. 115

3. Install oil flinger (248A) on shaft (122) if removed (Fig. 116).

NOTE: The oil flinger is a press fit onto shaft. Use a driver of proper size to prevent damage to oil flinger.

4. Place bearing clamp ring (253B) over shaft (122). Note orientation.
5. Install outboard bearings (112A) on shaft (122).

⚠ CAUTION

The LTX uses duplex bearings mounted back to back. Make sure orientation of the bearings is correct.

NOTE: There are several methods used to install bearings. The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

6. Place lockwasher (382) on shaft (122). Place tang of lockwasher in keyway of shaft.
7. Thread locknut (136) onto shaft (122). Tighten locknut until snug. Bend any tang of lockwasher (382) into a slot of locknut.

NOTE: Tighten locknut if necessary to align the closest tab of lockwasher with slot on locknut.

8. Install inboard bearing (168A) on shaft (122).

NOTE: Regreaseable bearing has a single shield. The inboard bearing is installed with shield away from impeller.

NOTE: There are several methods used to install bearings. The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

NOTE: Coat internal surfaces of bearings with lubricant to be used in service.

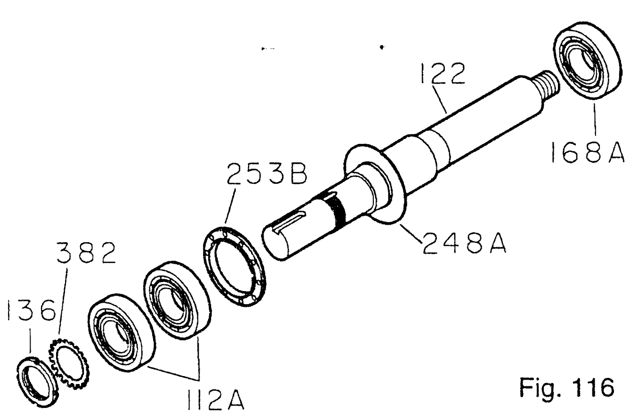


Fig. 116

9. Coat outside of outboard bearing (112A) and bearing housing (134A) bore with oil.
10. Install bearing housing (134) onto shaft/bearing assembly (Fig. 117).

NOTE: Do not force assembly together.

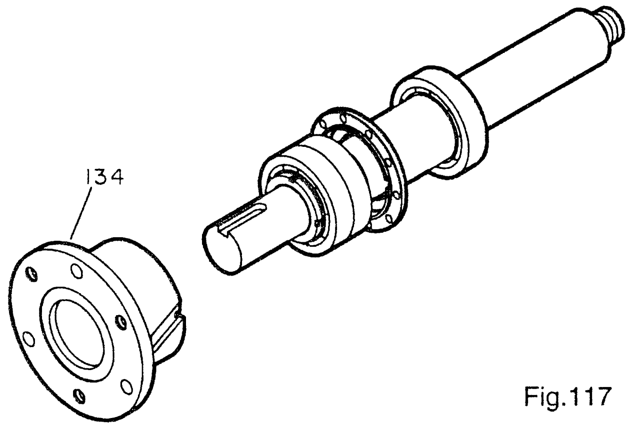


Fig.117

11. Install clamp ring bolts (236A). Check shaft for free turning. Refer to *Table 9* for bolt torque values (Fig. 118).

CAUTION

Tighten clamp ring bolts (236A) in a criss cross pattern.

12. Install new O-ring (496).
13. Install outboard labyrinth oil seal (332A) into bearing housing (134). It is an O-ring fit. Position the labyrinth seal drain slots at the bottom (6 o'clock) position.

NOTE: Make sure the keyway edges are free of burrs.

NOTE: Cover the keyway lengthwise with a piece of electrical tape prior to installing the labyrinth seal. This will protect the O-rings.

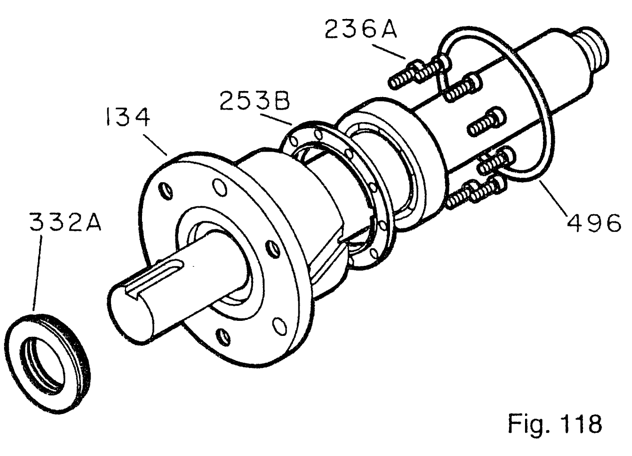


Fig. 118

14. Coat outside of bearing housing (134A) with oil.
15. Coat all internal surfaces of bearing frame (228) with oil.
16. Install shaft assembly into frame (228A). Check shaft for free turning (Fig. 119).
17. Install clamping bolts (370C) into bearing housing (134A). Hand tighten.
18. Install jacking bolts (370D) with locking nuts (423) into housing (134A). Hand tighten.

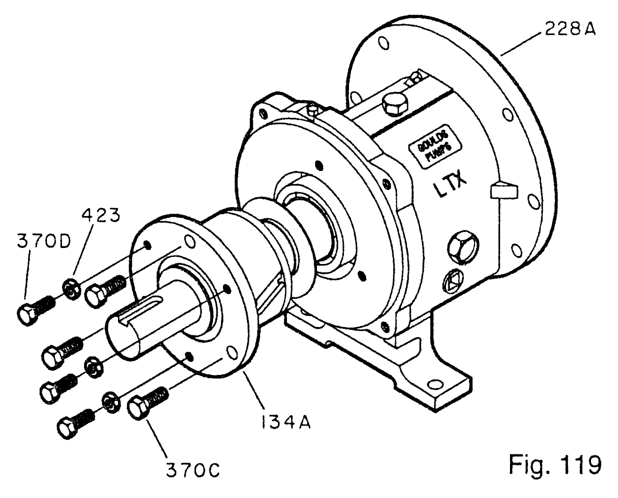


Fig. 119

XLT-X, X17

NOTE: Make sure that threads are clean and apply thread sealant to pipe threads and fittings.

1. Install oil fill plug (113A), oil drain plug (408A), sight glass (319), sight oiler plug (408J), four oil mist connection plugs (408H), or grease fittings (193) and grease relief plugs (113), and oil cooler inlet and outlet plugs (408L, 408M) in bearing frame (228A) (Fig. 120).

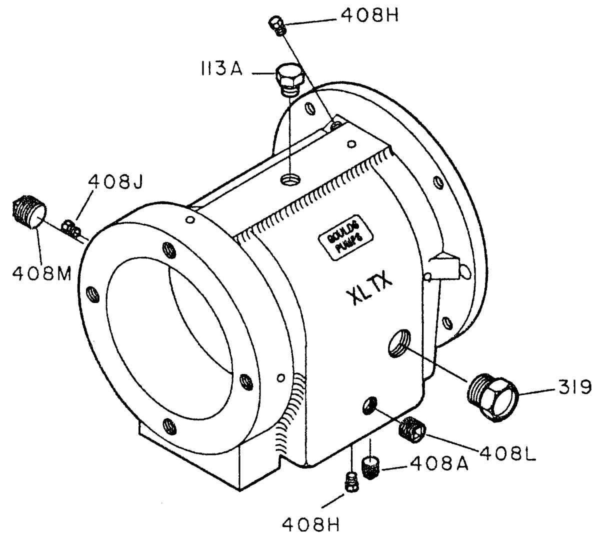


Fig. 120

2. Install outboard bearing (112A) on shaft (122) (Fig. 121).

NOTE: Regreaseable bearing has a single shield. The outboard bearing is installed with shield toward impeller.

NOTE: There are several methods used to install bearings, The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

⚠ WARNING

Shaft (122) may be heavy. Use care when handling.

3. Place lockwasher (382) on shaft (122). Place tang of lockwasher in keyway of shaft.

Thread locknut (136) onto shaft (122). Tighten locknut until snug. Bend any tang of lockwasher (382) into a slot of locknut.

NOTE: Tighten locknut if necessary to align the closest tab of lockwasher with slot on locknut.

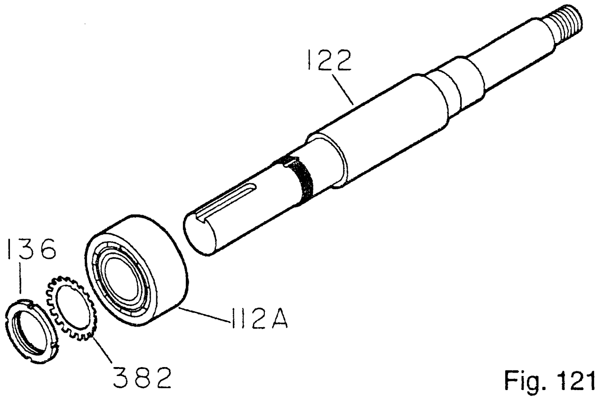


Fig. 121

5. Coat outside of outboard bearing (112A) and bore of bearing housing (134) with oil.

6. Install bearing housing (134) onto shaft/bearing assembly (Fig. 122).

NOTE: Do not force assembly together.

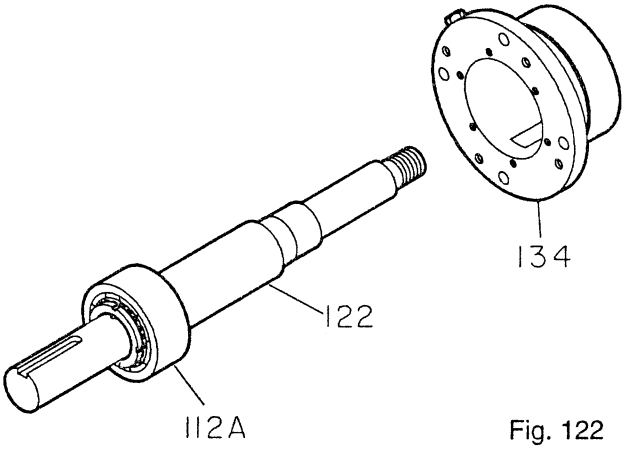


Fig. 122

7. Install gasket (360C), end cover (109A), bolts (371C). Refer to *Table 9* for bolt torque values. Check shaft for free turning (Fig. 123).

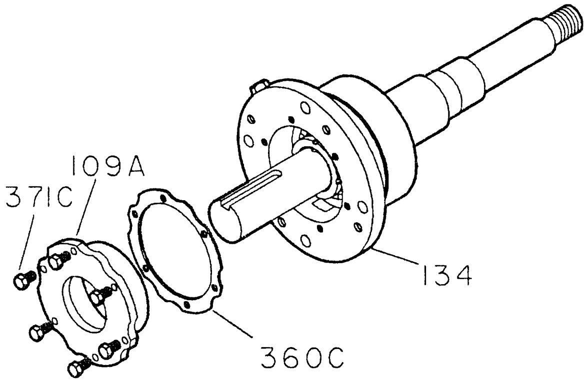


Fig. 123

8. Install inboard bearing (168A) on shaft (122) (Fig. 124).

NOTE: Regreaseable bearing has a single shield. The inboard bearing is installed with shield away from impeller.

NOTE: There are several methods used to install bearings, The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

NOTE: Coat internal surfaces of bearings with lubricant to be used in service.

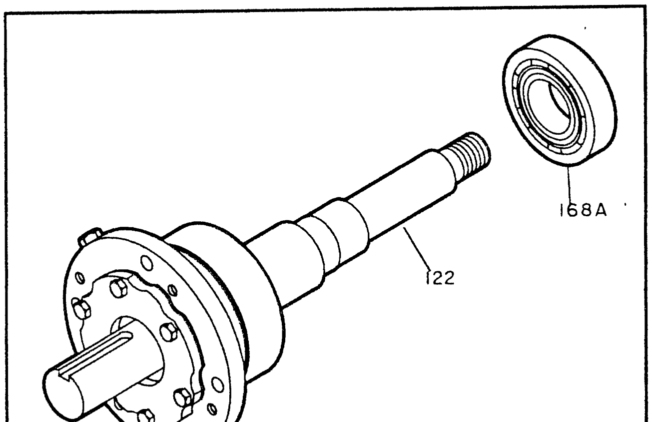


Fig. 124

9. Install new O-ring (496) (Fig. 125).
10. Install outboard labyrinth oil seal (332A) into end cover (109A). It is an O-ring fit. Position the labyrinth seal drain slots at the bottom 6 o'clock position (Fig. 125).

NOTE: Make sure the keyway edges are free of burrs.

NOTE: Cover the keyway lengthwise with a piece of electrical tape prior to installing the labyrinth seal. This will protect the O-rings.

11. Coat outside of bearing housing (134) with oil.
12. Coat all internal surfaces of bearing frame (228A) with oil.

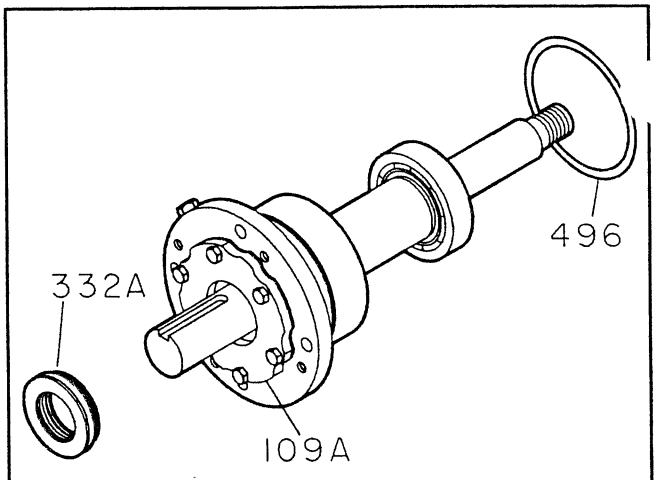


Fig. 125

13. Install shaft assembly into frame (228A). Check shaft for free turning (Fig. 126).
14. Install clamping bolts (370C) into bearing housing (134). Hand tighten.
15. Install jacking bolts (370D) with locking nuts (423) into housing (134). Hand tighten.
16. Attach bearing frame foot (241) with bolts (370F). Hand tighten.

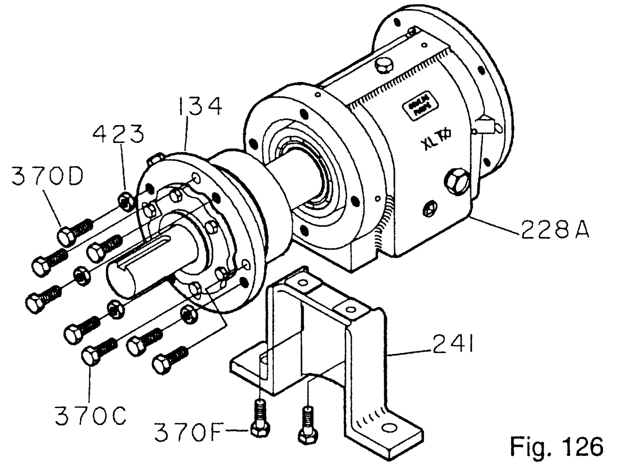


Fig. 126

STX, MTX with Duplex Bearings

1. Install the oil fill plug (113A), oil drain plug (408A), sight window (319), sight oiler plug (408J), four oil mist connection plugs (408H), or grease fittings (193) and grease relief plugs (113), and oil cooler inlet and outlet plugs (408L, 408M) in bearing frame (228) (Fig. 127).

2. Attach bearing frame foot (241) with bolts (370F). Hand tighten (Fig. 127).

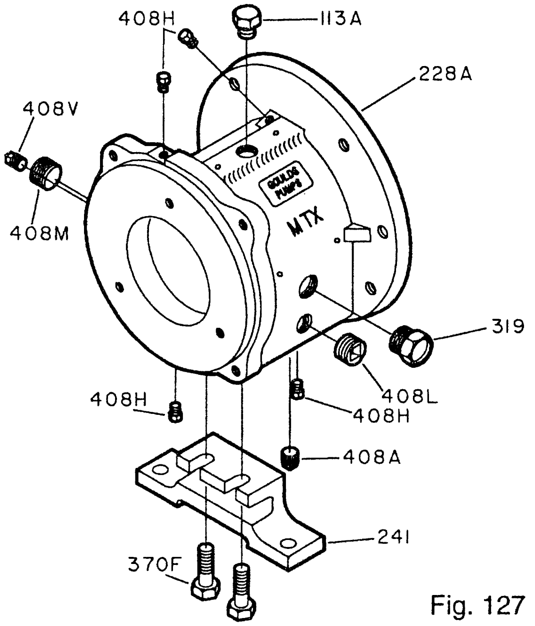


Fig. 127

NOTE: There are several methods used to install bearings. The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

3. Install outboard bearings (112A) on shaft (122).

CAUTION

Duplex bearings are mounted back to back. Make sure orientation of bearings is correct.

4. Place lockwasher (382) on shaft (122). Place tang of lockwasher in keyway of shaft (Fig. 128).

5. Thread locknut (136) onto shaft (122). Tighten locknut until snug. Bend any tang of lockwasher (382) into a slot of locknut.

NOTE: Tighten locknut if necessary to align the closest tab of lockwasher with slot on locknut.

6. Place bearing clamp ring (253B) over shaft (122). Note orientation.

7. Install inboard bearing (168A) on shaft (122).

NOTE: Regreaseable bearing has a single shield. The inboard bearing is installed with shield away from impeller.

NOTE: Coat internal surfaces of bearings with lubricant to be used in service.

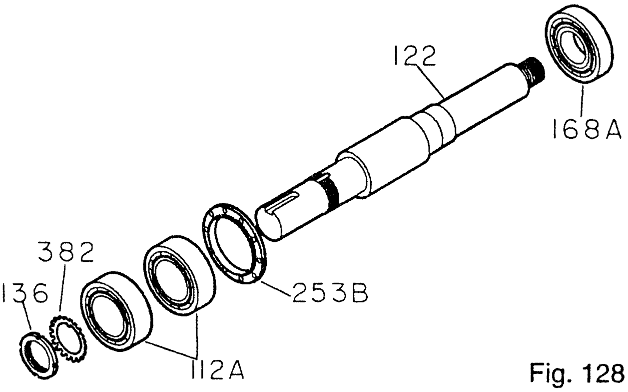


Fig. 128

8. Coat outside of outboard bearing (112A) and bore of bearing housing (134) with oil.

9. Lower shaft/bearing assembly into bearing housing (134) (Fig. 129).

NOTE: Do not force assembly together.

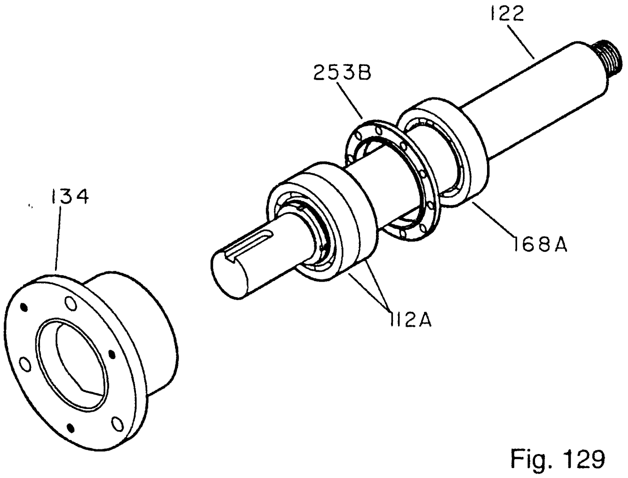


Fig. 129

10. Install clamp ring (253B) with bolts (236A). Tighten bolts in a criss-cross pattern. Check shaft for free turning. Refer to *Table 9* for bolt torque values (Fig. 130).
11. Install new O-ring (496).
12. Install outboard labyrinth oil seal (332A) into bearing housing (134). It is an O-ring fit. Position the labyrinth seal drain slots at the bottom 6 o'clock position (Fig. 130).

NOTE: Make sure the keyway edges are free of burrs.

NOTE: Cover the keyway lengthwise with a piece of electrical tape prior to installing the labyrinth seal. This will protect the O-rings.

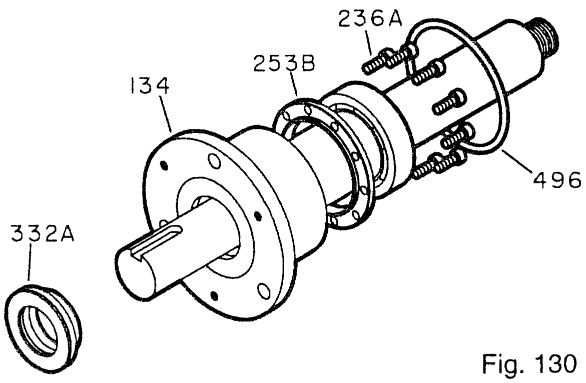


Fig. 130

13. Coat outside of bearing housing (134) with oil.
14. Coat all internal surfaces of bearing frame (228A) with oil.
15. Install shaft assembly into frame (228A). Check shaft for free turning (Fig. 131).
16. Install clamping bolts (370C) into bearing housing (134A). Hand tighten.
17. Install jacking bolts (370D) with locking nuts (423) into housing (134A). Hand tighten.

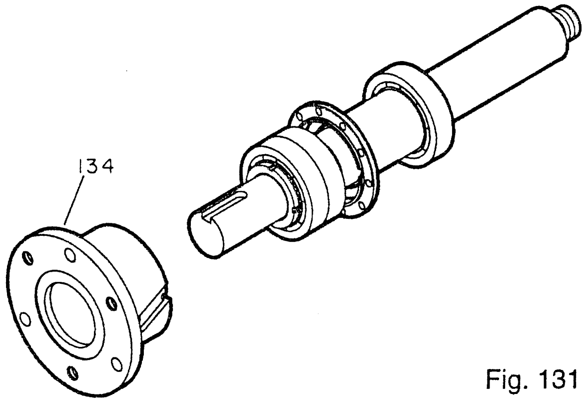


Fig. 131

XLT-X, X17 with Duplex Bearings

NOTE: Make sure that threads are clean and apply thread sealant to pipe threads and fitting

1. Install the oil fill plug (113A), oil drain plug (408A), sight window (319), sight oiler plug (408J), four oil mist connection plugs (408H), or grease fittings (193) and grease relief plugs (113), and oil cooler inlet and outlet plugs (408L, 408M) in bearing frame (228) (Fig. 132).

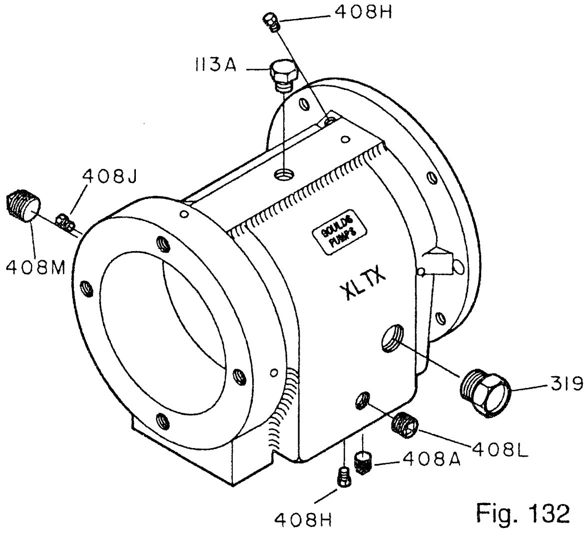


Fig. 132

2. Install outboard bearings (112A) on shaft (122) (Fig. 133).

NOTE: There are several methods used to install bearings, The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

⚠ CAUTION

Duplex bearings are mounted back to back. Make sure bearing orientation is correct.

3. Place lockwasher (382) on shaft (122). Place tang of lockwasher in keyway of shaft.
4. Thread locknut (136) onto shaft (122). Tighten locknut until snug. Bend any tang of lockwasher (382) into a slot of locknut.

NOTE: Tighten locknut if necessary to align the closest tab of lockwasher with slot on locknut.

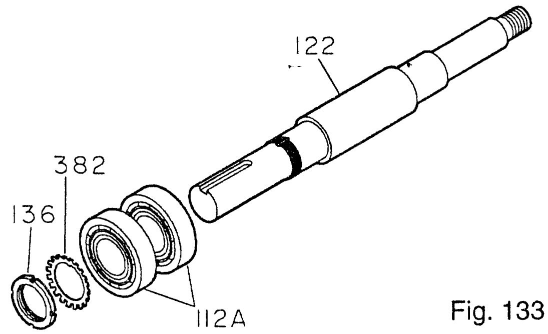


Fig. 133

5. Coat outside of outboard bearing (112A) and bore of bearing housing (134) with oil.
6. Install bearing housing (134) onto shaft/bearing assembly (Fig. 134).

NOTE: Do not force assembly together.

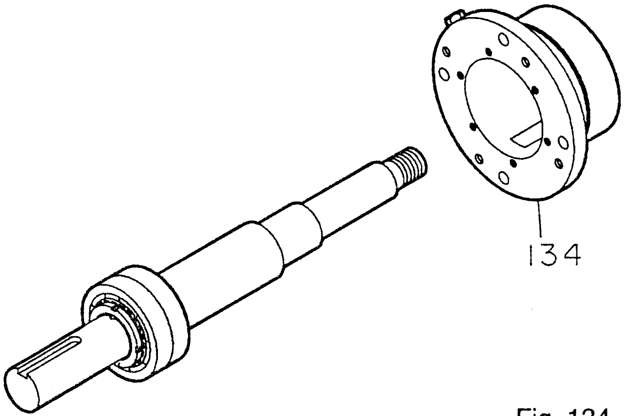


Fig. 134

7. Install gasket (360C), end cover (109A), and bolts (371C). Refer to *Table 9* for bolt torque values. Check shaft for free turning (Fig. 135).

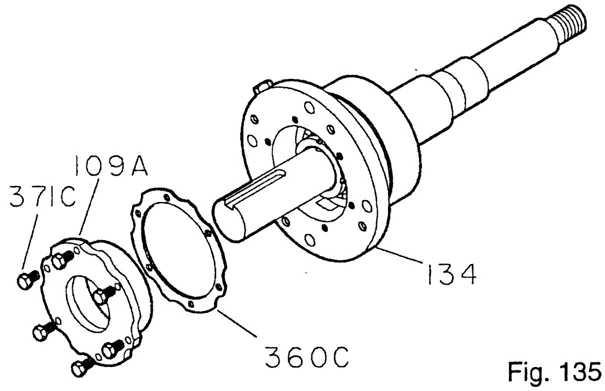


Fig. 135

8. Install inboard bearing (168A) on shaft (122) (Fig. 136).

NOTE: Regreaseable bearing has a single shield. The inboard bearing is installed with shield away from impeller.

NOTE: There are several methods used to install bearings. The recommended method is to use an induction heater that heats as well as demagnetizes the bearings.

⚠ WARNING

Wear insulated gloves when using a bearing heater. Bearings will get hot and can cause physical injury.

NOTE: Coat internal surfaces of bearings with lubricant to be used in service.

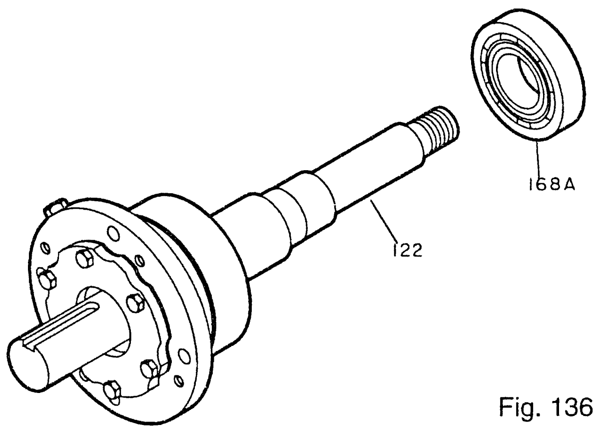


Fig. 136

9. Install new O-ring (496) (Fig. 137).
10. Install outboard labyrinth oil seal (332A) into end cover (109A). It is an O-ring fit. Position the labyrinth seal drain slots at the bottom 6 o'clock position.

NOTE: Make sure the keyway edges are free of burrs.

NOTE: Cover the keyway lengthwise with a piece of electrical tape prior to installing the labyrinth seal. This will protect the O-rings.

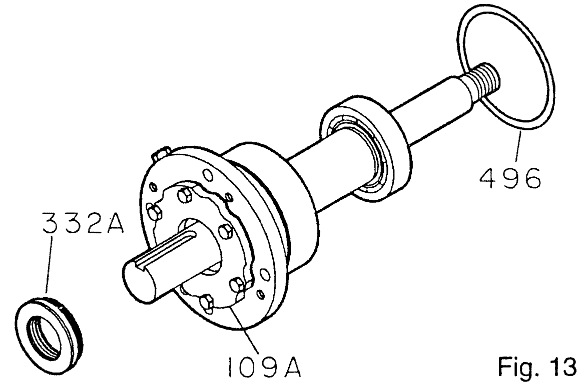


Fig. 137

11. Coat outside of bearing housing (134) with oil.
12. Coat all internal surfaces of bearing frame (228A) with oil.
13. Install shaft assembly into frame (228A). Check shaft for free turning (Fig. 138).
14. Install clamping bolts (370C) into bearing housing (134). Hand tighten.
15. Install jacking bolts (370D) with locking nuts (423) into housing (134). Hand tighten.
16. Attach bearing frame foot (241) with bolts (370F). Hand tighten.

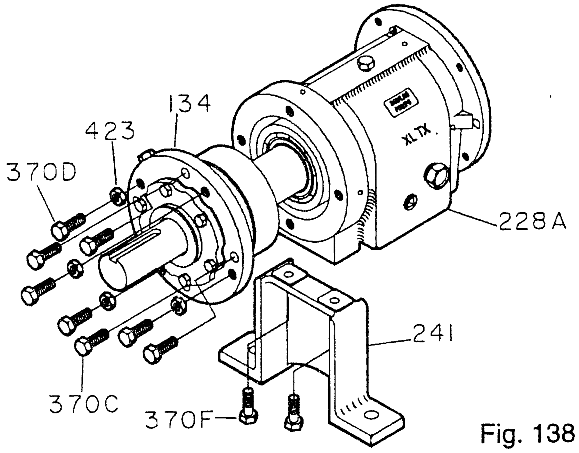


Fig. 138

ALL MODELS

1. Support frame assembly in horizontal position.
2. Check shaft end play. Move shaft forward then backward by hand, noting indicator movement. If total indicator reading is greater than *Table 10* values, disassemble and determine cause (Fig. 139).

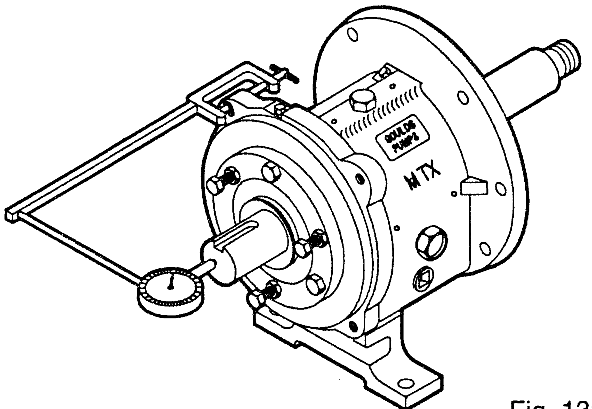


Fig. 139

3. Check shaft/sleeve runout. Put on shaft sleeve (126) if used, and thread on impeller, hand tight. Rotate shaft 360 degrees. If total indicator reading is greater then .002 in., disassemble and determine cause. Remove impeller and shaft sleeve (Fig. 140).

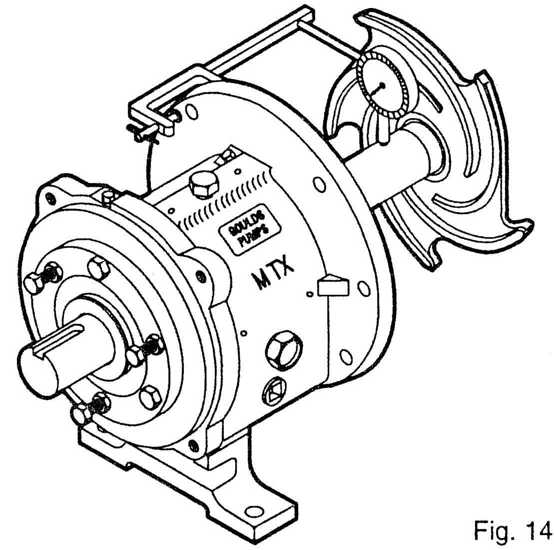


Fig. 140

4. Check frame face run out. Rotate shaft so indicator rides along the fit for 360 degrees. If total indicator reading is greater than 0.001 in. (.025 mm) disassemble and determine cause (Fig. 141).

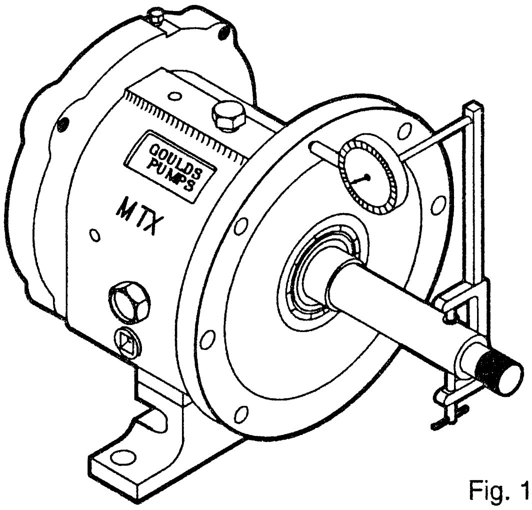


Fig. 141

5. Place manila gasket (360D) on frame (228) (Fig. 142).

NOTE: The gasket is designed to fit one way only. The dowel pins (469B) may be started in their holes to hold the gasket in place.

6. Install frame adapter (108), onto frame assembly. Align bolt holes and dowel locations with those on frame (Fig. 142).
7. Install dowel pins (469B) and bolts (370B). Tighten bolts to *Table 9* torque specifications in a criss-cross pattern.

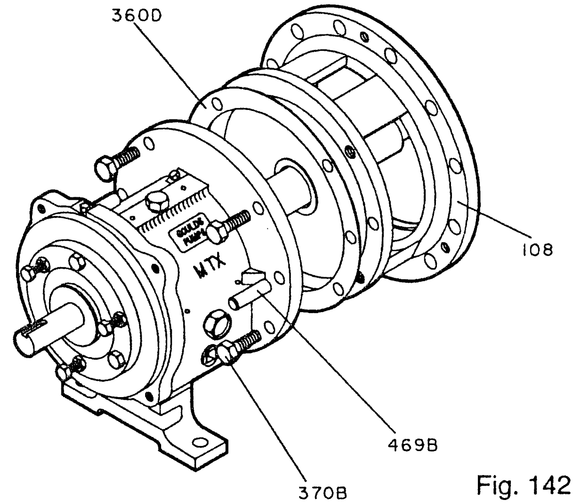


Fig. 142

8. Check adapter fits. Rotate shaft through 360 degrees. If total indicator reading is greater than .005 in. (.13 mm), determine the cause and correct before proceeding (Fig. 143).

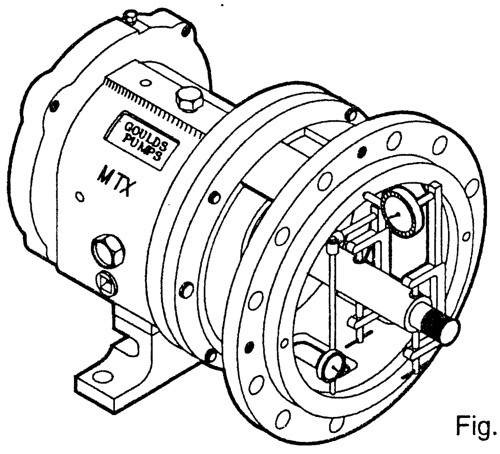
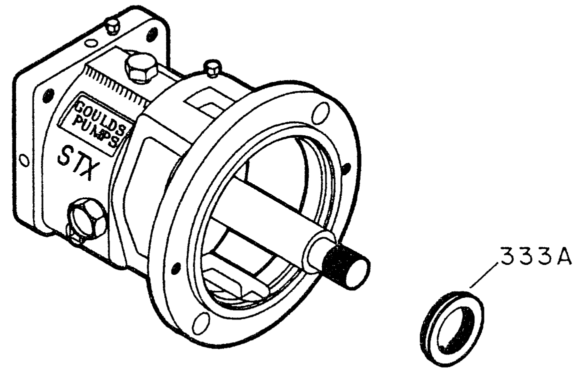


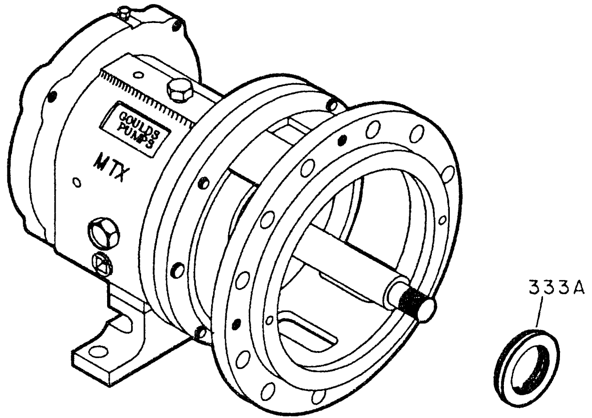
Fig. 143

9. Install inboard labyrinth oil seal (333A) into adapter (108) / bearing frame (228). It is an O-ring fit. Position the labyrinth seal drain slots at the bottom (6 o'clock) position. (Fig. 144).

NOTE: For detailed labyrinth seal installation instructions, see Appendix III, Labyrinth Seal Installation Instructions.



STX Fig. 144



MTX/LTX
XLT-X, X17 Fig. 145

Pumps With Mechanical Seals:

1. Install seal chamber cover or backplate (184) with nuts (370H) (Fig. 146).

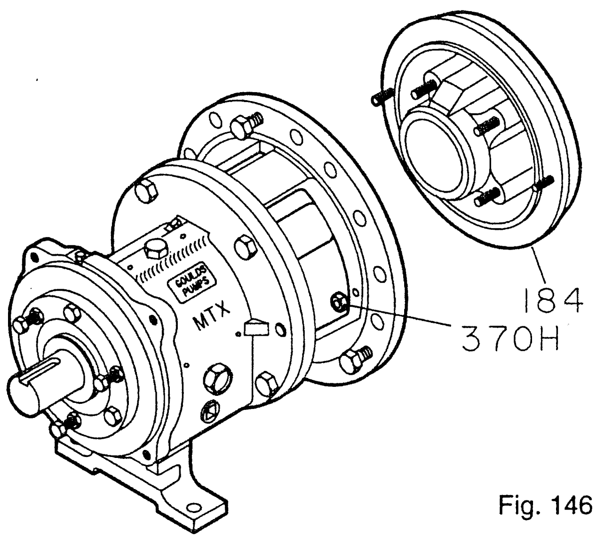


Fig. 146

2. Check seal chamber cover run-out. Rotate indicator through 360 degrees. If total indicator reading is greater than 0.005 in. (.13 mm), determine cause and correct before proceeding (Fig. 147).

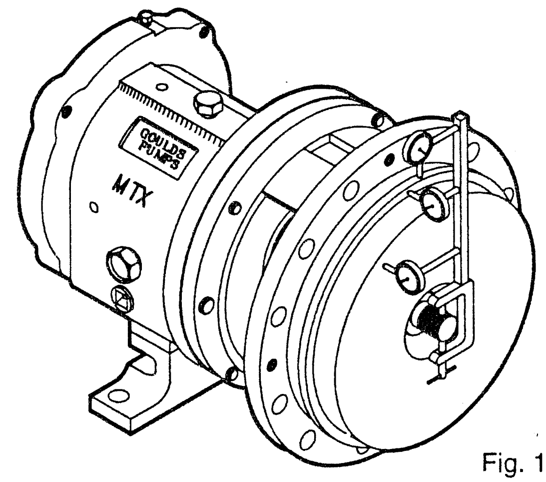


Fig. 147

3. Install shaft sleeve (126) if used (Fig. 148).

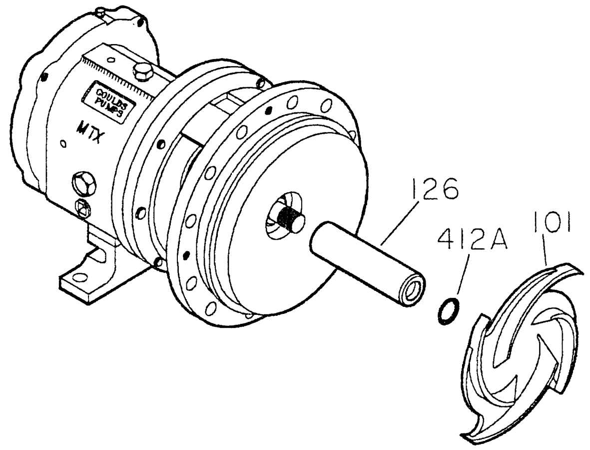
NOTE: If using 3198 with a Teflon® sleeve, the sleeve should already be installed and finish machined.

NOTE: Make sure sleeve is fully seated.

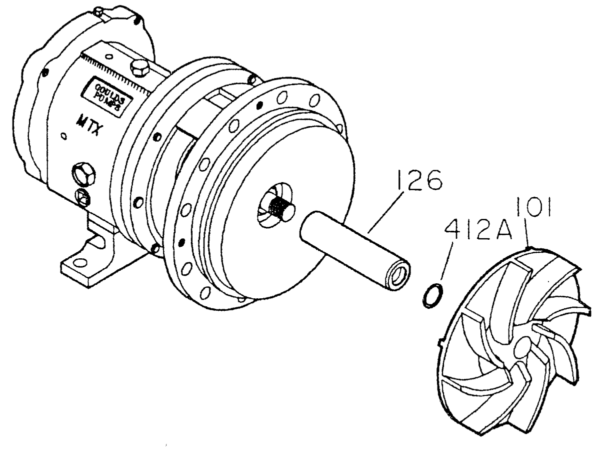
⚠ WARNING

Wear a heavy set of work gloves when handling impeller (101) as sharp edges may cause physical injury.

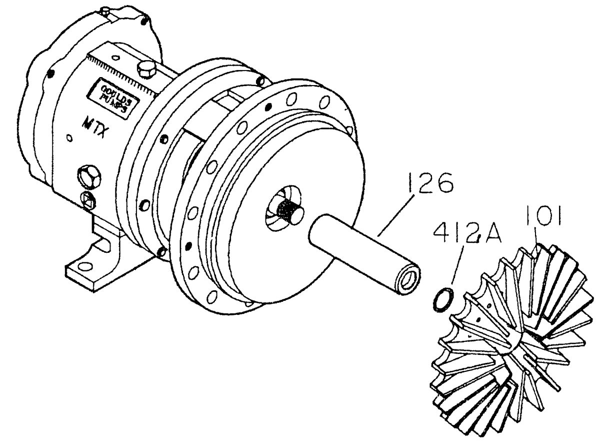
4. **STX, MTX, LTX -** Install impeller (101) with O-ring (412A).



3196, NM 3196, 3198, 3796 Fig. 148



CV 3196 Fig. 149



LF 3196 Fig. 150

XLT-X & X17 - Install the impeller (101) without the O-ring (412A) and Teflon® washer (428D) on plug (458Y).

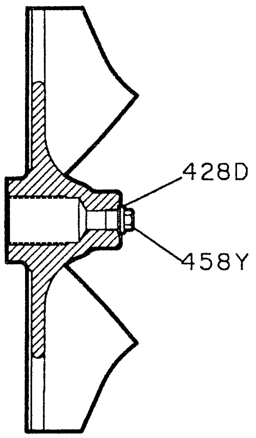


Fig. 151

5. Put shaft wrench and coupling key on shaft. When impeller (101) makes firm contact with sleeve (126), raise shaft wrench (counterclockwise, viewed from impeller end of shaft) off bench and slam it down (clockwise, viewed from impeller end of shaft). A few sharp raps will tighten impeller (101) properly (Fig. 152).

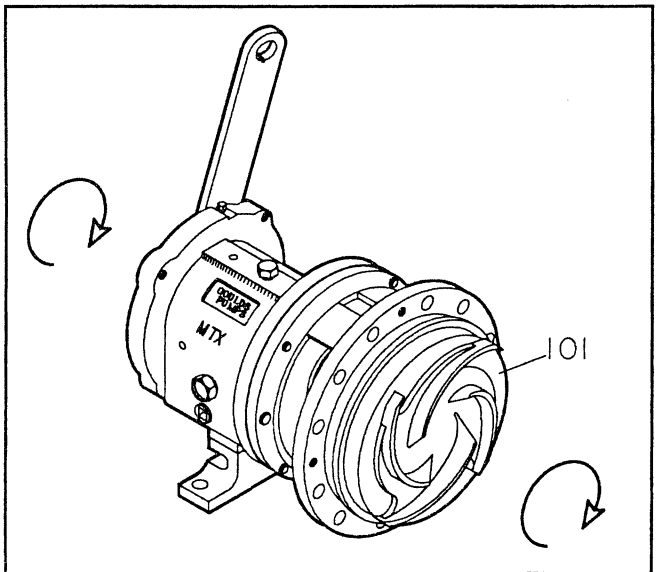


Fig. 152

6. Loosen clamp bolts (370C), and jacking bolts (370D). Measure gap between impeller (101) and seal chamber/stuffing box cover (184) with a feeler gauge. When 0.030 in. clearance is reached, tighten clamp bolts (370C), jacking bolts (370D), and locking nuts (423) (Fig. 153)

NOTE: This approximates the impeller position when set at 0.015 in. (.38 mm) from casing. Final impeller adjustment must be made after installation into casing.

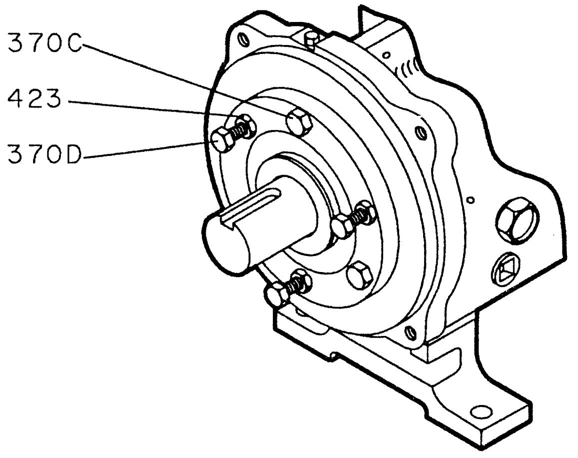


Fig. 153

7. Check impeller (101) runout. Check vane tip to vane tip. If total indicator reading is greater than 0.005 in. (.13 mm), determine cause and correct before proceeding (Fig. 154).

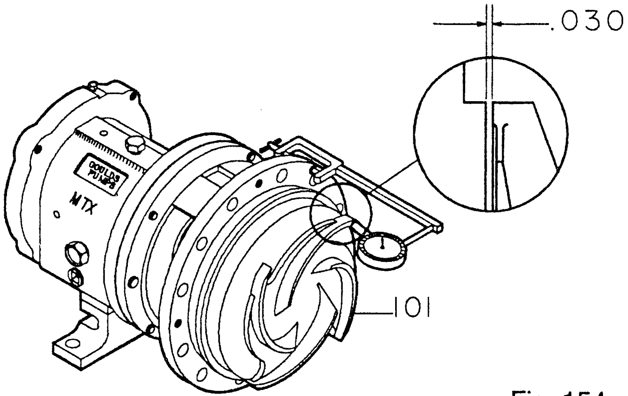


Fig. 154

NOTE: The face of the CV 3196 impeller is not machined. Checking the face runout on the CV 3196 impeller is not required.

8. Blue the shaft sleeve (126) or shaft (122) if no sleeve is used. Scribe a mark at gland gasket face of seal chamber/stuffing box cover (184). This will be the datum for installation of mechanical seal (Fig. 155).

NOTE: The mechanical seal reference dimension for the NM 3196 and the 3198 is based on the gland seat face of the backplate.

NOTE: If installing a cartridge mechanical seal, the shaft or sleeve does not need to be marked. The seal is self setting.

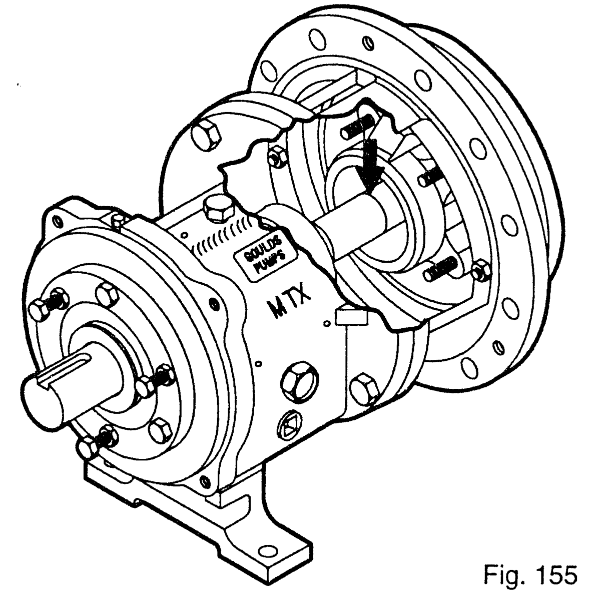


Fig. 155

9. Remove the impeller (101), and shaft sleeve (126) if used.

NOTE: Do not remove a Teflon® sleeve from a knurled 3198 shaft.

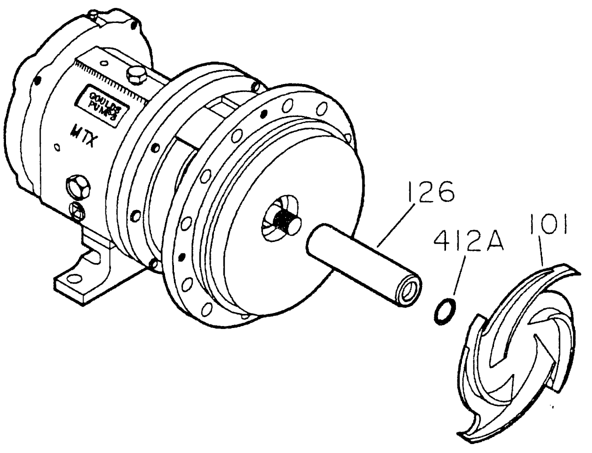


Fig. 156

10. Remove the seal chamber cover or the backplate (184).

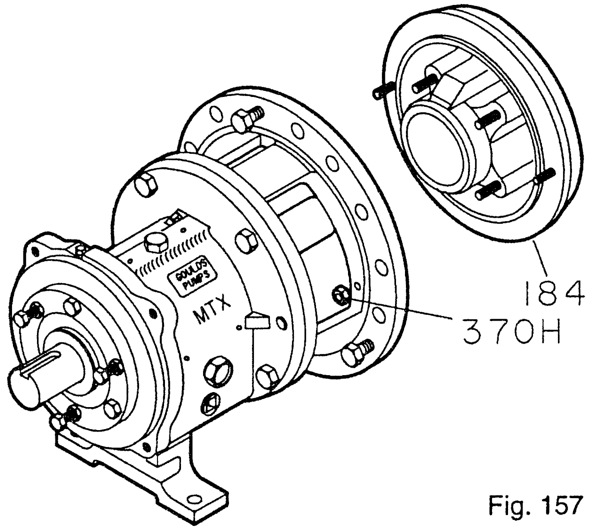


Fig. 157

For inside mounted seals:

11. Install stationary seat into gland (107) per seal manufacturer's instructions.

12. Slide gland (107) with stationary seat over shaft, up to adapter face (Fig. 158).

13. Install mechanical seal on shaft (122) or shaft sleeve (126) per seal manufacturer's instructions. Install shaft sleeve (126) if used (with seal).

NOTE: Anti-galling compound can be applied to the sleeve bore to aid in disassembly.

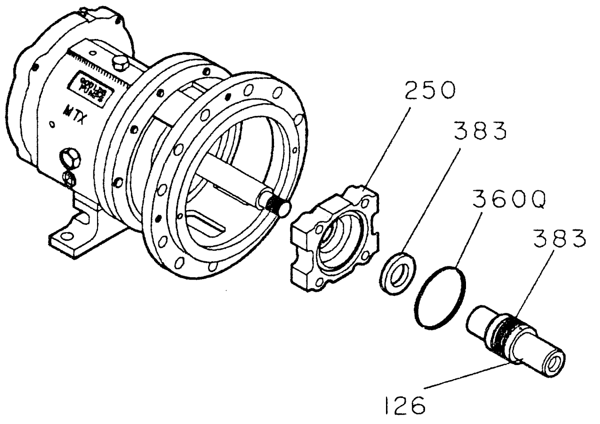


Fig. 158

14. Install seal chamber cover (184) with nuts (370H) (Fig. 159).

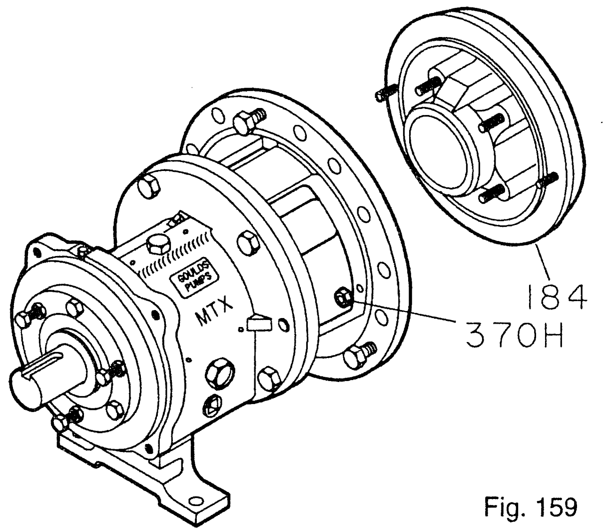


Fig. 159

⚠ WARNING

Wear a heavy set of work gloves when handling impeller (101) as sharp edges may cause physical injury.

15. Install impeller (101) with new O-ring (412A). Put shaft wrench and coupling key on shaft. When impeller (101) makes firm contact with sleeve (126), raise shaft wrench (counterclockwise when viewed from impeller end of shaft) off bench and slam it down (clockwise when viewed from impeller end of shaft). A few sharp raps will tighten impeller (101) properly (Fig. 160).

NOTE: Be sure to use a properly balanced impeller.

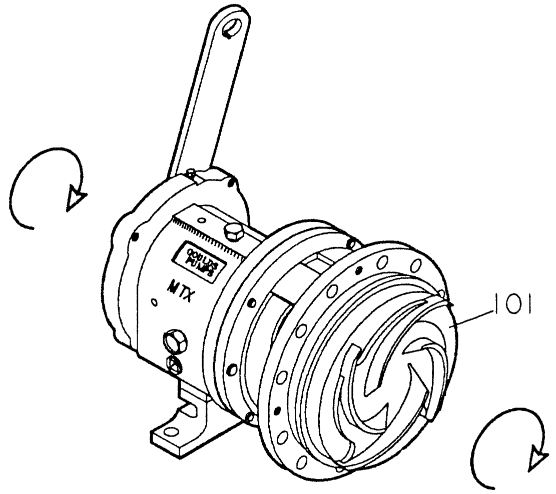


Fig. 160

16. Install gland (107) with nuts (355) (Fig. 161).

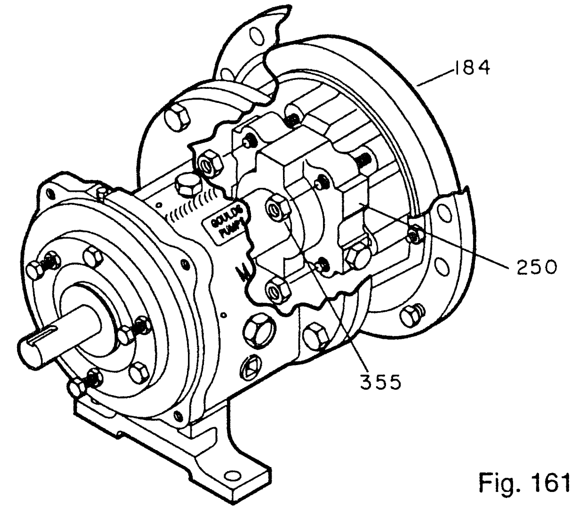


Fig. 161

For outside mounted seals:

11. Install the mechanical seal on the shaft (122) or sleeve, if used (126) per the seal manufacturer's instructions. Install the sleeve with the seal, if used.

12. Slide gland and then stationary seat, with gaskets, on the shaft or sleeve (Fig. 162).

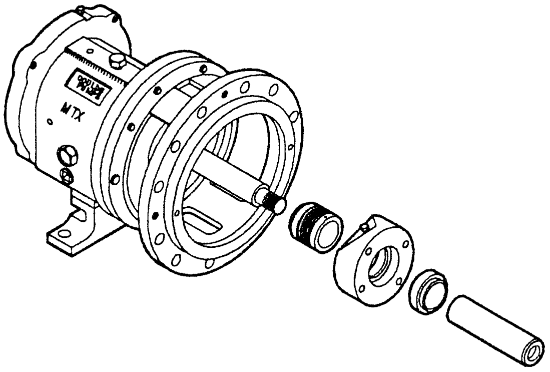


Fig. 162

13. Install the seal chamber or backplate (184) with hex nuts (370H). Be sure that the gland studs line up with the holes in the gland (Fig. 163).

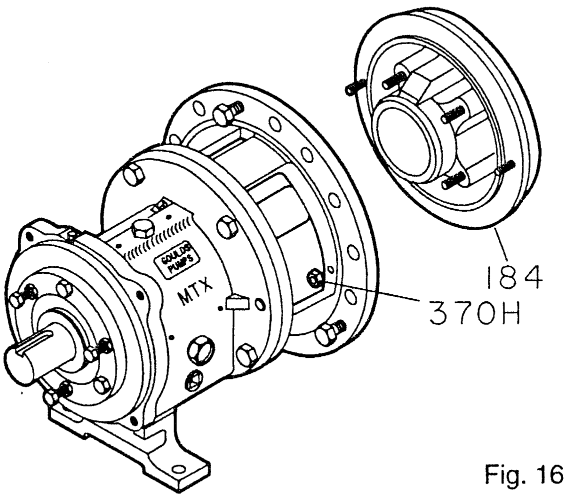


Fig. 163

14. Install the impeller (101) with a new o-ring (412A). Put the shaft wrench and coupling key on the shaft. When the impeller makes firm contact with the sleeve, raise the shaft wrench (counterclockwise when viewed from the impeller end of the shaft) off the bench and slam it down (clockwise when viewed from the impeller end of the shaft). A few sharp raps will tighten the impeller properly (Fig. 164).

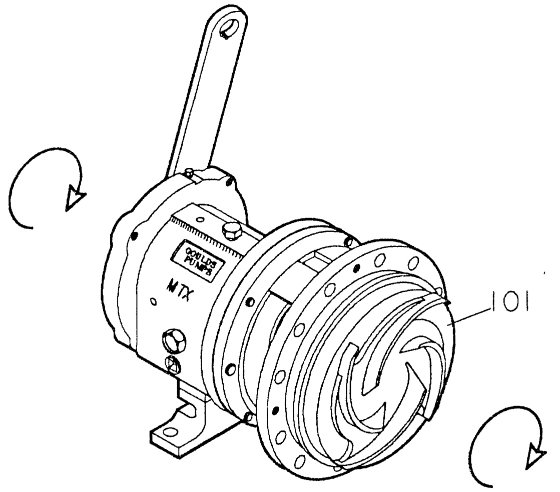


Fig. 164

NOTE: Be sure to use a properly balanced impeller.

15. Install the gland (107) with hex nuts (355).

Pumps With Packing:

1. Install stuffing box cover (184) with nuts (370H) (Fig 165).

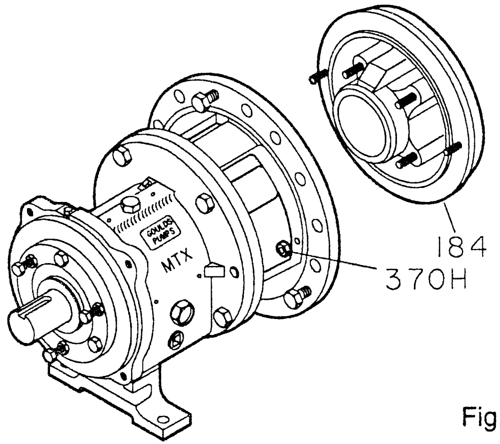


Fig. 165

2. Check stuffing box cover run-out. Rotate indicator through 360 degrees. Total indicator reading greater than 0.005 in. (.13 mm) indicates a problem (Fig. 16

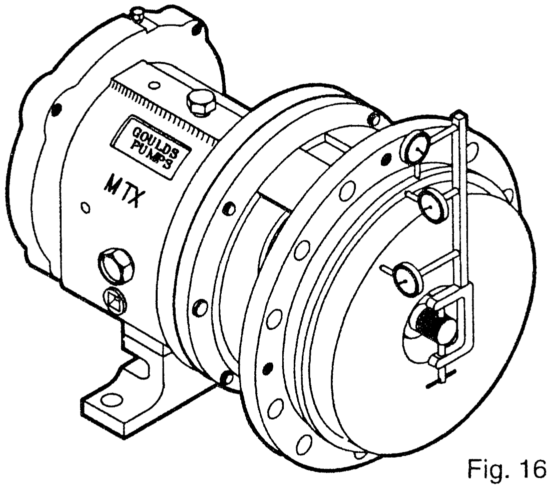


Fig. 166

3. Install shaft sleeve (126) (Fig. 167).

NOTE: Anti-galling compound can be applied to the sleeve bore to aid in disassembly.

NOTE: Make sure sleeve is fully seated.

⚠ WARNING

Wear a heavy set of work gloves when handlin impeller (101) as sharp edges may cause injury.

4. Install impeller (101) with O-ring (412A). Put shaft wrench and coupling key on shaft. When impeller (101) makes firm contact with sleeve (126), raise shaft wrench (counterclockwise when viewed from impeller end of shaft) off bench and slam it down (clockwise when viewed from impeller end of shaft). A few sharp raps will tighten impeller properly (Fig. 168).

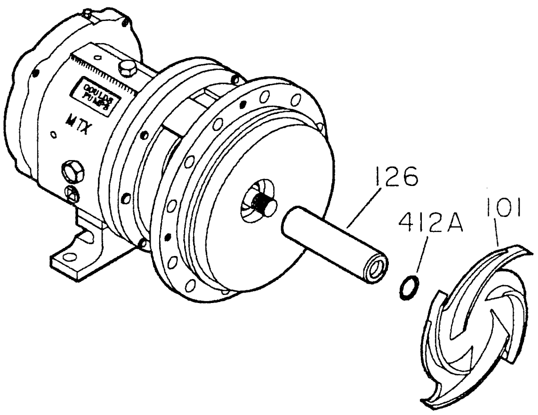


Fig. 167

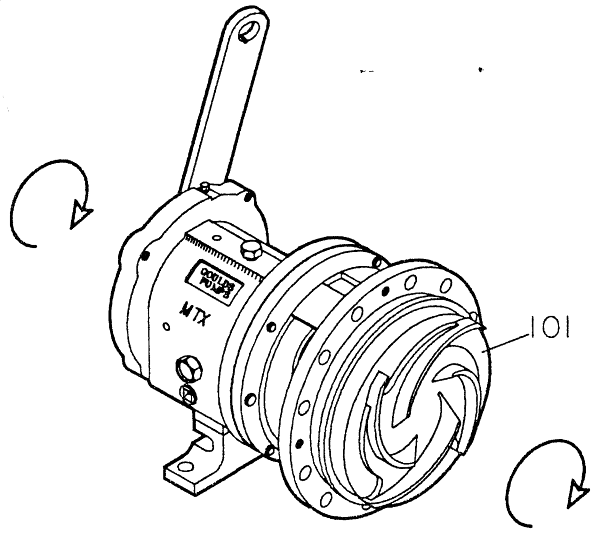


Fig. 168

5. Loosen clamp bolts (370C), and jacking bolts (370D) (Fig. 169). Measure gap between impeller (101) and seal chamber/stuffing box cover (184) with a feeler gauge. When 0.030 in. (.76 mm) clearance is reached, tighten clamp bolts (370C), jacking bolts (370D), and locking nuts (423) (Fig. 169).

NOTE: This approximates the impeller position when set at 0.015 in. (.38 mm) from casing.

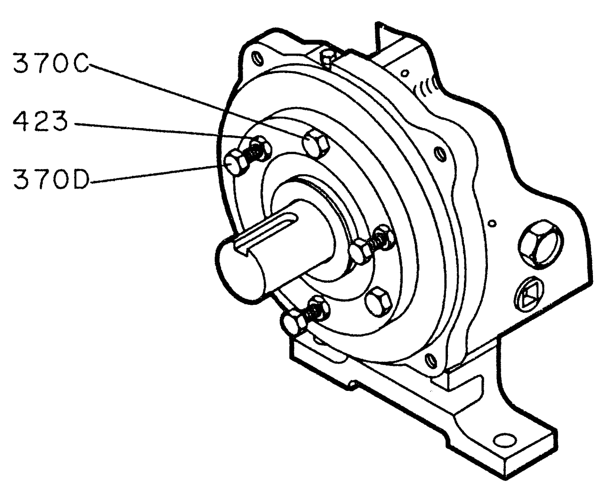


Fig. 169

6. Check impeller runout. Check vane tip to vane tip. Total indicator reading greater than 0.005 in. (.13 mm) indicates a problem (Fig. 170).

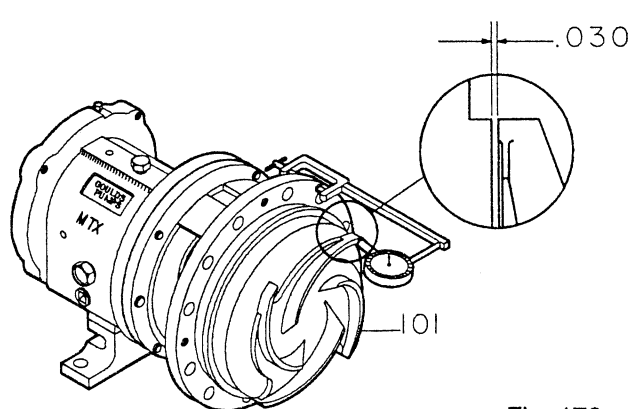


Fig. 170

NOTE: The face of the CV 3196 impeller is not machined. Checking the face runout on the CV 3196 impeller is not required.

7. Install packing and gland according to *Section 4, Operation.*

Pumps With Dynamic Seals:
(3196, CV 3196, LF 3196 only)

1. Place backplate (444) flat side down on the bench (Fig. 127).
2. Place repeller (262) in backplate (444), sleeve side up.
3. Place Teflon gasket (264) on backplate (444), lining up holes.
4. Place stuffing box cover (184) on backplate (444), lining up holes.
5. Install four (4) socket head cap screws (265), tighten securely.
6. Install new sealing element into gland.
7. Install gasket (360Q) and gland (107) on stuffing box cover (184). Install nuts (355).

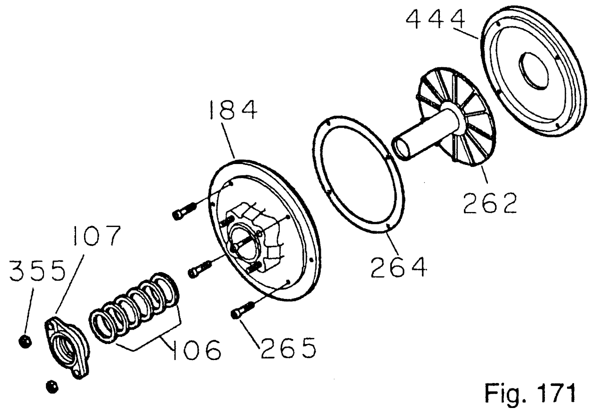


Fig. 171

8. Install dynamic seal assembly. Install nuts (370H) (Fig. 172).

NOTE: Anti-galling compound can be applied to the sleeve bore to aid in disassembly.

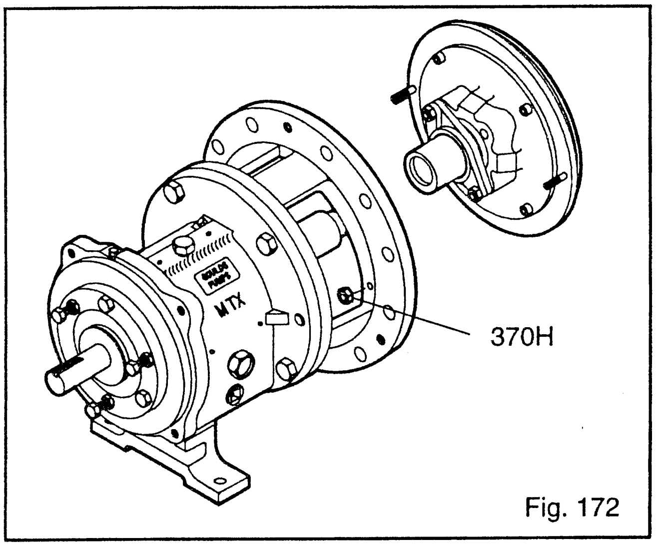


Fig. 172

9. Check stuffing box cover run-out. Rotate indicator through all 360 degrees. Total indicator reading greater than 0.005 in. indicates a problem (Fig. 173).

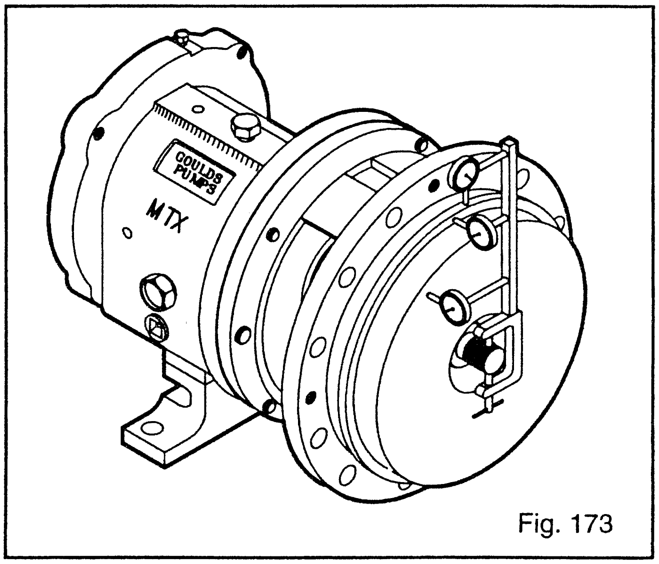


Fig. 173

ALL MODELS STX, MTX, LTX, XLT-X, X17

Reinstall Back Pull-Out Assembly

⚠ WARNING

Back pull-out assembly weighs more than 50 lbs. Do not handle unassisted as physical injury may occur.

1. Clean casing fit and install casing gasket (351) in place on seal chamber/stuffing box cover.
2. Loosen clamping bolts (370C) and jacking bolts (370D) on bearing housing (Fig. 174).

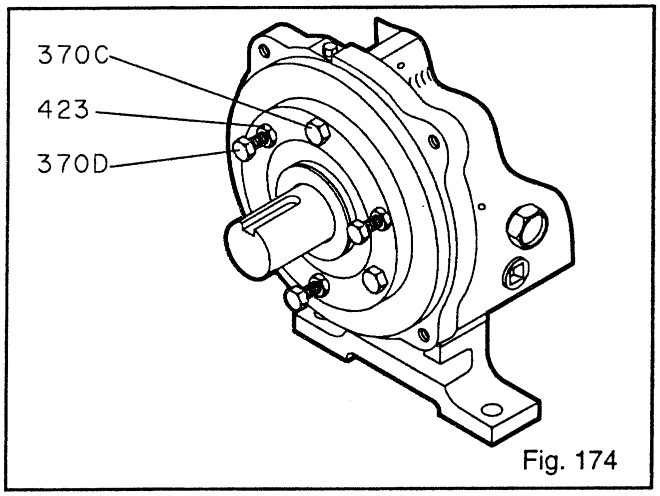


Fig. 174

3. Install back pull-out assembly in casing (Fig. 175, 176).

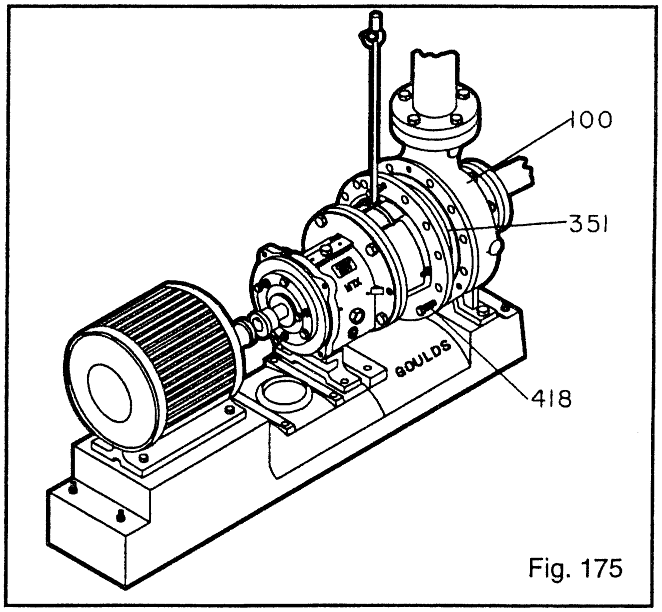


Fig. 175

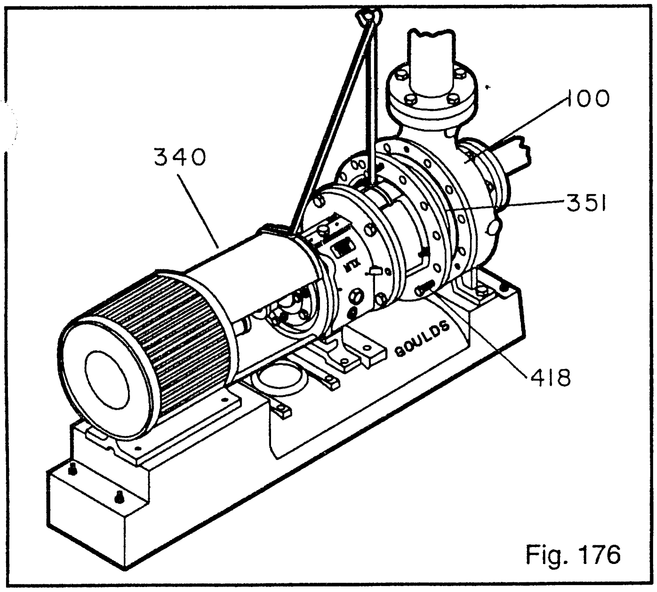


Fig. 176

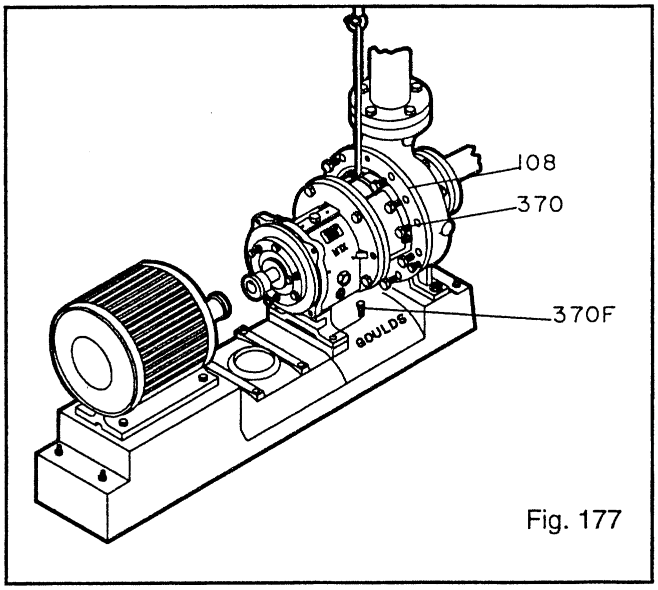


Fig. 177

4. Install casing bolts (370), finger tight. Casing bolts (370) may be coated with anti-galling compound to aid disassembly. Tighten the casing bolts per *Table 9* torque values. Install casing jack screws (418), snug tight (Fig. 177).

CAUTION

Do not overtighten casing jack screws (418).

5. Replace shims under frame foot and tighten frame foot to baseplate. To insure that the proper shim is used, a dial indicator should be mounted to measure distance between top of frame and baseplate. This distance should not change as frame foot bolting is tightened.
6. Check total travel of impeller in casing. With new parts, acceptable range is 0.030 in. (.76 mm). to 0.065 in. (1.65 mm). If outside this range, improper parts or installation or too much pipe strain is present. Determine cause and correct.
7. Adjust impeller clearance according to procedure outlined in the Preventive Maintenance Section.
8. Replace auxiliary piping at this time.
9. Fill pump with proper lubricant. Refer to *Section 5, Preventive Maintenance* for requirements.

NOTE: For reassembly of the C-Face adapter, see Appendix V.

POST ASSEMBLY CHECKS

After completion of these operations, check if it is possible to rotate shaft easily by hand. If all is proper, continue with pump start-up.

ASSEMBLY TROUBLESHOOTING

Symptom	Cause	Remedy
Excessive shaft end play.	Bearing internal clearance too great. Snap ring loose in bearing housing groove.	Replace bearings with correct type. Reseat.
Excessive shaft/sleeve runout.	Sleeve worn. Shaft bent.	Replace Replace.
Excessive bearing frame flange runout.	Shaft bent. Bearing frame flange distorted.	Replace Replace.
Excessive frame adapter runout.	Corrosion. Adapter to frame gasket not seated properly.	Replace. Reseat.
Excessive seal chamber/stuffing box cover runout.	Seal chamber/stuffing box cover not properly seated in frame adapter. Corrosion or wear.	Replace.
Excessive impeller vane tip runout.	Bent vane(s).	Replace impeller.

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PARTS LIST WITH MATERIALS

Item	Qty per Pump	Part Name	3196, CV 3196, 3796				
			All D.I.	D.I. w/ 316SS Impeller	All 316SS	All CD4MCu	All Alloy 2
100	1	Casing	1012	1012	1203	1216	1204
101	1	Impeller	1013	1203	1203	1216	1204
105	1	Lantern Ring	Teflon®				
106	1 Set	Stuffing Box Packing	Non-Asbestos Braid				
107	1	Gland—Packed Box	1203			1204	
108	1	Frame Adapter	1013				
109C	1 X	Outboard Bearing End Cover	1001				
112A	1	Outboard Bearing	Double row angular contact (duplex pair for LTX)				
113	2	Plug—Grease Relief	2210				
113B	1	Plug—Oil Fill	2210				
122	1	Shaft—Less Sleeve	▲	2229			2230
122	1	Shaft—With Sleeve	2238				
126	1	Shaft Sleeve	2229				2230
134	1	Bearing Housing	1001				
136	1	Bearing Locknut	Steel				
168A	1	Radial Bearing	Single Row Ball				
184	1	Seal Chamber/Stuffing Box Cover	1012	1012	1203	1216	1204
193	2	Grease Fitting	Steel				
228	1	Bearing Frame	STX All Others - 1001				
236A	10	Cap Screw—Bearing Clamp Ring	2210				
241	1	Frame Foot	1001				
248	1	Oil Thrower	2210				
250	1	Gland—Mechanical Seal	Material Varies				
253B	1	Bearing Clamp Ring	2210				
319	1	Sight Glass	Glass/Steel				
332A	1	Outboard Labyrinth Seal w/O-rings	Carbon Filled Teflon® with Viton® O-rings				
333A	1	Inboard Labyrinth Seal w/O-rings	Carbon filled Teflon® with Viton® O-rings				
351	1	Casing Gasket	Aramid Fiber w/EPDM				
353	4	Gland Stud	2229				
355	4	Gland Stud Nut	2229				
358	1	Plug—Casing Drain	2210		2229	2230	
358Y	1 X	Plug, Impeller	2229			2230	
360C	1 X	Gasket—Thrust End Cover	Vellumoid				
360F	1	Gasket—Frame-to-Adapter	Vellumoid				
360Q	1	Gasket—Gland-to-Stuffing Box Cover	Material Varies				
361A	1	Retaining Ring	Steel				
370	★	Bolt—Adapter to Case	2210		2228		
370B	4	Bolt—Frame-to-Adapter	2210				
370C	✸	Clamp Bolt—Bearing Housing	2210				
370D	✸	Jack Bolt—Bearing Housing	2210				
370E	2	Bolt—Frame Foot to Frame	2210				
370H	2	Stud—Stuffing Box Cover-to-Adapter	2228				
371C	6 X	Cap Screw-End Cover to Bearing Housing	2210				
382	1	Bearing Lockwasher	Steel				
383	1	Mechanical Seal	Material Varies				
400	1	Coupling Key	2210				
408A	1	Plug—Oil Drain	2210				
408H	4	Plug —Oil Mist Connection	2210				
408J	1	Plug—Oiler	2210				
408L	1	Plug—Oil Cooler Inlet	2210				
408M	1	Plug—Oil Cooler Outlet	2210				
408N	1	Plug—Sight Glass	2210				
418	3	Jack Bolt—Adapter-to-Case	2228				
423	3	Jam Nut—Bearing Housing Jack Bolt	2210				
423B	2	Hex Nut—Stuffing Box Cover to Adapter	2228				
428	1	Gasket, Plug	Teflon®				
458Y	1 X	Plug, Impeller	2229			2230	
469B	2	Dowel Pin—Frame-to-Adapter	Steel				
496	1	O-ring Bearing Housing	Buna N				
412A	1	O-ring —Impeller	Teflon®				
497F	1	O-ring—Outboard Labyrinth Rotor	Viton®				
497G	1	O-ring—Outboard Labyrinth Stator	Viton®				
497H	1	O-ring—Inboard Labyrinth Rotor	Viton®				
497J	1	O-ring—Inboard Labyrinth Stator	Viton®				
503	1 #	Adapter Ring	1013				
529	1	Lockwasher—Frame Foot-to-Bearing Frame	Steel				

✸ 3 for STX MTX, LTX, 4 for XLT-X, X17	★ Qty 4 for 6" STX 8 for 8" STX 8 for 8" MTX 16 for 13" MTX, LTX, XLT-X, 24 for 15" XLT-X 12 for X17	▲ 2229 for Mech Seals, 2237 all other	X XLT - X& X17 only Qty # STX Only

3196, CV 3196, 3796						NM 3196	3198
All 317SS	All Monel	All Nickel	All HastC	All Hast B	Al Titanium	Vinylester	DI/ Teflon®
1209	1119	1601	1215	1217	1220	6929	9639
1209	1119	1601	1215	1217	1220	6929	6944
						—	—
						—	—
1209	1119	1601	1215	1217	1220	—	—
2232	2450	2155	2248	2247	2156	2229	—
	2229						6947
2232	2450	2155	2248	2247	2156	2229	—
1209	1119	1601	1215	1217	1220	6929	9639
2232	2150	2155	2248	2247	2156	2229	2229
2232	2150	2155	2248	2247	2156	2229	2229
2232	2150	2156	2248	2247	2156	—	—
2232	2150	2156	2248	2247	2156	—	—
2232	2150	2155	2248	2247	2156	—	—

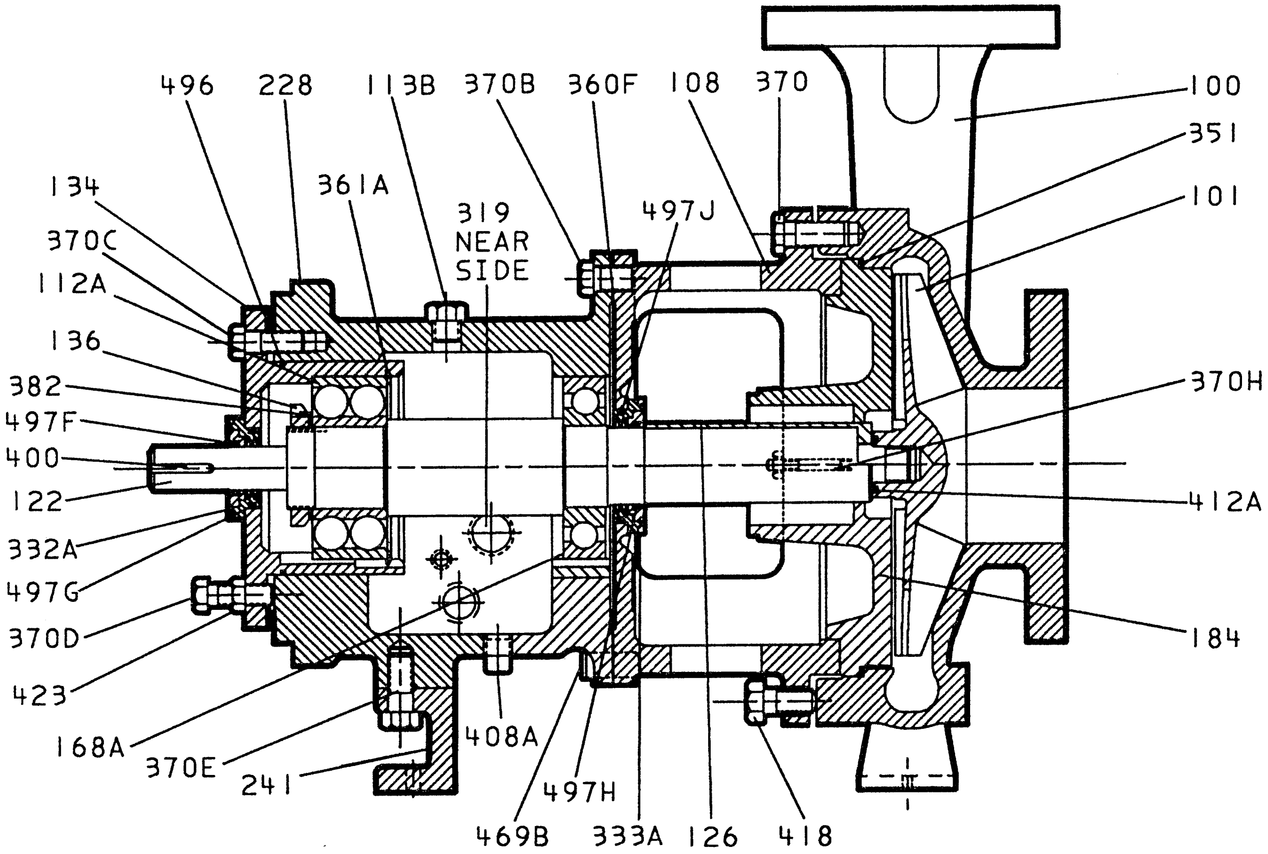
MATERIAL CROSS REFERENCE CHART

Material	Goulds Pumps Material Code	ASTM	DIN	ISO	JIS
Cast Iron	1001	A48 CLASS 20			
Ductile Iron	1012	A395 Gr60-40-18			
Ductile Iron	1013	A536 Gr60-42-10			
CD4MCu	1041	A744 CD4MCU			
Monel	1119	A494 GrM-35-1			
316SS	1203	A744 CF-8M	1.4408		G5121 (SC514)
Alloy 20	1204	A744CN-7M	1.4500		
317SS	1209	A744CG-8M	1.4448		
Hastelloy C	1215	A494 CW-6M			
CD4MCu	1216	A744CD4MCU	9.4460		
Hastelloy B	1217	A494 N-7M			
Titanium	1220	B367 GrC-3			
Nickel	1601	A494 GrCZ100			
Monel	2150	B164 UNS N04400			
Nickel	2155	B160 UNS N02200			
Titanium	2156	B348 Gr2			
Carbon Steel	2210	A108Gr1211			
304SS	2228	A276 Type 304			
316SS	2229	A276 Type 316			
Alloy 20	2230	B473 (N08020)			
317SS	2232	A276			
4150 Steel	2237	A322Gr4150			
4140 Steel	2238	A434Gr4140			
Alloy B-2	2247	B335 (N10665)			
Alloy C-276	2248	B574 (N10276)			
GMP-2000	6929	N/A			
PFA Lined Steel	6944	N/A			
PFA Lined 316SS	6947	N/A			
PFA Lined Ductile Iron	9639	N/A			

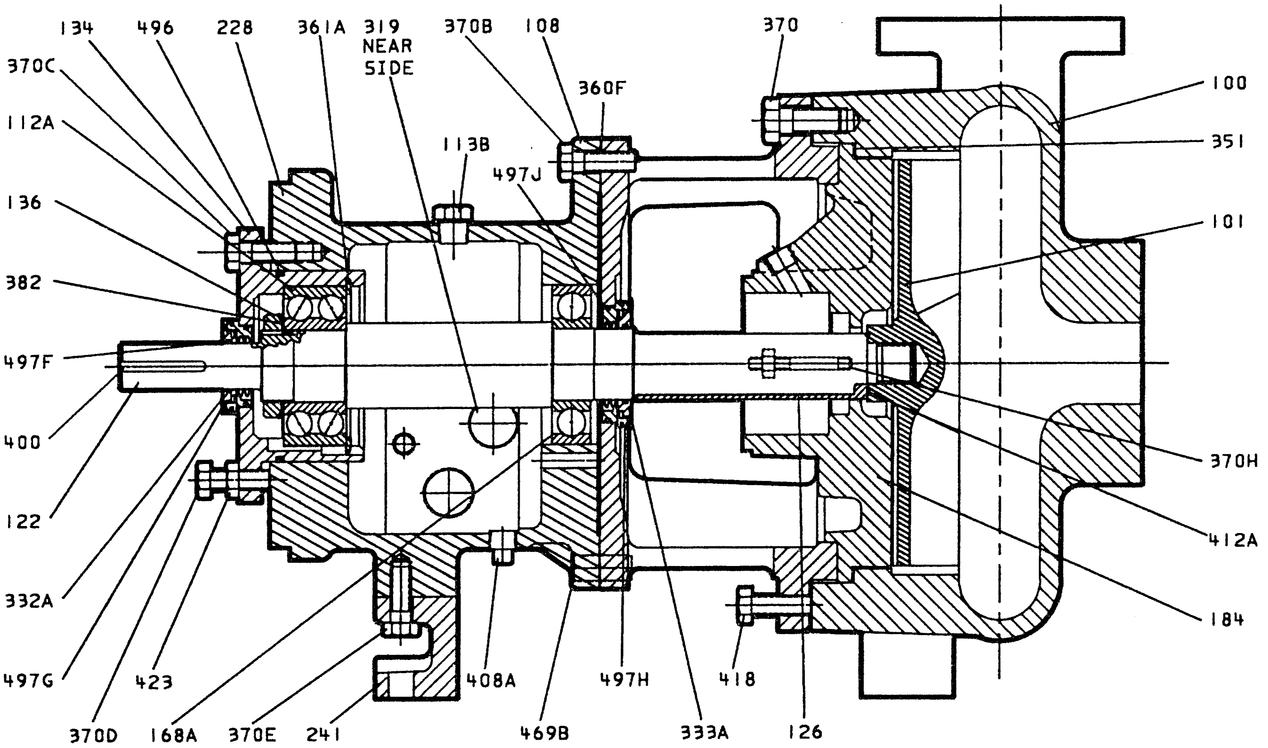
Fasteners/Plugs

Material	Goulds Pumps Material Code	ASTM
Carbon Steel	2210	A307Gr.B.
Stainless Steel	2228	F593Gr1
316 Stainless Steel	2229	F593Gr2

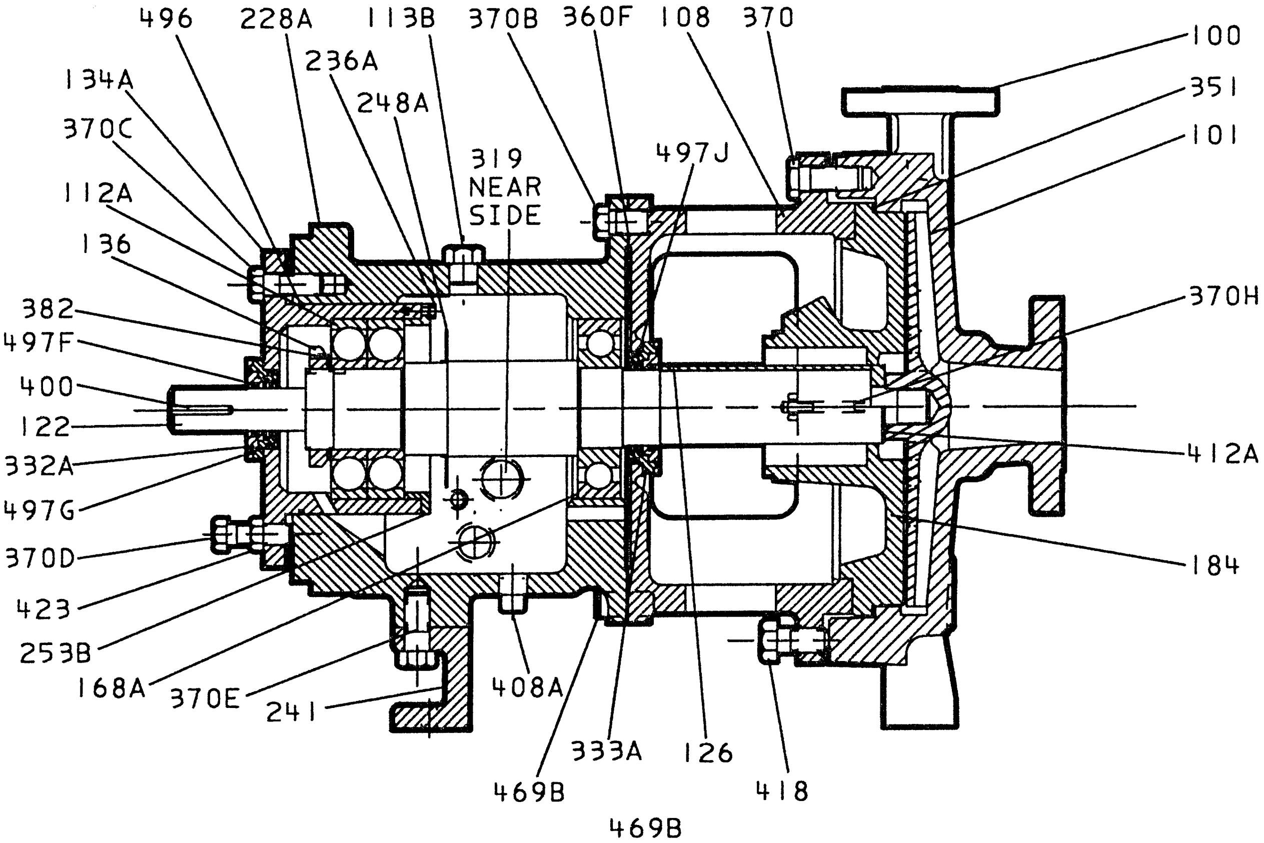
Model 3196 Cross Sectional



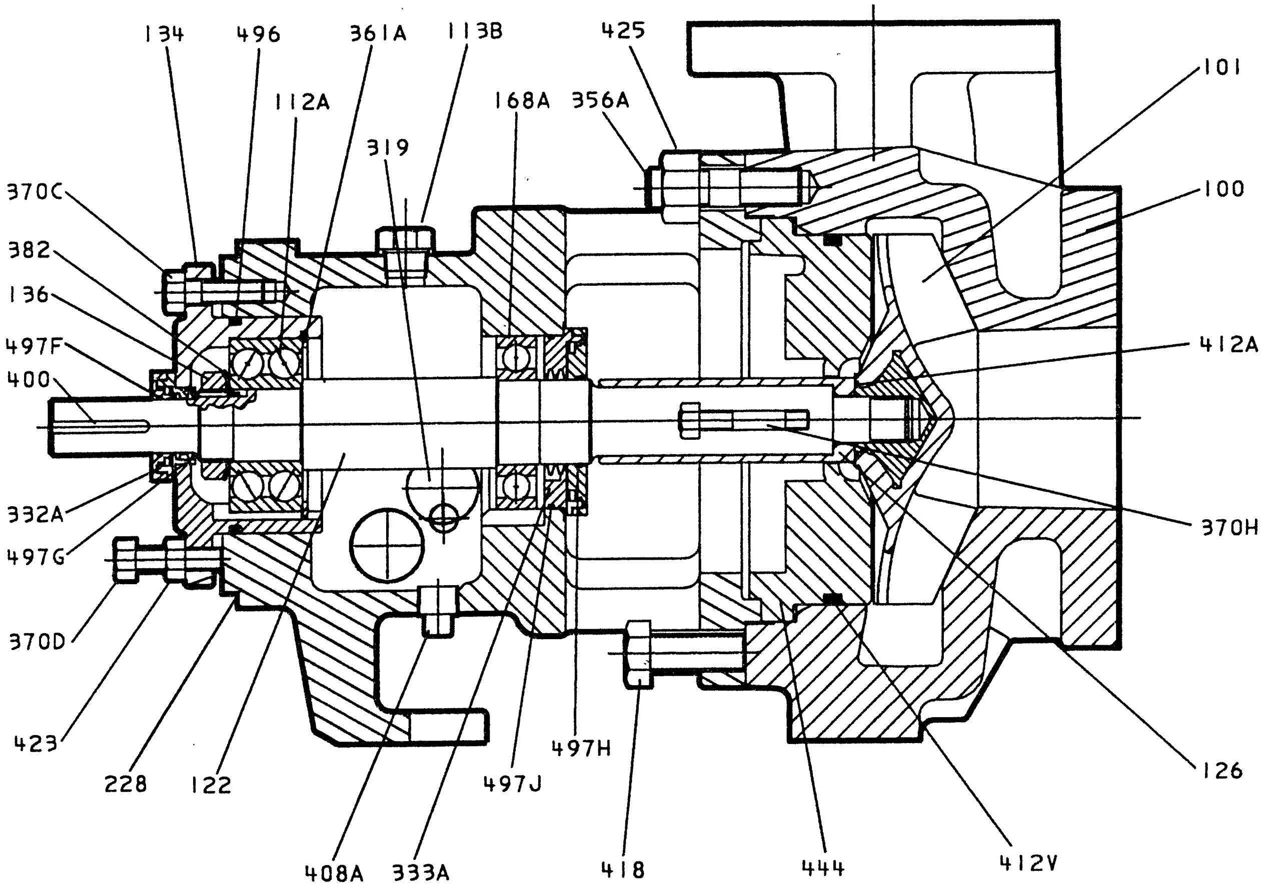
Model CV 3196 Cross Sectional



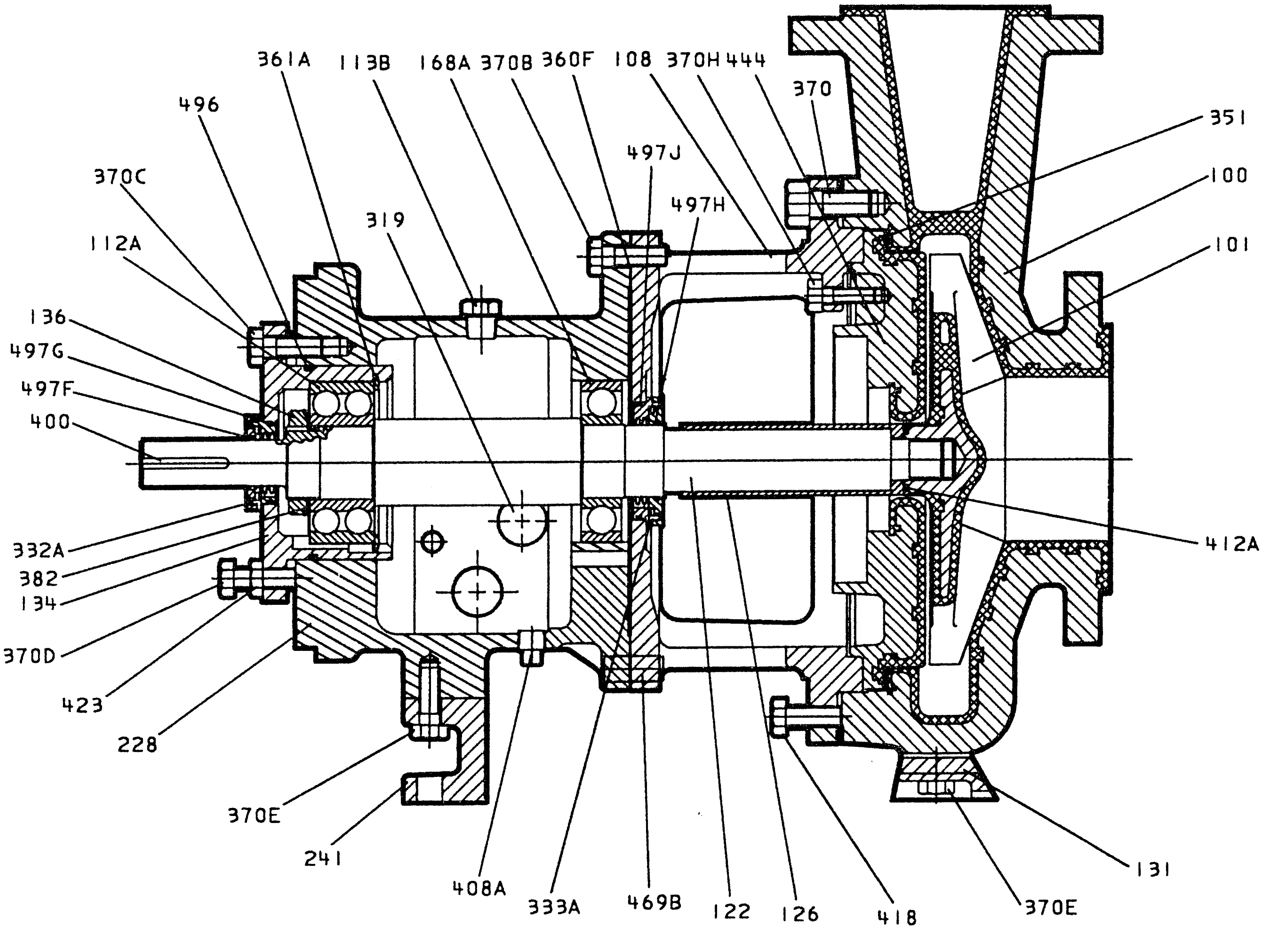
Model LF 3196 Cross Sectional



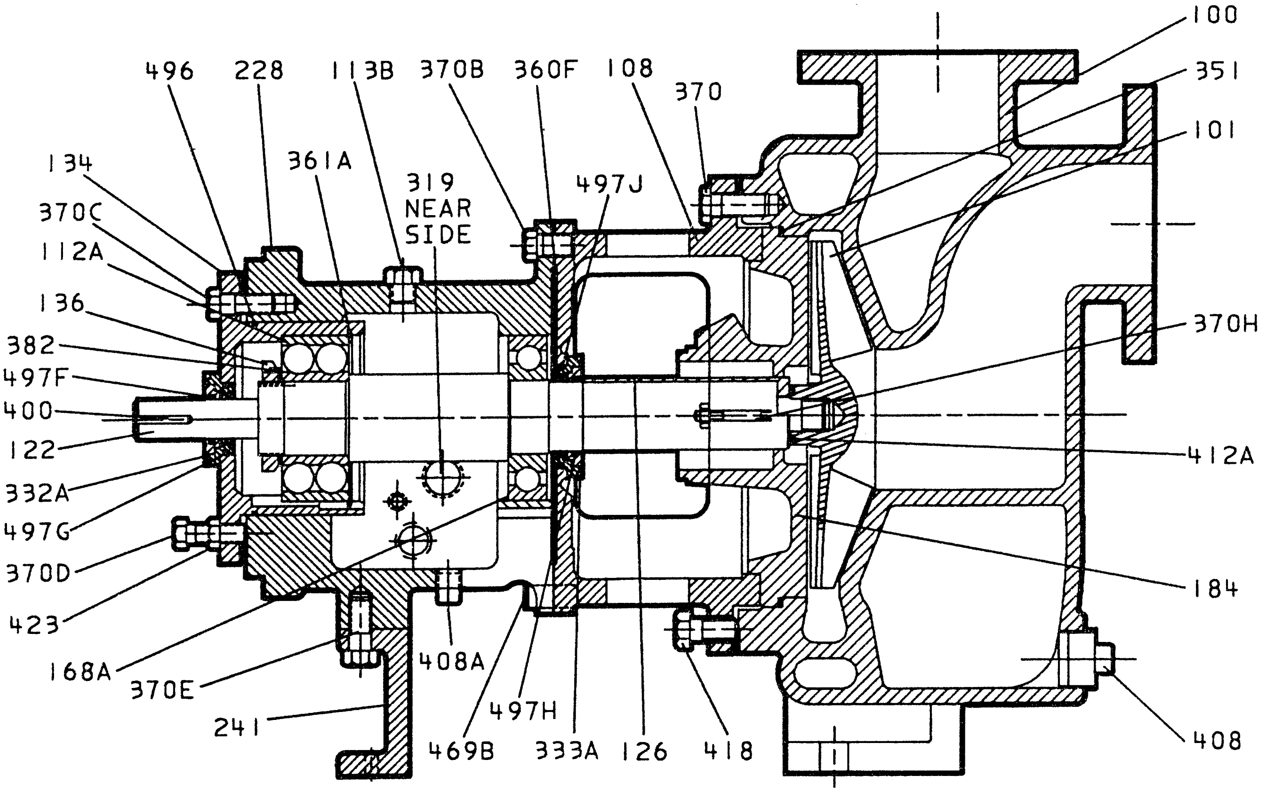
Model NM 3196 Cross Sectional



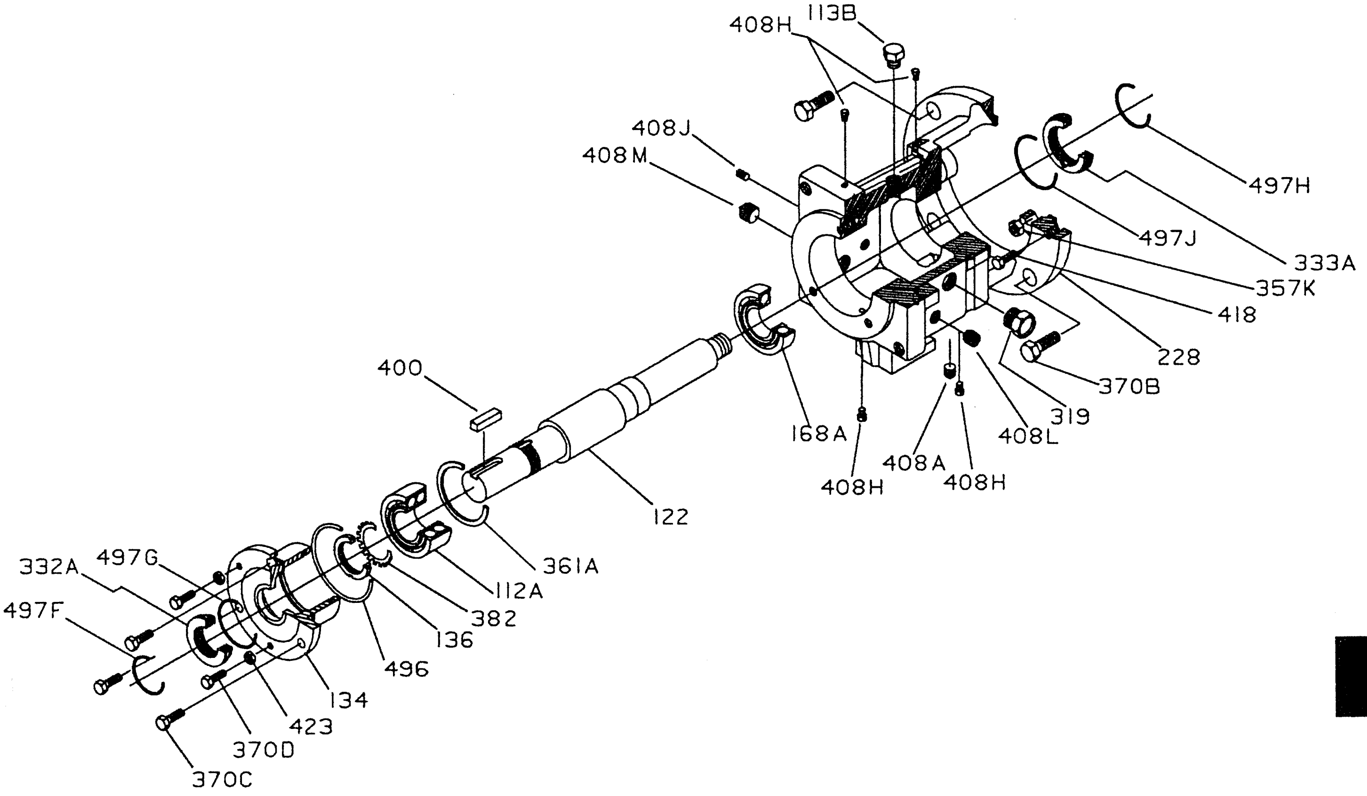
Model 3198 Cross Sectional



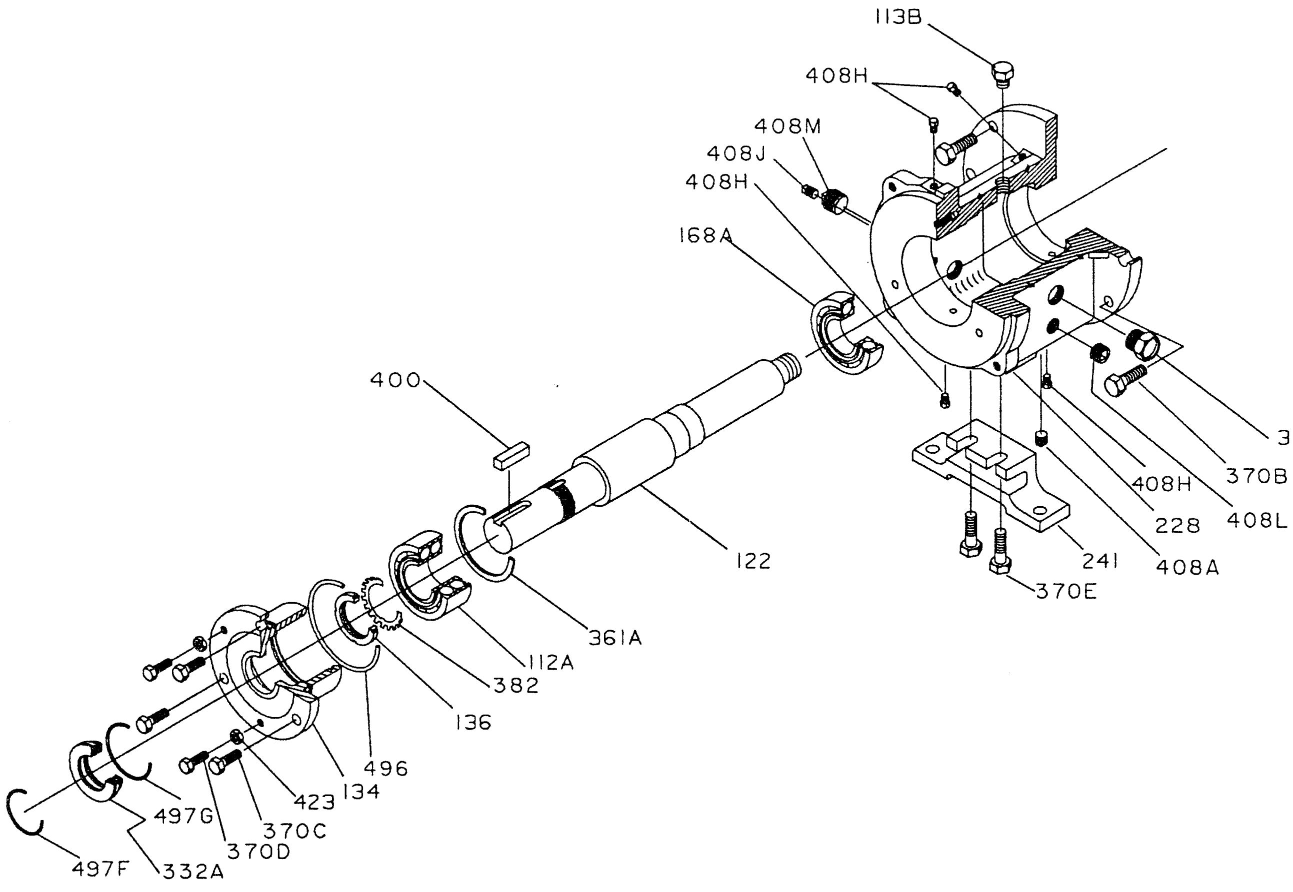
Model 3796 Cross Sectional



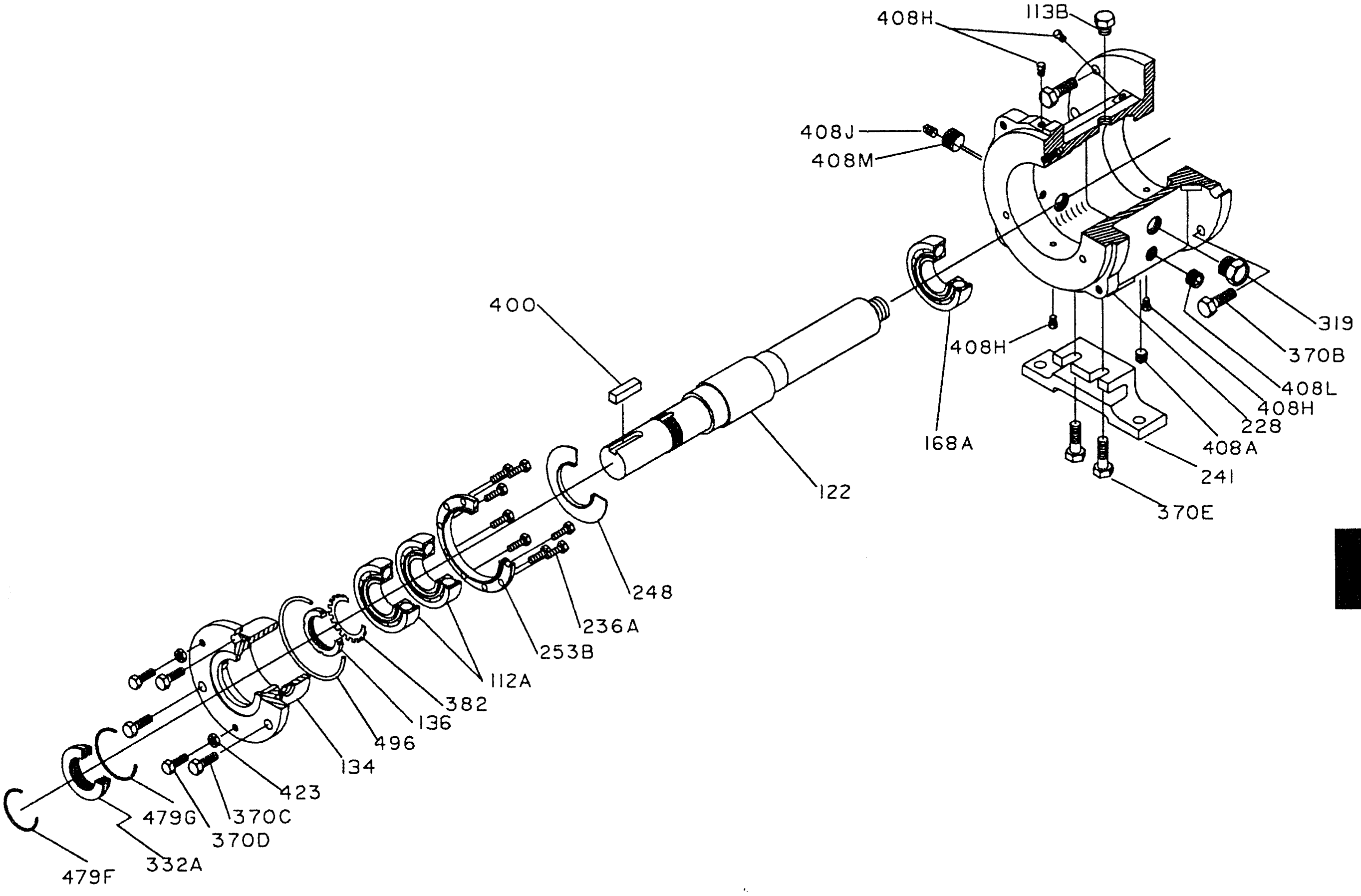
STX Power End



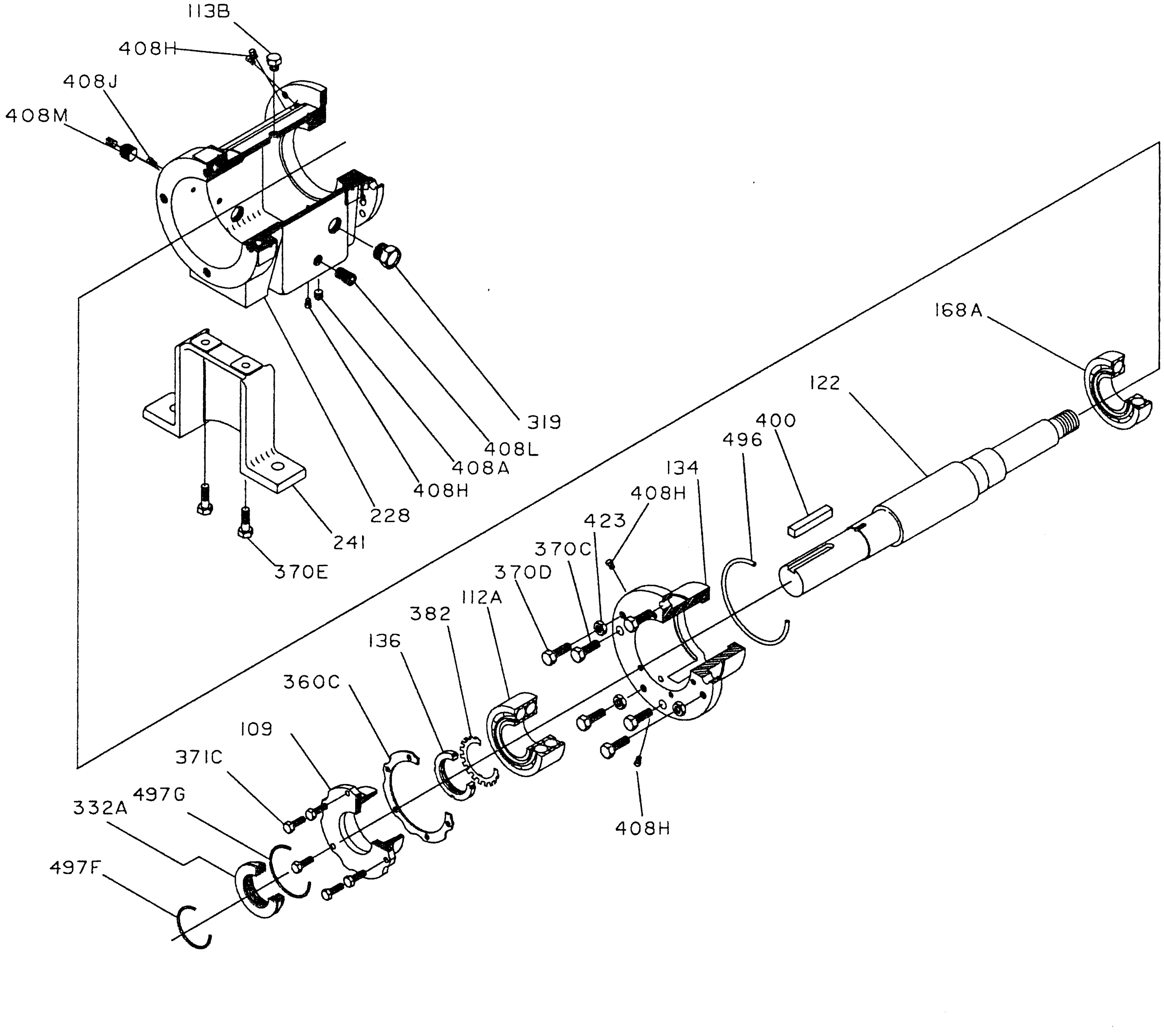
MTX Power End



LTX Power End



XLT-X Power End



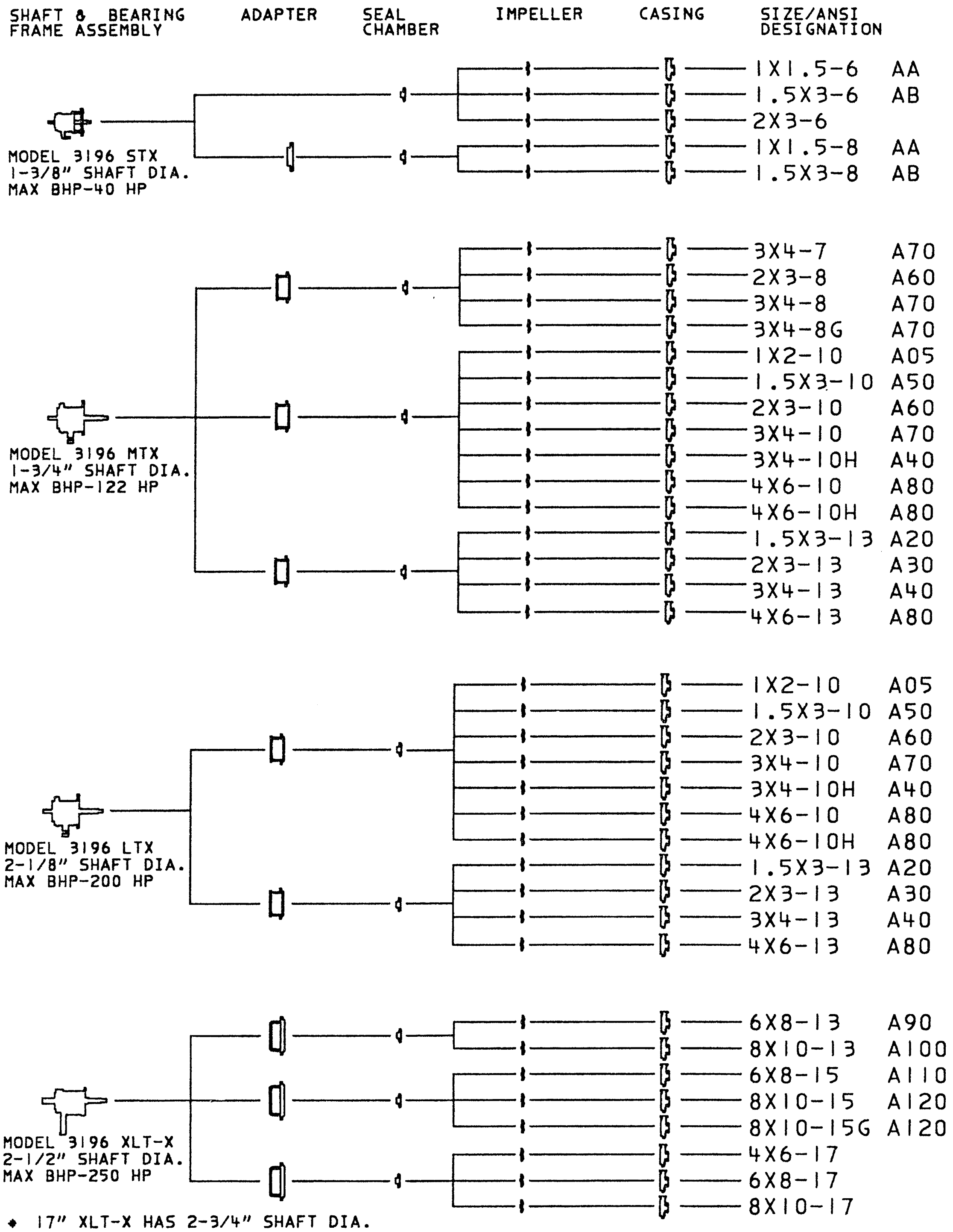
SPARE PARTS

When ordering spare parts, always state Goulds Serial No. and indicate part name and item number from relevant sectional drawing. It is imperative for service reliability to have a sufficient stock of readily available spares.

RECOMMENDED SPARE PARTS

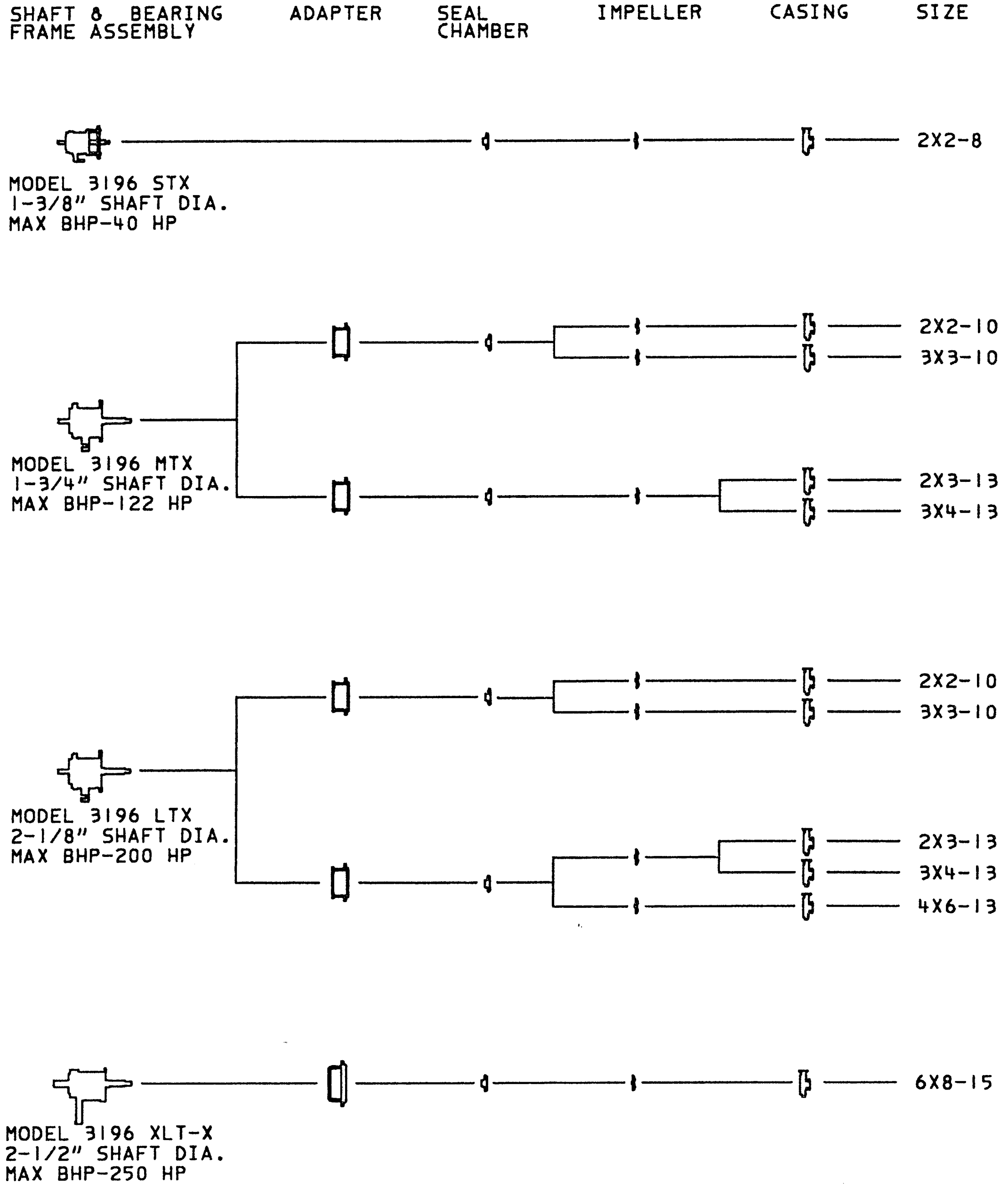
- Impeller (101)
  Shaft (122A)
- Shaft Sleeve (126)
- Outboard Bearing (112A)
- Inboard Bearing (168A)
- Casing Gasket (351)
- Frame-to-Adapter Gasket (360D)
- Bearing Housing Retaining Ring (361A)
- Bearing Lockwasher (382)
- Bearing Locknut (136)
- Impeller O-Ring (412A)
- Bearing Housing O-Ring (496)
- Outboard Labyrinth Seal Rotary O-Ring (497F)
- Outboard Labyrinth Seal Stationary O-Ring (497G)
- Inboard Labyrinth Seal Rotary O-Ring (497H)
- Inboard Labyrinth Seal Stationary O-Ring (497J)
- Lantern Ring Half (105) (Packed Stuffing Box)
- Stuffing Box Packing (106) (Packed Stuffing Box)
- Packing Gland (107) (Packed Stuffing Box)
- Impeller Gasket (428D) XLT-X & X17

3196
MODULAR/DIMENSIONAL INTERCHANGEABILITY



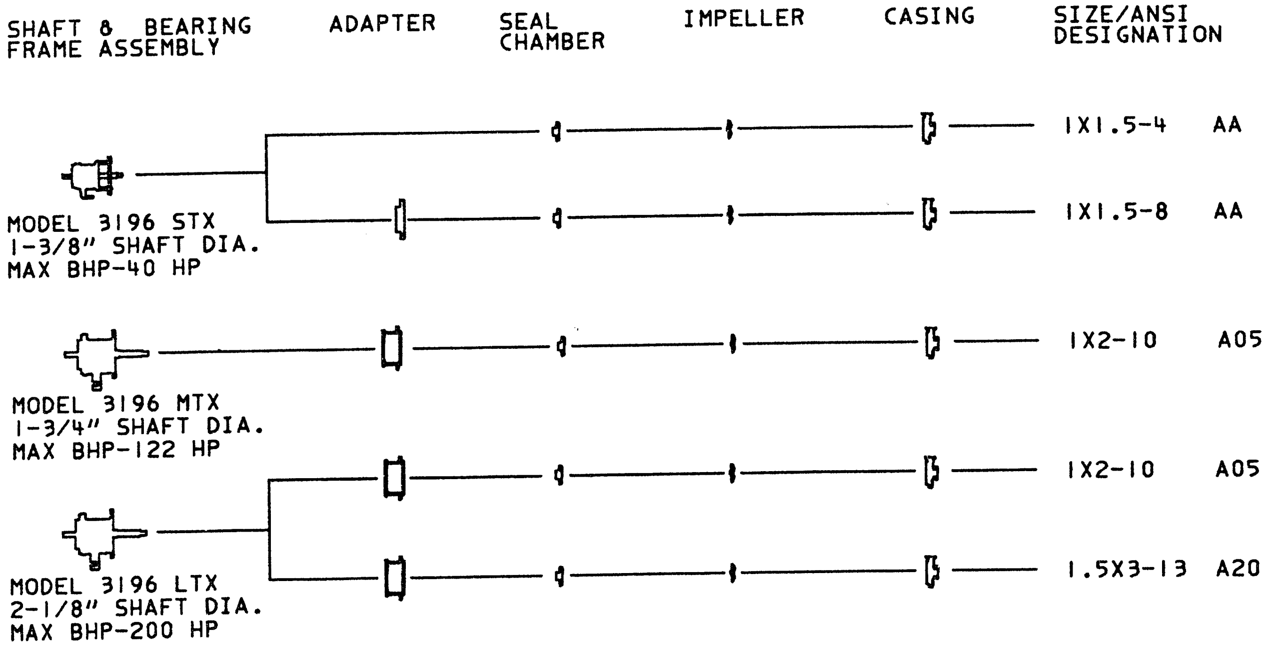
◆ 17" XLT-X HAS 2-3/4" SHAFT DIA.
MAX BHP-350 HP

CV 3196
MODULAR/DIMENSIONAL INTERCHANGEABILITY



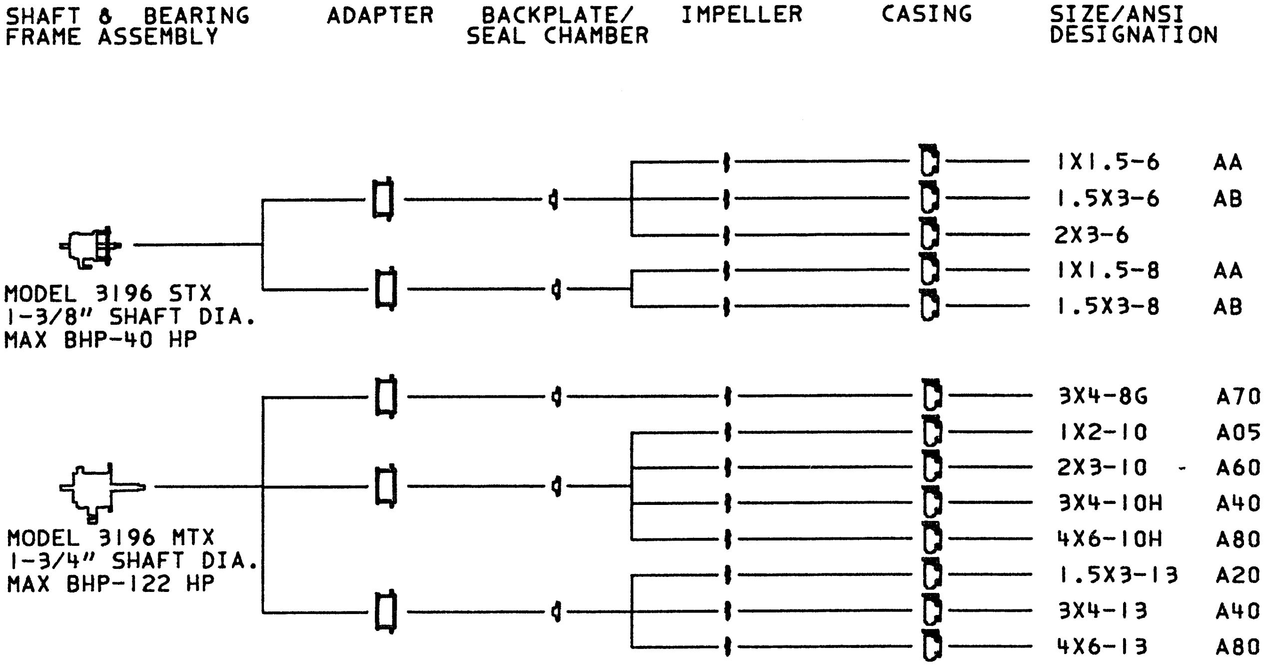
INTERCHANGEABILITY

LF 3196
MODULAR/DIMENSIONAL INTERCHANGEABILITY



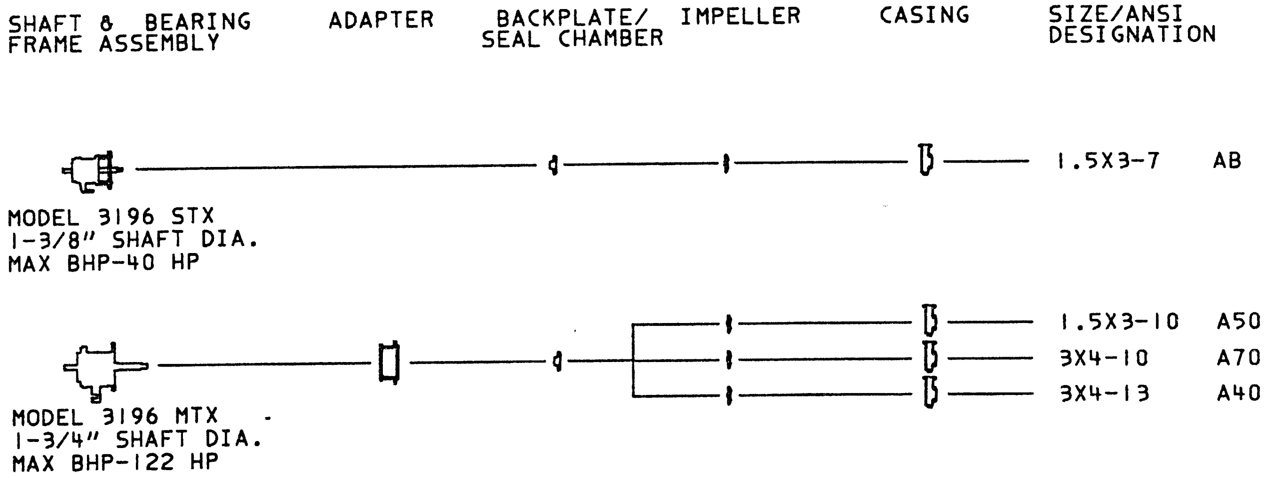
INTERCHANGEABILITY

NM 3196
MODULAR/DIMENSIONAL INTERCHANGEABILITY



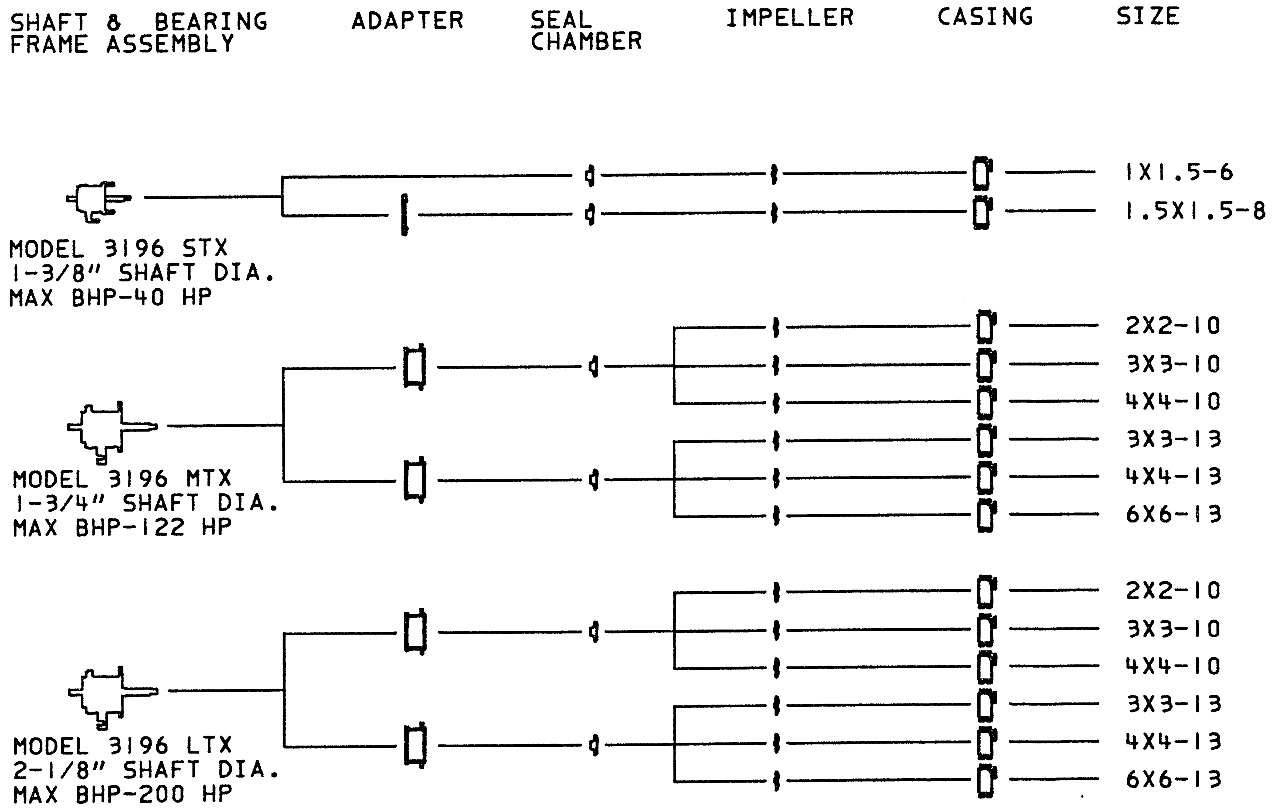
INTERCHANGEABILITY

3198
MODULAR/DIMENSIONAL INTERCHANGEABILITY



3796

MODULAR/DIMENSIONAL INTERCHANGEABILITY



APPENDIX I

Lubrication Conversion		
	Pumpage Temperature below 350°F (177°C)	Pumpage Temperature above 350°F (177°C)
NLGI Consistency	2	3
Mobil	Mobilux EP2	SCH32
Exxon	Unirex N2	Unirex N3
Sunoco	Multipurpose 2EP	
SKF	LGMT 2	LGMT 3

CAUTION

Never mix greases of different consistency (NLGI 1 or 3 with NLGI 2) or different thickener soaps (sodium or calcium with lithium). The consistency usually becomes softer and will not provide adequate lubrication to the bearings.

Pumpage temperatures above 350°F (177°C) should be lubricated by a high temperature grease. Mineral oil greases should have oxidation stabilizers and a consistency of NLGI 3.

NOTE: If it is necessary to change grease type or consistency, the bearings must be removed and the old grease removed.

FRAME LUBRICATION CONVERSION

Conversion from Flood Oil to Pure Oil Mist

There are several ways to apply oil mist. Goulds has designed X-Series Power Ends to accept a variety of oil mist configurations. The following instructions are written for two popular systems in use.

NOTE: Make sure that pipe threads are clean and apply thread sealant to plugs & fittings.

NOTE: The LTX requires that the bearing housing be changed when making the conversion from flood oil to oil mist lubrication. After the proper bearing housing has been installed follow the instructions as they apply to STX, MTX, XLT-X, X17.

A. Non-Vented Oil Mist System

1. Attach oil mist inlet to ¼" NPT connection at top, outboard end of frame (plugged with 408H allen head plug), and top, center of frame (plugged with 113A hex head plug).
2. Attach drain at bottom center of frame ⅜" NPT hole (plugged with 408A magnetic drain plug).
3. Follow oil mist generator manufacturer's instructions for oil mist volume adjustment, and operation.

B. Vented Oil Mist System

1. Attach oil mist inlet connection to ¼" NPT connections at outboard and inboard ends of frame.
2. Attach vent connection at ½" NPT hole located in top center of frame.
3. Attach drain connection at ⅜" NPT hole located at bottom center of frame (plugged with 408A magnetic drain plug).
4. Follow oil mist generator manufacturer's instructions for oil mist volume adjustment and operation.

CAUTION

Oil mist falls under Title III of the Clean Air Act and must be controlled or the user will be subject to penalty.

Conversion from Flood Oil to Regreaseable

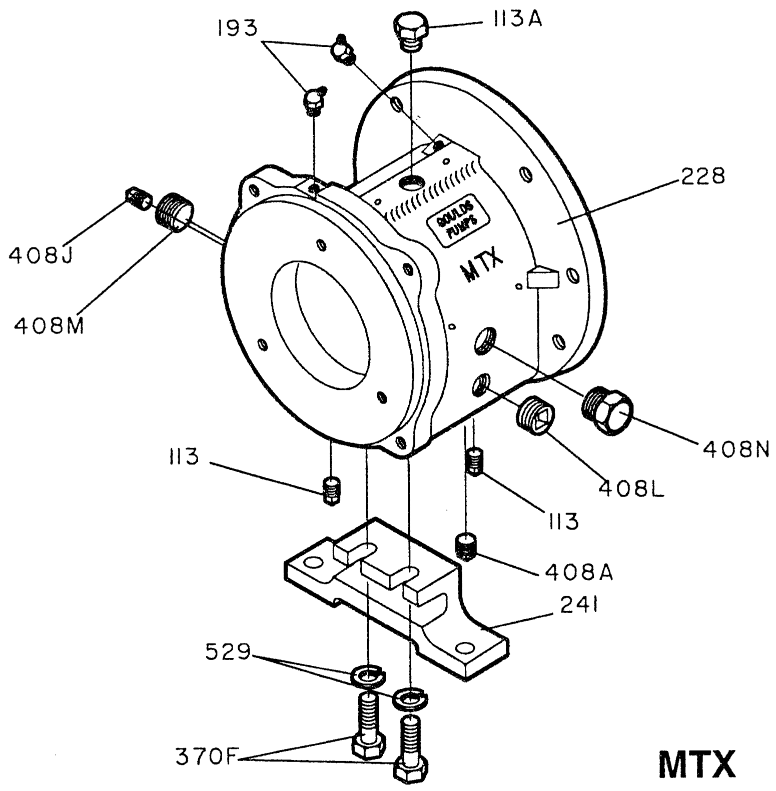
NOTE: Make sure that pipe threads are clean and apply thread sealant to plugs and fittings.

NOTE: LTX regreaseable power end requires a changeout of the bearing housing and bearing clamp ring. This housing provides a grease path to the bearings.

1. Plug inboard oil return in bearing frame.
   STX: Use epoxy, keep drilled hole clear.

   MTX, LTX, XLT-X, X17: Use set screw, install from adapter side, bottom in hole.
2. Plug outboard oil return slot in bearing housing, keep through holes clear. (does not apply to LTX)
3. Replace both bearings with single shield type. Refer to Assembly Section for installation guidelines.(Ref. Bearing Chart Table 11)
4. Install grease fittings at top, inboard and top, outboard ¼" NPT connections in bearing frame (plugged with 408H allen head plug).
5. Remove 2 (408H) Allen head plugs from bottom side of frame prior to greasing bearings. Reinstall hex head plugs (113) after bearings have been greased.

Item No.	Size	Description	Qty.
113	1/4"-18 NPT	Ext. Hex/square Head Pipe Plug	2
113A	1/2"-14 NPT	Ext. Hex/square Head Pipe Plug	1
193	1/4"-18 NPT	Grease Fitting	2
228	----	Bearing Frame	1
241	----	Frame Foot	1
370F	1/2"	Hex Cap Screw	2
408A	3/8"-18 NPT	Ext. Square Head Pipe Plug (magnetic)	1
408J	1/4"-18 NPT	Ext. Hex/square Head Pipe Plug	1
408L	1/2"-14 NPT	Square Coutersunk Headless Pipe Plug	1
408M	1" 11-1/2" NPT	Square Coutersunk Headless Pipe Plug	1
319	1" 11-1/2" NPT	Sight Window	1
529	1/2"	Light Helical Spring Lock Washer	2



MTX
Grease Lube

APPENDIX II

Installation Instructions for Goulds ANSI B15.1 Coupling Guards

⚠ WARNING

Before assembly or disassembly of the coupling guard is performed the motor must be de-energized, the motor controller/starter put in a locked-out position and a caution tag placed at the starter indicating the disconnect. Replace coupling guard before resuming normal operation of the pump. Goulds Pumps assumes no liability for avoiding this practice.

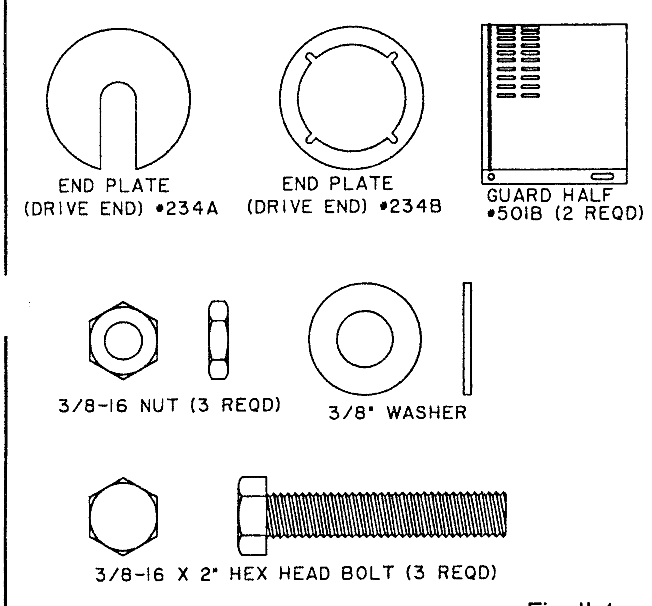


Fig. II-1

Simplicity of design allows complete assembly of the coupling guard, including the end plate (pump end), in about fifteen minutes. If the end plate is already in place, assembly can be accomplished in about five minutes.

Assembly:

NOTE: If end plate (pump end) is already installed, make any necessary coupling adjustments and then proceed to Step 2.

1. **STX, MTX, LTX** - Align end plate (pump end) to the Bearing Frame. (No impeller adjustment required.)

XLT-X Align the end plate (pump end) to the pump bearing housing so that the large slots on the end plate clear the bearing housing tap bolts and the small slots are aligned to the impeller adjusting bolts. Attach the end plate to the bearing housing using the jam nuts on the impeller adjusting bolts as shown in Fig. II-3.

After the end plate is attached to the bearing housing, the impeller clearance must be checked and reset as explained in *Section V - Preventive Maintenance*.

NOTE: Coupling adjustments should be completed before proceeding with coupling guard assembly.

STX, MTX, LTX

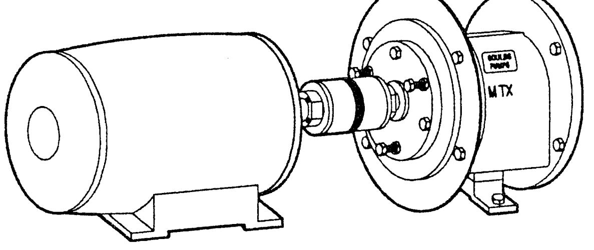
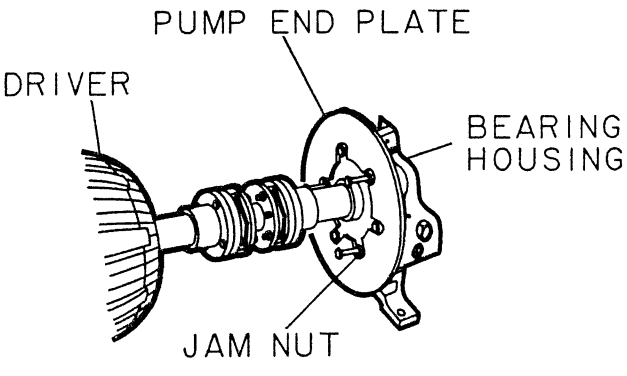


Fig. II-2



XLT-X

Fig. II-3

2. Spread bottom of coupling guard half (pump end) slightly and place over pump end plate as shown in Fig. II-4. The annular groove in the guard half is located around the end plate (Fig. II-5).

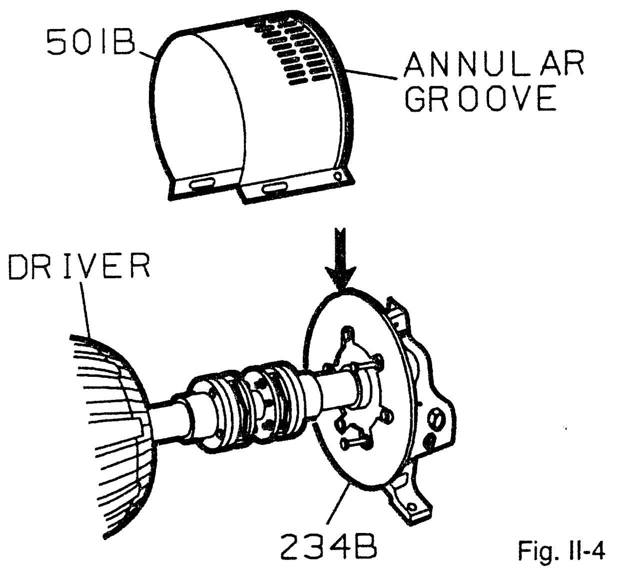


Fig. II-4

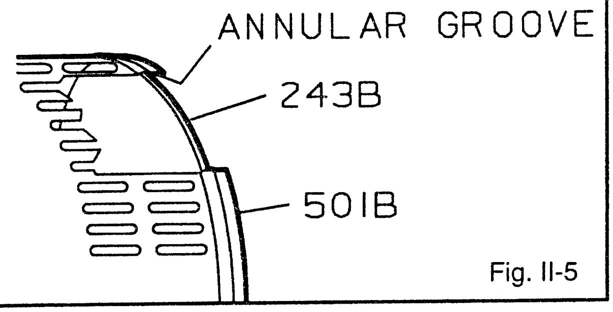


Fig. II-5

3. After the coupling guard half (pump end) is located around the end plate, secure it with a bolt, nut and two (2) washers through the round hole at the front end of the guard half as shown in Fig. II-6. Tighten securely (Fig. II-7).

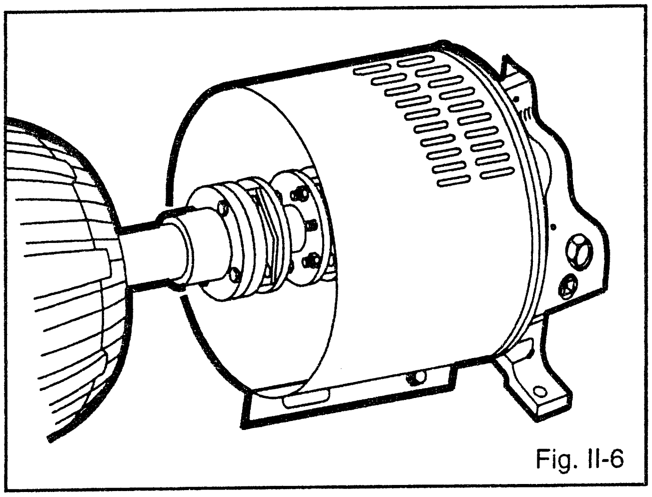


Fig. II-6

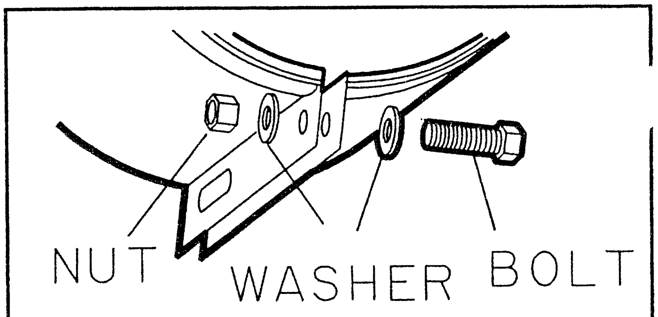


Fig. II-7

4. Spread bottom of coupling guard half (driver end) slightly and place over coupling guard half (pump end) so that annular groove in coupling guard half (driver end) faces the motor as shown in Fig. II-8.

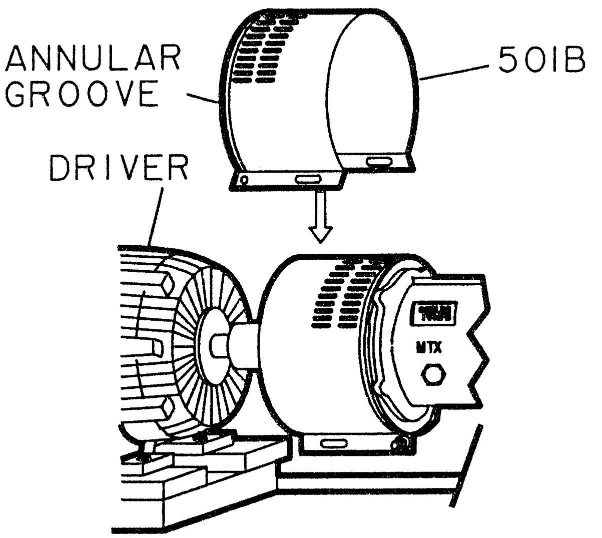


Fig. II-8

5. Place end plate (driver end) over motor shaft as shown in Fig. II-9. Locate the end plate in the annular groove at the rear of the coupling guard half (driver end) and secure with a bolt, nut, and two (2) washers through the round hole at the rear of the guard half. Finger tighten only.

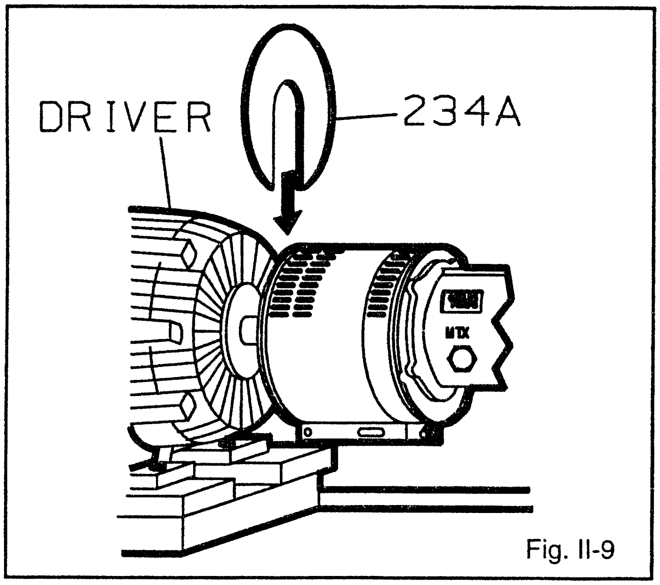


Fig. II-9

6. Adjust length of coupling guard to completely cover shafts and coupling as shown in Fig. II-10 by sliding coupling guard half (driver end) towards motor. After adjusting guard length, secure with bolt, nut and two (2) washers through the slotted holes at the center of the guard and tighten. Check all nuts on the guard assembly for tightness.

⚠ WARNING

Before assembly or disassembly of the coupling guard is performed, the motor must be de-energized, the motor controller/starter put in a locked-out position and a caution tag placed at the starter indicating the disconnect. Replace coupling guard before resuming normal operation if the pump. Goulds Pumps assumes no liability for avoiding this practice.

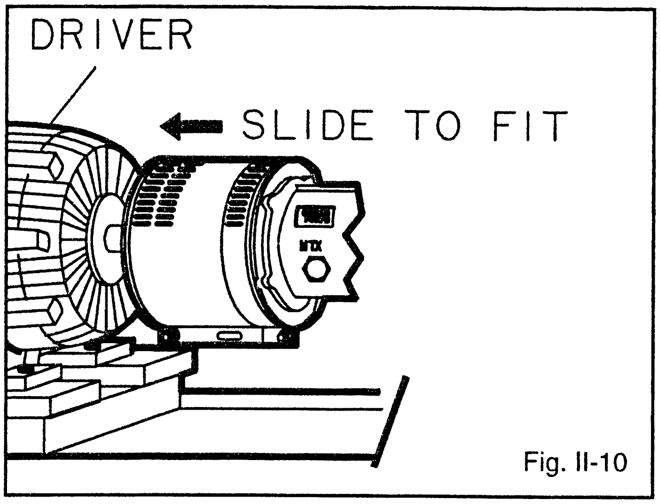


Fig. II-10

Disassembly

The coupling guard must be removed for certain maintenance and adjustments to the pump, such as adjustment of the coupling, impeller clearance adjustment, etc. The coupling guard should be replaced after maintenance is completed.

DO NOT resume normal pump operation with the coupling guard removed.

NOTE: Refer to illustrations for assembly in reverse order.

1. Remove nut, bolt, and washers from center slotted hole in the coupling guard. Slide motor end coupling guard half towards pump. Fig. II-10.
2. Remove nut, bolt, and washers from coupling guard half (driver end), and remove end plate. Fig. II-9.
3. Spread bottom of coupling guard half slightly and lift off. Fig. II-8.
4. Remove remaining nut, bolt, and washers from coupling guard half (pump end). Spread bottom of coupling guard half slightly and lift off. Fig. II-4.

This completes disassembly of the coupling guard.

NOTE: It is not necessary to remove the end plate (pump end) from the pump bearing housing. The bearing housing tap bolts are accessible without removing the end plate in case maintenance of internal pump parts is necessary. Before removing the pump bearing housing, refer to Section 6 - Disassembly & Reassembly.

APPENDIX III

Alignment

SET UP

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

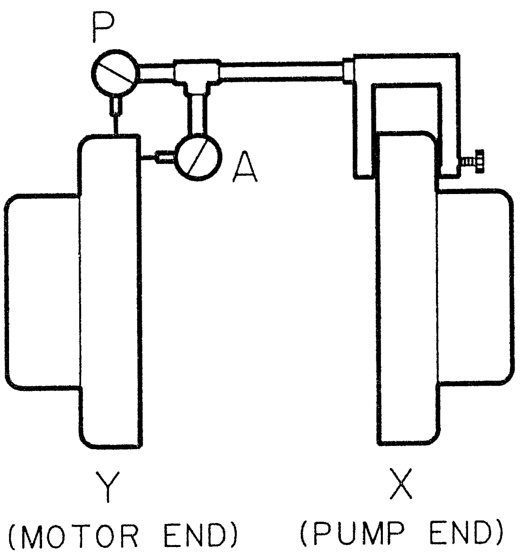


Fig. III-1

MEASUREMENT

1. To ensure accuracy of indicator readings, always rotate both coupling halves together so indicators contact the same point on coupling half Y. This will eliminate any measurement problems due to runout on coupling half Y.
2. Take indicator measurements with driver feet hold-down bolts tightened. Loosen hold down bolts prior to making alignment corrections.
3. Take care not to damage indicators when moving driver during alignment corrections.

ANGULAR ALIGNMENT

A unit is in angular alignment when indicator A (Angular indicator) does not vary by more that .002 in. (.05 mm) as measured at four points 90° apart.

Vertical Correction (Top-to-Bottom)

1. Zero indicator A at top dead center (12 o'clock) of coupling half Y.
2. Rotate indicators 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), (Fig. III-2).

   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).

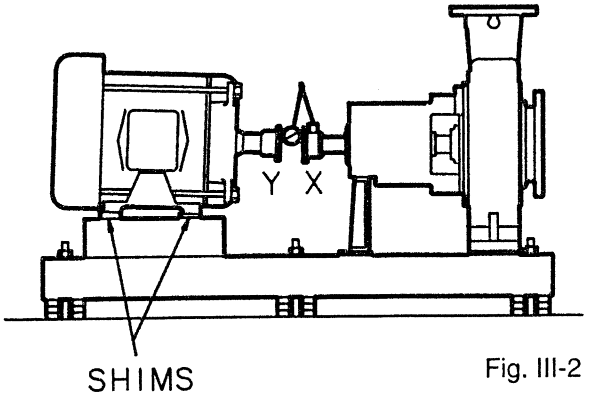


Fig. III-2

4. Repeat steps 1-3 until indicator A reads .002 in (.05 mm) or less.

Horizontal Correction (Side-to-Side)

1. Zero indicator A on left side of coupling half Y, 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** - 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.

3. **Positive Reading** - The coupling halves are closer together on the right side than the left. Correct by either sliding the shaft end of the driver to the right or the other end to the left (Fig. III-3).

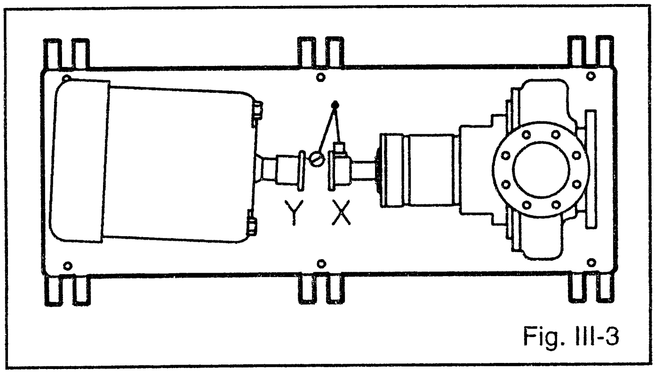


Fig. III-3

4. Repeat steps 1 through 3 until indicator A reads .002 in. (.05 mm) 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 indicator P (parallel indicator) does not vary by more than .002 in. (.05 mm) 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 indicator P at top dead center of coupling (12 o'clock) half Y (Fig. III-1).
2. Rotate indicator to bottom dead center (6 o'clock). Observe needle and record reading.
3. **Negative Reading** - Coupling half X is lower than coupling half Y. Correct by removing shims of thickness equal to half of the indicator reading under each driver foot.

   Positive Reading - Coupling half X is higher than coupling half Y. Correct by adding shims of thickness equal to half of the indicator reading from each driver foot (Fig. III-4).

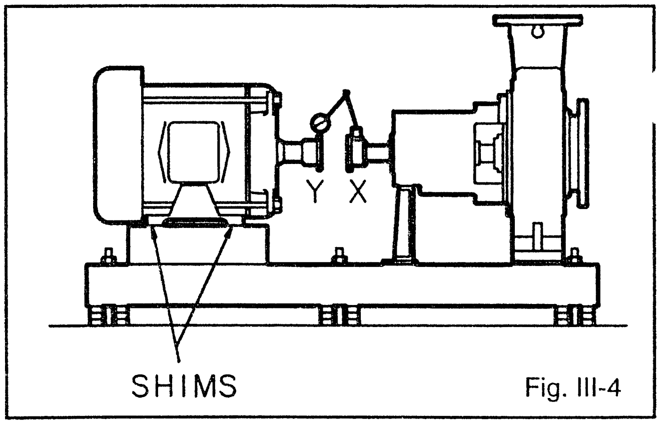


Fig. III-4

NOTE: Equal amounts of shims must be added to or removed from each driver foot. Otherwise the vertical angular alignment will be affected.

4. Repeat steps 1 through 3 until indicator P reads within .002 in. (.05 mm) or less when hot, or per Table 1 when cold.

Horizontal Correction (Side-to-Side)

1. Zero indicator P on the left side of coupling half Y, 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** - Coupling half Y is to the left of coupling half X. Correct by sliding driver evenly in the appropriate direction (Fig. III-5).

   Positive Reading - Coupling half Y is to the right of coupling half X. Correct by sliding driver evenly in the appropriate direction.

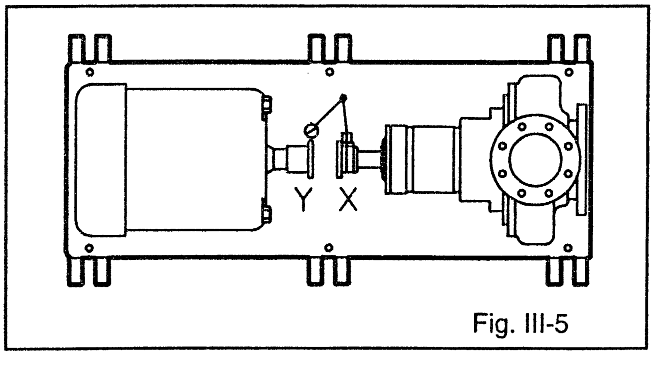


Fig. III-5

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

4. Repeat steps 1 through 3 until indicator P reads .002 in. (.05 mm) or less.
5. Re-check both horizontal and vertical readings to ensure adjustment of one did not disturb the other. Correct as necessary.

COMPLETE ALIGNMENT

A unit is in complete alignment when both indicators A angular) and P (parallel) do not vary by more than .002 in. (.05 mm) as measured at four points 90° apart.

Vertical Correction (Top-to-Bottom)

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

Horizontal Correction (Side-to-Side)

1. Zero indicators A and P on the left side of coupling half Y, 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 the needle, measure and record the 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.

APPENDIX IV

Labyrinth Seal Installation Instructions

Description of Operation

The labyrinth oil seal serves two functions. The first being to exclude environmental contamination from the power-end. This is accomplished with a series of tight clearance fits between the stationary and rotor. Any water that manages to enter the seal is eliminated from the seal through a drain slot located at the six o'clock position when installed.

On the oil side, a series of oil grooves are present to direct any oil between the shaft and stationary back into the oil sump through a drain slot at the six o'clock position.

Viton® O-rings are supplied as standard due to their chemical resistance. The stationary uses an O-ring to fit the labyrinth seal to the housing. The stator uses an O-ring to fit the labyrinth to the housing. The rotor uses an O-ring to seal along the shaft and to serve as the drive.

Installation Procedures

⚠ CAUTION

The Goulds labyrinth oil seal is a one piece assembly. Do not attempt to separate the rotor and stator. Damage to the seal may result.

1. Assemble the power end per the instructions in *Section 6 - Disassembly & Reassembly.*

⚠ CAUTION

The edges of the keyway can be sharp. Failure to cover the keyway may result in a cut O-ring and a damaged seal.

2. Wrap tape around the coupling end of the shaft to cover the keyway.

NOTE: The smooth surface of electrical tape provides an excellent surface to slide the rotor O-ring over.

3. Press the seal over the shaft into the thrust bearing housing or thrust bearing end cover by hand until the shoulder of the seal is seated against the housing/cover.

NOTE: An O-ring lubricant is not required, but can be used if desired. If used, be sure the lubricant is compatible with the O-ring material and plant standards.

4. ***For STX units:*** Press the seal over the shaft into the bearing frame by hand until the shoulder of the seal is seated against the frame.

   For all other units: Once the frame adapter is installed on the bearing frame, press the seal over the shaft into the frame adapter by hand until the shoulder of the seal is seated against the adapter.

NOTE: An O-ring lubricant is not required, but can be used if desired. If used, be sure the lubricant is compatible with the O-ring material and plant standards.

NOTE: During start-up when the parts of the labyrinth oil seal establish a voluntary running clearance, a small amount of wear is experienced as the parts are in contact. This wear produces a carbon filled Teflon® residue, visible at the outside diameter of the seal and at the drain slot. This is the result of the two surfaces being smoothed, similar to burnishing. A lubricant should not be applied between the faces at installation. Once the running clearance has been established, no further wear is experienced and no decrease in seal performance occurs as a result of the carbon/ Teflon® residue.

APPENDIX V

C-Face Adapter Installation Instructions

Disassembly

1. Remove the motor by loosening the motor mounting bolts (371). Refer to *Table V-1* for the number of bolts.

Table V-1
Number of Motor Bolts

Pump Frame	Motor frame	No. of Bolts
STX	All	4
MTX	143-286	4
	324-365	8

⚠ CAUTION

The motor may be heavy and should be properly supported with a clean, uncorroded eye bolt or a strap under both end bells.

NOTE: Use of a C-Face adapter will result in one of the following configurations — a foot mounted adapter with an overhung motor or an unsupported adapter and a foot mounted motor.

2. Remove the C-Face adapter (340) from the pump bearing frame (228A) by loosening the four bolts (371N) attached to the bearing frame flange.

NOTE: Both coupling hubs do not need to be removed.

Inspections

1. Visually inspect the C-face adapter (340) for cracks. Check surfaces for rust, scale, or debris. Remove all loose or foreign material (Fig. V-1).
2. Check for corrosion or pitting.

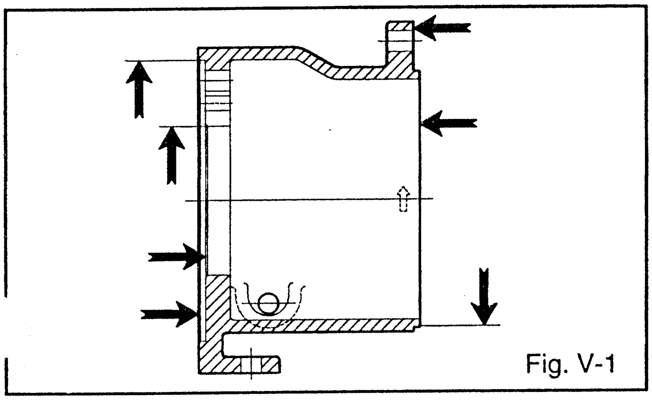


Fig. V-1

Reassembly

1. Mount both the pump and motor coupling hubs if not already mounted.
2. Slide the C-Face adapter (340) over the pump shaft (122) and mount against the pump bearing frame (228A) flange using four bolts (371N). Torque bolts to the values shown in *Table V-2*.
3. Mount the motor to the C-Face adapter (340) using the four or eight motor bolts (371). Torque bolts to the values shown in *Table V-2*.

Table V-2
Bolt Torque

Location	Frame	Lubricated Threads	Dry Threads
C-face adapter-to-frame	STX	20 ft-lbs (27 N-m)	30 ft-lbs (40 N-m)
	MTX	20 ft-lbs (27 N-m)	30 ft-lbs (40 N-m)
	LTX	20 ft-lbs (27 N-m)	30 ft-lbs (40 N-m)
C-face adapter-to-motor	143TC-145TC	8 ft-lbs (11 N-m)	12 ft-lbs (16 N-m)
	182TC-286TC	20 ft-lbs (27 N-m)	30 ft-lbs (40 N-m)
	324TC-365TC	39 ft-lbs (53 N-m)	59 ft-lbs (80 N-m)

Alignment

A shaft alignment is not required when using the C-Face adapter. The rabbetted fits of the motor to the adapter and the adapter to the bearing frame automatically aligns the shaft to within the specified limits.

APPENDIX VI

3198 Teflon® Sleeve Field Replacement Procedure

The Model 3198 Teflon® sleeve is field replaceable, provided a controlled oven capable of heating the sleeve to 550° F (228° C) and a method of machining the sleeve after installation on the shaft are available.

⚠ CAUTION

Do not heat the sleeve with an open flame. Irreparable damage will occur to the sleeve.

For those users who do not have the above facilities, shaft/sleeve sub-assemblies are available from Goulds.

1. Remove the old or damaged sleeve (126) from the shaft (122). The sleeve may be cut lengthwise with a sharp knife.
2. Thoroughly clean the shaft. Pay particular attention to the knurled area of the shaft under the sleeve.

NOTE: The replacement sleeve will not have the same dimensions as the sleeve which was removed until it is mounted on the shaft and machined.

3. Heat the replacement sleeve in a controlled oven at 550° F (288° C) for 40 minutes.

⚠ CAUTION

Do not heat the sleeve with an open flame — irreparable damage will occur to the sleeve.

⚠ WARNING

The oven and sleeve are hot. Use insulated gloves to prevent burn injuries.

4. Remove the sleeve from the oven.
5. Slide the sleeve onto the shaft immediately after removing it from the oven. Push the sleeve onto the shaft until the sleeve bottoms out on the shoulder of the shaft (Fig. VI-1). The hook end of the sleeve will extend beyond the knurled portion of the shaft.

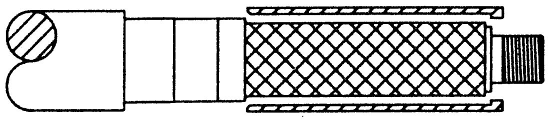


Fig. VI-1

6. As the sleeve cools, it will shrink in length. Apply light pressure to keep the sleeve against the shaft shoulder. Maintain pressure until the hook portion of the sleeve seats itself against the shoulder under the hook (Fig. V-2).

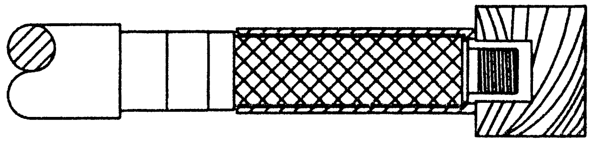


Fig. VI-2

⚠ CAUTION

Care must be taken not to damage the end of the sleeve.

7. Allow the shaft and sleeve to cool completely.

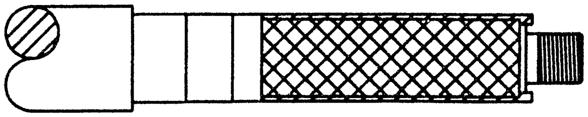


Fig. VI-3

8. Machine the Teflon® sleeve to the dimensions and finish shown in *Table VI-1.*

Table VI-1

3198 Teflon®
Sleeve Diameter and Finish

Frame	Sleeve OD	Surface Finish
STX	1.375 / 1.373	16 µ in.
MTX	1.750 / 1.748	16 µ in.

9. Face off the sleeve shoulder even with and parallel to the shaft shoulder (Fig. VI-4).

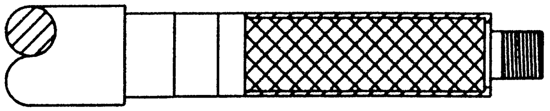


Fig. VI-4

APPENDIX VII

Three Year Performance Guarantee

ANSI Pump Seal Chambers

(Goulds Models: 3196, CV 3196, LF 3196, 3796, and 3996)

Goulds Pumps guarantees the performance of our Engineered seal chambers (BigBore™ and TaperBore™ *Plus*) and the mechanical seals installed in the seal chambers for three years from the shipment date of the pump.

1. Unconditional warranty against workmanship and material for the three (3) year period.

2. Warranty conditional based on pump installation, operation, and maintenance.
    a) Pumps installed with piping loads not to exceed Goulds maximum stated flange loads.
    b) Alignment per Goulds Instruction and Operation Manual.
    c) Pump must be operated within the pump operation range as specified on the appropriate CDS curve.
    d) Pumps must be operated with seal flush arrangement specified by Goulds, or a Goulds Pumps representative.

3. This guarantee excludes:
    a) Consequential damages, in and out charges, etc.
    b) Labor, transportation, and related costs incurred by customer to make a warranty claim.
    c) Re-installation costs.
    d) Reimbursement for loss caused by interruption of service.

Goulds Field Service:
Telephone #1-800-327-7700
Fax: 315-568-7477

24 Hour Customer Service # 1-800-446-8537

Three Year Performance Guarantee

X Series Power End

(Goulds Models: 3196, CV 3196, LF 3196, NM 3196, 3198, and 3796)

Goulds Pumps guarantees the performance of the Power End for three years from the date of manufacture stamped on the power end. The guarantee does not cover the shaft sleeve, or adapter, or frame foot.

1. Unconditional warranty against workmanship and material for the three (3) year period.

2. Warranty conditional based on pump installation, operation, and maintenance.
   a) Pumps must be installed with piping loads not to exceed Goulds maximum stated flange loads.
   b) Alignment per Goulds Instruction and Operation Manual.
   c) Pump must be operated within the pump operation range as specified on the appropriate CDS curve.
   d) Pumps must be lubricated per Goulds recommended lubrication specifications as stated in the Instruction and Operation Manual.

3. This guarantee excludes:
   a) Consequential damages, in and out charges, etc.
   b) Labor, transportation, and related costs incurred by customer to make a warranty claim.
   c) Re-installation costs.
   d) Reimbursement for loss caused by interruption of service.

24 Hour Customer Service # 1-800-446-8537

Special Note: Customers using bearing defect analysis to determine power end failure can claim warranty using the technique described below:
a) A baseline vibration signature must be taken immediately upon start up of the pump. Operating point must be stated for the corresponding signature.
b) Quarterly condition monitoring of the pump must be carried out. Data must be trended over time, and operating point must correspond to the original baseline vibration data.
c) Vibration data must be supplied to Goulds Pumps Industrial Products Group, Field Service Department. Failure will be determined with consultation from Field Service.

HOW TO ORDER

When ordering parts call
1-800-446-8537
or your local Goulds Representative

EMERGENCY SERVICE

Emergency parts service is available
24 hours/day, 365 days/year . . .
Call 1-800-446-8537

TOTAL
QUALITY
Our Job

GOULDS PUMPS
INDUSTRIAL PRODUCTS GROUP
Seneca Falls, New York 13148

Form No. EPD-249 10/97

Printed in U.S.A.

DUTY MASTER®
POLYPHASE A-C MOTORS
INSTALLATION – MAINTENANCE TAG

ACCEPTANCE

Thoroughly inspect this equipment before accepting shipment from the transportation company. If any damage or shortage is discovered do not accept until all appropriate notations are made on freight bill. Any damage discovered after receipt of equipment should be immediately reported to the carrier.

SAFETY

Eyebolts, lifting lugs or lifting openings, if provided, are intended only for lifting the motor and motor-mounted standard accessories not exceeding, in total, 30% of the motor weight. These lifting provisions should never be used when lifting or handling the motor and other equipment (i.e., gears, pumps or other driven equipment) as a single unit. Eyebolt lifting capacity rating is based on a lifting alignment coincident with eyebolt centerline. Eyebolt capacity reduces as deviation from this alignment is increased. Be sure eyebolts are tight and prevented from turning before lifting.

INSTALLATION

All motors covered by this tag should be installed, protected and used in accordance with National Electric Code and NEMA standard publication MG-2 and applicable local codes. Motors should be grounded in the conduit box in accordance with the National Electric Code or applicable local codes. Electrical accessories should also be grounded.

GENERAL

The user must select a motor starter and overcurrent protection suitable for this motor and its application. Consult motor starter application data as well as the National Electric Code and/or other applicable local codes.

Special motors for use by United States Government including special specifications, master plans, etc., refer to the applicable master plans and specifications involved.

On motors received with the shaft blocked by the factory, remove blocking before operating the motor. If motor is to be reshipped, alone or installed to another piece of equipment, the shaft must again be blocked against axial movement to prevent brinelling of the bearings during shipment. Rotating parts, such as couplings, pulleys, internal-external fans and unused shaft extensions should be permanently guarded against accidental contact with hands or clothing.

Loading and operation of A-C motors should be in accordance with the nameplate data.

Frames and accessories of motors should be grounded in accordance with National Electrical Code Article 430. For general information on grounding refer to Article 250. Recommended location for grounding device, conduit box mounting screw.

Rotating parts, such as couplings, pulleys, internal-external fans and unused shaft extensions should be permanently guarded against accidental contact with hands or clothing.

INSPECTION

Before connecting the motor to an electrical supply inspect for any damage resulting from shipment. Turn the shaft by hand to insure free rotation.

DRAIN PLUGS

If motor is totally enclosed, fan cooled, or non-ventilated the condensate drain plugs should be removed, unless the motor has special stainless tee drains. All drains are located in the lowest portion of the end shields.

MOUNTING

Mount the motor on a foundation sufficiently rigid to prevent excessive vibration. Grease lubricated ball bearing motors may be mounted with the feet at any angle. After careful alignment, bolt motor securely in place. Use shim to fill any unevenness in the foundation. All motor feet should sit solidly on foundation before mounting bolts are tightened.

TESTING

If the motor has been in storage for an extensive period or has been subjected to adverse moisture conditions, it is best to check the insulation resistance of the stator winding with a megohmeter. Depending on the length and conditions of storage it may be necessary to regrease or change rusted bearings.

If the resistance is lower than one megohm the windings should be dried in one of the two following ways:

1) Bake in oven at temperatures not exceeding 90°C until insulation resistance becomes constant.

2) With rotor locked, apply low voltage and gradually increase current through windings until temperature measured with thermometer reaches 194°F. Do not exceed this temperature.

WIRING

Connect the motor to the power supply of identical characteristics, according to the connection diagram on the motor nameplate. Suitable fuses and overload protection should be provided.

ROTATION

To reverse the direction of rotation, disconnect and lockout power and interchange any two of the three line leads for three-phase motors, for two-phase four wire, disconnect and lockout power and interchange the line leads on any one phase. For two-phase three wire, disconnect and lockout power and interchange phase one and phase two line leads.

RECOMMENDED WIRE SIZE

Motor Horsepower

Volts	1-3	5	7½	10	15	20	25	30	40	50	60	75
230	14	12	10	8	6	4	2	1	00	000	0000	300
460	14	14	14	12	10	8	6	6	4	2	1	0
575	14	14	14	14	10	10	8	8	6	4	3	1

Volts	100	125	150	200	250	300	350	400	450	500	600	700
230	500	–	–	–	–	–	–	–	–	–	–	–
460	000	0000	300	500	700	900	1500	600*	750*	900*	1750*	–
575	0	000	0000	300	500	600	800	1000	1500	600*	900*	1500*
**2300	–	–	–	–	6	4	3	2	1	1	0	00

*Parallel

**Use high voltage cable

⚠ DANGER

HIGH VOLTAGE AND ROTATING PARTS CAN CAUSE SERIOUS OR FATAL INJURY. INSTALLATION, OPERATION, AND MAINTENANCE OF ELECTRICAL MACHINERY SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. MAKE SURE THAT THE MOTOR AND EQUIPMENT ARE GROUNDED AND PROTECTED IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE, NEMA MG-1 AND APPLICABLE LOCAL CODES.

STARTING

⚠ CAUTION

BEFORE STARTING MOTOR, REMOVE ALL UNUSED SHAFT KEYS AND LOOSE ROTATING PARTS TO PREVENT THEM FROM FLYING OFF. CHECK DIRECTION OF ROTATION BEFORE COUPLING MOTOR TO LOAD.

⚠ NOTICE

THE MOTOR SHOULD START QUICKLY AND RUN SMOOTHLY AND WITH LITTLE NOISE. IF THE MOTOR SHOULD FAIL TO START IT MAY BE THAT THE LOAD IS TOO GREAT FOR THE MOTOR, THE VOLTAGE IS LOW OR THE MOTOR HAS BEEN MISCONNECTED. IN ANY CASE IMMEDIATELY SHUT MOTOR OFF AND INVESTIGATE THE CAUSE.

LUBRICATION

Oil Mist: See Oil Mist Instruction Manual #B-3654.

Grease: This motor was properly lubricated when installed. When the motor has been in storage for a period of six months or more, lubricate before starting. Reference Long Term Storage Bulletin, A-8018-1.

Lubrication of anti-friction bearings should be done as a part of a planned maintenance schedule. The Recommended Lubrication Interval should be used as a guide to establish this schedule.

Cleanliness is important in lubrication. Any grease used to lubricate anti-friction bearings should be fresh and free from contamination. Similarly, care should be taken to properly clean the grease inlet area of the motor to prevent grease contamination.

SERVICE CONDITIONS – Table 1

Standard Conditions:	Eight hours per day, normal or light loading, clean, @ 40°C (100°F) maximum ambient.
Severe Conditions:	Twenty-four hour per day operation or shock loading, vibration, or in dirt or dust @ 40-50°C (100-120°F) ambient.
Extreme Conditions:	Heavy shock or vibration, or dust.

LUBRICATION FREQUENCY (BALL BEARINGS) – Table 2

Horsepower	Standard Conditions	Severe Conditions	Extreme Conditions
1 thru $7^1/_2$, 1800 RPM & slower	3 years	1 year	6 months
10 thru 75, 1800 RPM & slower	2 years	6–12 months	3 months
100 & greater 1800 RPM & slower	1 year	6 months	1–3 months
All over 1800 RPM	6 months	3 months	1 month
ROLLER BEARINGS For Roller Bearings divide the time periods above by 2.			

LUBRICATION VOLUME – Table 3

	Volume in Cubic Inches	
FRAME SIZE	**1800 RPM and Slower**	**3600 RPM**
182 thru 215	0.5	0.5
254 thru 286	1.0	1.0
324 thru 365	1.5	1.5
404 thru 449	2.5	1.0

LUBRICATION INSTRUCTIONS

1. Select Service Condition from Table 1.
2. Select Lubrication Frequency from Table 2.
3. Select Lubrication Volume from Table 3.

LUBRICATION PROCEDURE

Bearings should be lubricated while stationary and the motor is warn.

1. Locate the grease inlet, clean the area, and replace the pipe plug with a grease fitting.
2. Locate and remove the grease drain plug, if provided.
3. Add the Recommended Volume of the Recommended Lubricant until clean grease appears at the grease drain, at the grease relief, or along the shaft opening.
4. Replace the grease inlet plug and run the motor for two hours.
5. Replace the grease drain plug.

RECOMMENDED LUBRICANT

For motors operating in ambient temperatures shown below, use the following lubricant or its equal:

BALL BEARING MOTORS

OPERATING TEMP. –25°C (–15°F) TO 50°C (120°F)

CHEVRON OIL	SRI NO. 2
EXXON	UNIREX NO. 2
SHELL OIL CO.	DOLIUM
TEXACO INC.	PREMIUM RB

MINIMUM STARTING TEMPERATURE –60°C (–76°F)

SHELL OIL CO.	AEROSHELL NO. 7

ROLLER BEARING MOTORS

OPERATING TEMP. –25°C (–15°F) TO 50°C (120°F)

CHEVRON OIL	BLACK PEARL EP NO. 2
TEXACO, INC.	PREMIUM RB

⚠ NOTICE

MIXING LUBRICANTS IS NOT RECOMMENDED DUE TO POSSIBLE INCOMPATIBILITY. IF IT IS DESIRED TO CHANGE LUBRICANT, FOLLOW LUBRICATION INSTRUCTIONS AND REPEAT LUBRICATION A SECOND TIME AFTER 100 HOURS OF SERVICE. CARE MUST BE TAKEN TO LOOK FOR SIGNS OF LUBRICANT INCOMPATIBILITY, SUCH AS EXTREME SOUPINESS VISIBLE FROM THE GREASE RELIEF AREA.

SPECIAL APPLICATIONS

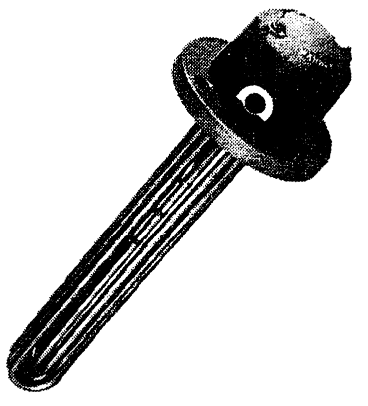
Silicone grease may be required in special high temperature applications. Consult Reliance Electric Engineering for specific recommendations and for substitution of other lubricants shown above.

RELIANCE ELECTRIC

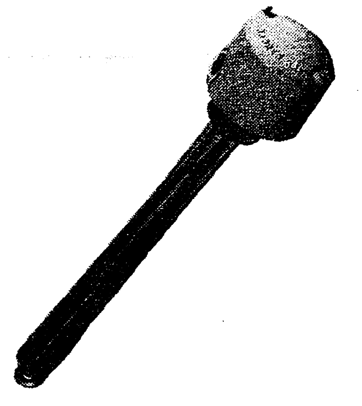
**WARREN ELECTRIC
CORPORATION**

**36 Franklin Street, P.O. Box 86, warren, Rhode Island 02885
TEL: (401) 245-3700 FAX: (401) 2459331**

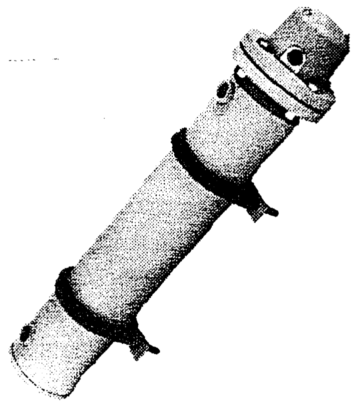
Installation, Operation and Maintenance Instructions for Electric Immersion Heaters



Flanged Immersion Heater



Screw Plug Immersion Heater



Circulation Heater

PLEASE READ **AND** FOLLOW ALL INSTRUCTIONS BEFORE INSTALLING

PRE-INSTALLATION

1. Unpack each heater upon delivery. Inspect each heater carefully for shipping damages. Report any claims to the carrier. Do not operate damaged equipment. Consult WARREN ELECTRIC CORPORATION for instructions.

2. Compare the wattage, voltage rating and phase listed on each nameplate against your supply voltage, phase and the requirements of your installation. Confirm that the sheath material and watt density of each heater is compatible with the material being heated. Check packing list.

WARNING

ALL ELECTRICAL WORK MUST BE DONE BY QUALIFIED PERSONNEL IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE AND APPLICABLE STATE AND LOCAL CODES.

BEFORE WIRING, SERVICING OR CLEANING THE HEATER(S), TURN OFF POWER AND INSTALL A LOCKOUT ON THE HEATER CIRCUITS AT THE SERVICE PANEL. FAILURE TO DO SO COULD ALLOW OTHERS TO TURN ON POWER UNEXPECTEDLY, WHICH MAY CAUSE FATAL ELECTRICAL SHOCK.

MOUNTING

Each heater shall be installed so that the heated section is totally immersed at all times. The liquid level must always be above the heated portion of the heater elements by at least several inches. **Failure of the heater could occur if this is not done as the heater may overheat and damage the heating element sheaths or resistance wire inside the sheaths.**

Do not bend the heating elements. Consult Warren Electric Corporation if bending is necessary.

INSTALLATION

INSPECTION: Thoroughly inspect each heater prior to installation by checking the elements, terminal box, thermostat and thermocouple (if included). Immediately report any damage to the freight carrier who delivered the heater(s). Any sign of moisture or water stains on the packaging could be a sign of possible moisture damage. (See paragraph MOISTURE OR WETNESS before proceeding or wiring.)

MECHANICAL: Install each heater (with gasket provided if flanged, or quality pipe sealant if NPT) in the tank or vessel. Horizontal installation is preferred, and proper air venting of flow is essential. If the heater is installed horizontally, the discharge must be at the top (12 o'clock) at either end, at or beyond the heated section. The inlet should be at or beyond the heated section at the opposite end. **IMPORTANT: The heated portion of the heater elements must remain completely immersed and completely flooded whenever energized.** If the heater is installed vertically, the direction of flow shall be upward and no air pockets should exist above the discharge.

Clean the gasket surface before seating the heater. Be sure each heater is installed properly with a gasket or pipe sealant. Observe **"Top"** Stamp on the flange (if any). Tighten all flange and electrical connections.

ELECTRICAL: The applied voltage should not exceed 10% of the highest heater nameplate voltage. Each heater circuit should have at least one temperature limiting control. (See paragraph **TEMPERATURE CONTROL.**) If there is a potential of a pressure build up, possibly due to a closed inlet and/or outlet valve, or temperature run away due to a control failure, a pressure relief valve, set at a pressure rating below the rating of the pressure vessel and exceeding the BTU capacity of the heaters by a minimum of 50% must be installed directly to the vessel containing the heater.

EXAMPLE based on water: (If other, consult valve supplier.)

100 kw x 3412 BTU/kw-hr=341,200 BTU/hr
341,200 BTU/hr x 1.5 = 5 11,800 BTU/hr

At least one temperature sensor or, preferably, a high limit control should be in close proximity to the heating element.

Multiple circuit heaters are to be wired to the color coded or numbered electrical terminals inside the terminal enclosure.

All wiring shall be done by qualified personnel in accordance with the National Electrical Code and applicable state and local codes. Each **heater** shall **be grounded in accordance with the** National **Electrical Code. (REF:** NEC **Articles 427, 250,** etc.)

Refer to the wiring diagram found on the inside of the terminal enclosure of each heater and the typical wiring diagrams on the back page of these instructions.

CONTACTORS: All heaters operated over 250 VAC must be contactor operated. Definite purpose contactors are usually the most economical. Selection of the 'proper contactor involves:

Select one or more contactors to handle each circuit or heater(s). The contactor ampere rating must exceed the total amperage applied to the contactor contacts and shall not be rated less than 125 percent of the total load of the heaters. The contactor coil voltage must match the control circuit voltage and be limited to 250 VAC. (See page 4 for typical wiring diagrams.)

Select a contactor enclosure(s) to match the size of the contactor selected. Also consider whether the enclosure should be general purpose, weather or explosion-resistant.

We recommend using only UL recognized components such as Square D types DP, DPA & SYD.

MOISTURE OR WETNESS: Warren Electric heating elements are manufactured with high quality magnesium oxide. (Continued on page 3...)

MOISTURE OR WETNESS cont... As added protection, each Warren Electric element terminal end normally has a flexible silicone moisture barrier just under the terminal insulator. All heaters manufactured and shipped by Warren Electric Corporation are electrically tested in accordance with UL specifications.

Exposure to weather conditions while transporting or storage at a job site in an open or unprotected area can cause water, excessive moisture or condensation to collect in the terminal area. Drying a heater internally usually requires baking the entire unit at 250 - 300 degrees F for 24 hours. This will usually correct a moisture problem. Drying a heater by operating at low voltage has rarely proven successful as the moisture stays in the cold lead section of the electrical elements in most cases. An ordinary hair dryer can sometimes be used to surface dry a terminal area.

If baking is not practical, consult our factory.

No heater shall be operated with a resistance to ground reading of less than 50 megohms. A qualifed electrician can check the megohm reading.

TERMINAL ENCLOSURES: The heater has either a general purpose, weather or explosion-resistant terminal enclosure which should have been selected based on the most extreme operating environment at the heater terminal area.

That is, a general purpose terminal enclosure can be used where there is no risk of water or other contamination, hazardous or explosive fumes, etc. It is dangerous to use a general purpose enclosure if the terminal area could be subjected to extreme conditions such as dripping water or an occasional washdown. The terminal enclosure selection is the sole responsibility of the purchaser and installer. Weather or explosion-resistant terminal enclosures are available but must be specified at the time of the heater order.

Weather or explosion-resistant terminal enclosures must be tightly sealed at the cover, conduit openings, fasteners and all other openings before exposure to adverse conditions. Gasket(s) and weather resistant washers are provided with weather resistant covers. Some models have an alternate screw-on terminal cover and these should have a gasket (included) or a non-hardening compound shall be put on the cover threads and the cover must be tightened after wiring.

TEMPERATURE CONTROL

The heater may have a thermostat(s), thermocouple or both. **Each heater circuit must have a temperature control to prevent overheating of each circuit.** Secondary safety high-limit manual reset temperature controls are also recommended except where a possible condition such as freezing or total loss of heat could become a major problem. Do not exceed the amperage and voltage rating of the thermostat. If a thermocouple is used, the type ("J", "IS', etc.) must be matched to the thermocouple temperature controller.

OPERATION and MAINTENANCE

BEFORE WIRING, SERVICING OR CLEANING THE HEATER(S), TURN OFF POWER AND INSTALL A LOCKOUT ON THE HEATER CIRCUITS AT THE SERVICE PANEL. FAILURE TO DO SO COULD ALLOW OTHERS TO TURN ON POWER UNEXPECTEDLY, WHICH MAY CAUSE FATAL ELECTRICAL SHOCK.

DO NOT OPERATE HEATER IF DRY. DO NOT OPERATE THE HEATER UNLESS THE HEATED SECTION OF THE ELEMENT BUNDLE IS COMPLETELY IMMERSED AT ALL TIMES.

CORROSION: After some use, each heater should be periodically removed from the tank or vessel and the heater element bundle (the immersed portion of the heater) should be inspected and checked for coatings and corrosion. Remove deposits from each heater before returning heater to service.

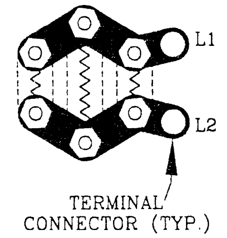
The tank and vessel should also be checked and sludge deposits should be removed. The heaters must not be operated in sludge.

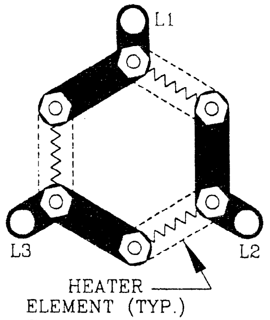
We suggest that periodic inspections be made to determine the appropriate frequency for cleaning and that a new heater flange gasket be installed whenever the heater flange is removed. The frequency of inspections will depend on use and fluid conditions.

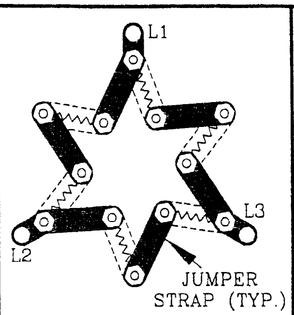
ELECTRICAL: Electrical connections must also be checked periodically. All connections must be tight, All terminal ends and connections should be clean of all contaminants.

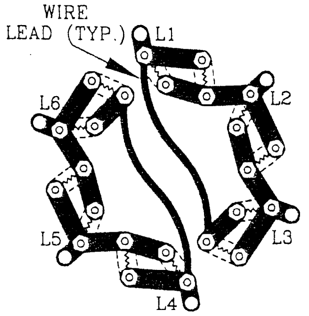
(Continued on page 4...)

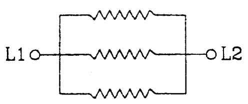
TYPICAL WIRING DIAGRAMS



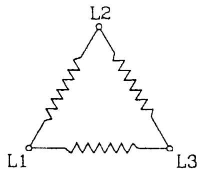




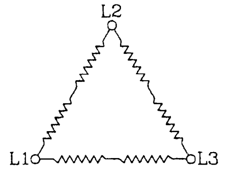




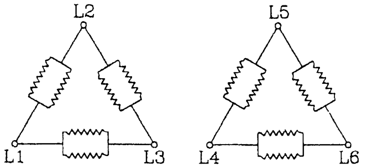
SINGLE PHASE
PARALLEL CIRCUIT
L1, L2 = RED



THREE PHASE
DELTA CIRCUIT
L1, L2, L3 = RED

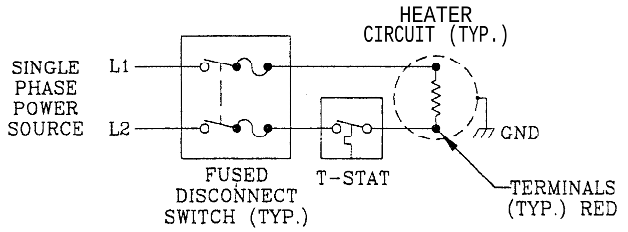


THREE PHASE
DELTA SERIES CIRCUIT
L1, L2, L3 = RED

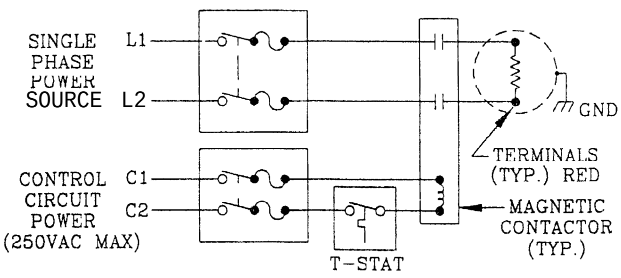


THREE PHASE
TWO DELTA PARALLEL
CIRCUITS
L1, L2, L3 = RED
L4, L5, L6 = SILVER

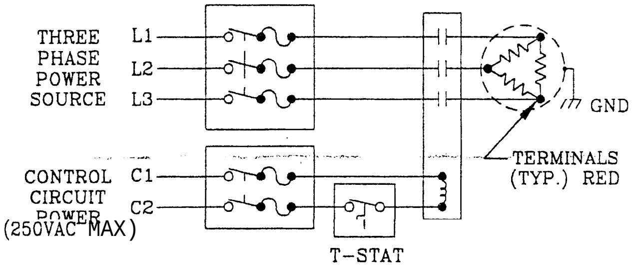
SUGGESTED WIRING FOR:
SINGLE PHASE HEATER WITH THERMOSTAT



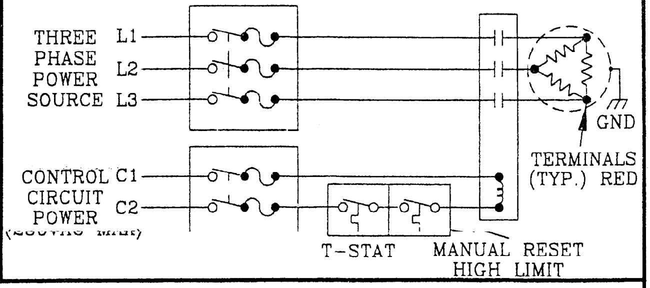
SUGGESTED WIRING FOR:
SINGLE PHASE HEATER VIA CONTACTOR
WITH THERMOSTAT



SUGGESTED WIRING FOR:
THREE PHASE HEATER VIA CONTACTOR
WITH THERMOSTAT



SUGGESTED WIRING FOR:
THREE PHASE HEATER VIA CONTACTOR
WITH THERMOSTAT & RESET



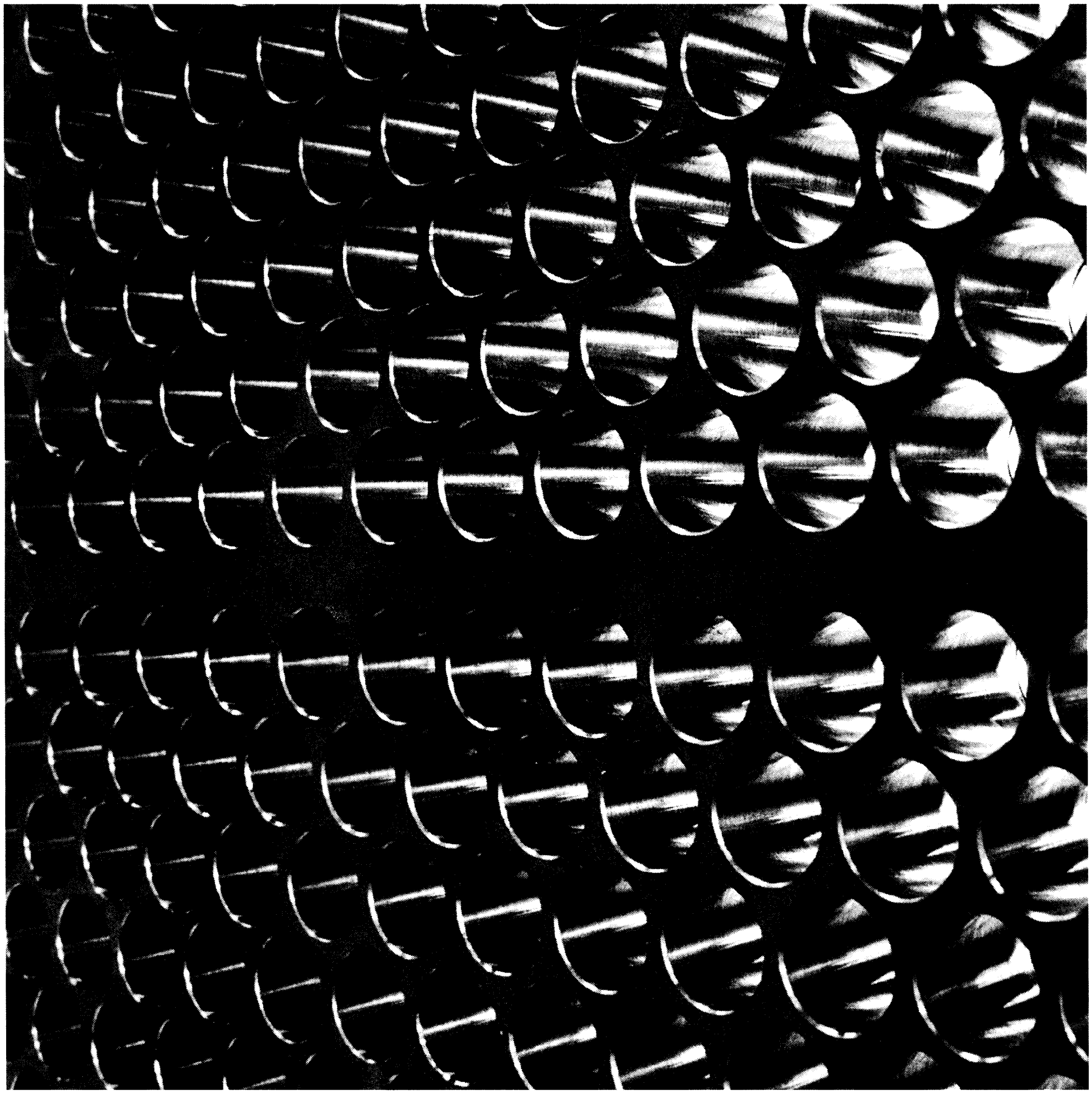
WARRANTY

WARRANTIES: There is no representation, warranty, or condition, of any kind, express or implied, unless otherwise expressly stipulated hereunder. Seller'ssole representation as to equipment sold hereunder is that such equipment is under warranty, for a period of fifteen (15) months from the date of delivery to buyer, to be free from manufacturing defects if used in accordance with seller's recommendations, except that this warranty does not cover switches or elements damaged by short circuit wiring or unauthorized servicing beyond normal adjustment, and such switches or elements will not be replaced without charge. The obligation of the seller hereunder is limited to making the replacement or repair, whichever the seller may elect, of any equipment sold by the seller, or any part thereof, acknowledged by seller to be defective. This warranty does not include or cover reimbursement of expenses incurred by reason of normal use and service of the equipment, or the expenses incurred in connection with the inspection or transportation of equipment or any part thereof to be repaired or replaced pursuant to this warranty.

KETEMA

Heat Transfer Division

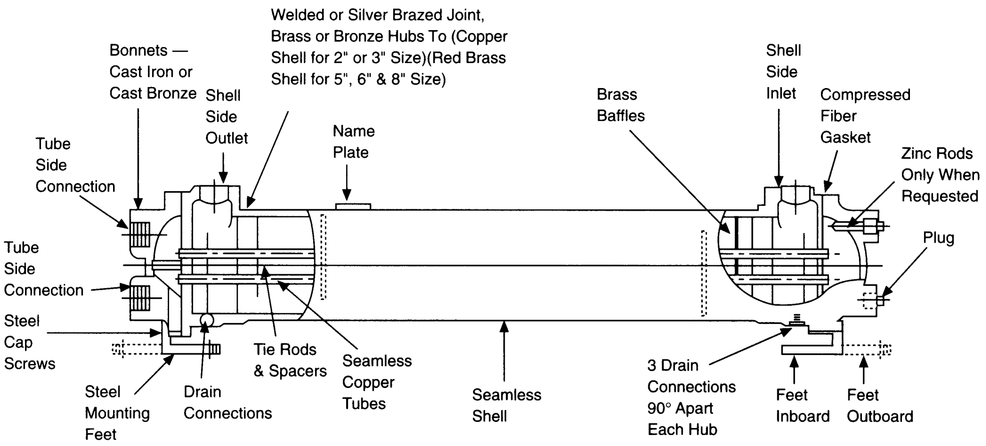
Installation and Operational Procedures for WHITLOCH Heat Exchangers



PARTS LISTS

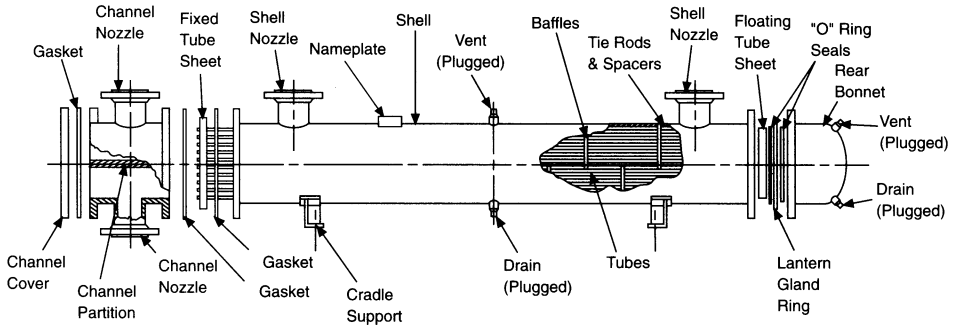
The instructions in this manual cover ordinary conditions that may arise. In special cases, our engineering department or our authorized local representative will be glad to offer additional assistance.

WHITLOCK TYPE — HT SERIES
1, 2 or 4 PASS EXCHANGER



Steel mounting feet may be rotated at 90° intervals and turned inboard or outboard.

WHITLOCK TYPE — HTP SERIES



WHITLOCK HI-TRANSFER HEAT EXCHANGERS

For more than 100 years, the Whitlock line of heat exchangers has led the heat transfer industry. Each Whitlock heat exchanger has been engineered to efficiently meet specific operational requirements. All Whitlock quality heat exchangers are manufactured in Ketema's modern manufacturing facility and fully tested before shipment. They will operate for years with little or no attention.

Satisfactory performance of Ketema's quality Whitlock heat exchangers can be best assured by correct installation and preventive maintenance.

Typically, the failure of heat exchanger equipment to perform to specifications may be caused by one or more of the following factors: (**1**) excessive fouling, (**2**) air or gas binding resulting from improper piping installation or lack of suitable vents, (**3**) operating conditions differing from design conditions, (**4**) maldistribution of flow in the unit, and (**5**) excessive clearances between the baffles and shell and/or tubes due to corrosion.

The following instructions and procedures, supplemented by the experience and mechanical ability of a competent engineer, will assure proper installation, operation, and maintenance of Whitlock heat transfer equipment.

INSTALLATION

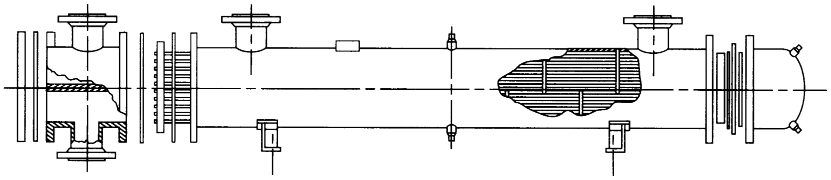
SITE SELECTION is the first step to insure proper installation of Whitlock heat transfer equipment. It is important that the heat exchanger is easily accessible for inspection, maintenance and cleaning.

Straight Tube heat exchangers with removable bundles; must allow for sufficient clearance at the stationary head end for removal of the bundle from the shell and provide adequate space beyond the rear head to accommodate removal of the shell cover and/or floating head cover.

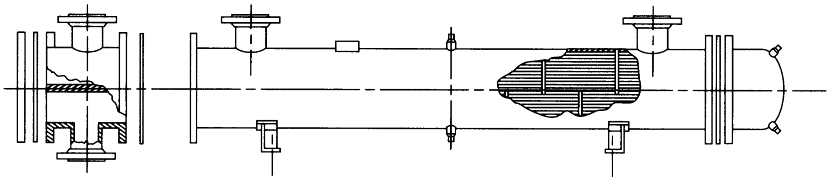
Fixed Tubesheet heat exchangers; should provide sufficient clearance at one end for withdrawal and replacement of the tubes and enough space beyond the head at the opposite end to permit removal of the bonnet or channel cover.

U-Tube heat exchangers; provide sufficient clearance at the stationary head end for withdrawal of the tube bundle, or at the opposite end to permit the removal of the shell.

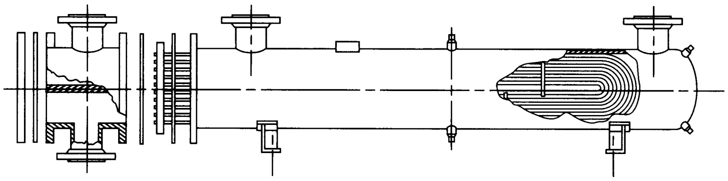
STRAIGHT TUBE



FIXED TUBESHEET



U-TUBE



WARNING: DRESS SAFELY.
Make a list of all protective clothing and/or safety equipment recommended by the manufacturers of all items or equipment used in the installation. Follow all the safety practices and procedures outlined by each respective manufacturer.

FOUNDATIONS must be sufficiently heavy as to provide permanent support without settling, and to absorb any normal vibrations from outside causes.

Most Whitlock heat exchangers are equipped with cradles for horizontal installation, or brackets for vertical installation. If the supports are integral, the foundation bolts at the end opposing the channel should be loosened to allow free expansion and contraction of the shell.

The exchanger should be set level and square so pipe connections can be made without forcing to reduce the possibility of leaks during operation.

INSPECT all exchanger openings for foreign material before installation. The entire system should be clean before starting operation. *Do not remove* protective plugs and covers until just prior to installation.

Pieces of gaskets, metal chips, scale and similar materials can plug tubes. To minimize the risk of blockage, take the following precautions:

- Use care in placing gaskets.
- Do not use valves with soft seats.
- Blow-out pipelines before connecting to the unit.

FITTINGS AND PIPING are critical steps in the proper installation of Whitlock heat transfer equipment. To insure the full rated capacity of the unit it is important to select the proper pipe sizes. While pipe connections for average conditions are specified on certified drawings, further thought must be given to plant conditions—such as length of pipes, fittings and other obstructions, and the allowable pressure drop through the heat exchanger.

By-Pass Valves should be provided in both circuits of the unit to permit periodic inspection or repair without interruption of the fluid flow.

Test Connections for thermometer well and pressure gauges should be installed close to the exchanger in the inlet and outlet piping, when not integral with the exchanger nozzles.

Inert Gas Vents should be provided to preclude gas binding of the heat transfer surface and a subsequent reduction in thermal capacity in condensing units.

Drain Piping must be suitable for discharge to the atmosphere (if permissible), or into a vessel at lower pressure. Do not pipe to a common closed manifold.

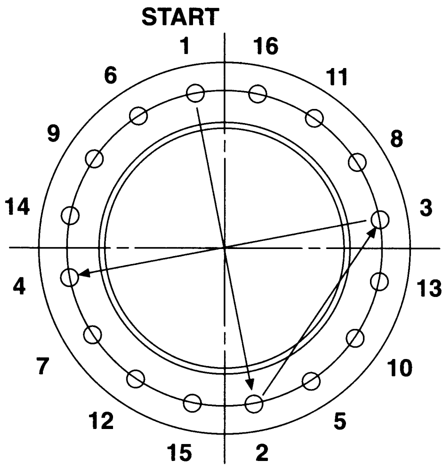
Fluid Pulsations and Mechanical Vibrations to heat exchangers must be minimized in all installations. Install surge drums when the liquid is being delivered to the unit by a reciprocating pump, as the vibration is apt to result in serious damage to the tubes.

Gage Glasses in condensing units should be installed to show liquid level.

Safety Device Tappings are provided with all Whitlock shells. To safeguard against failures or possible ruptures during service, the unit must be protected with safety or relief valves of an approved type and make, set at the proper pressure. In the tube circuit, such devices should be placed in the inlet piping between the nearest valve and the unit.

EXTERNAL BOLTED JOINTS may require re-tightening in a uniform, diametrically staggered pattern, as illustrated below. Even though all Whitlock heat transfer equipment is pressure tested before leaving the Ketema plant, normal relaxing of the gasketed joints may occur in the interval between testing and installation.

SIZE	TORQUE (FT. LBS.)	TORQUE STEPS
1/4-20	8	1
5/16-18	16	1
3/8-16	24	2
1/2-13	60	2
5/8-11	120	2
3/4-10	200	3
1-8	490	3
1/8-8	710	3
1/4-8	1000	3
1 1/2-8	1600	3
1 3/4-8	3000	4
2-8	4400	4



For neoprene gaskets multiply the torque values shown by 0.375.

OPERATION

Operational Procedures must be strictly adhered to in start-up and shut-down sequences, particularly of fixed tubesheet units where improper start-up or shut-down may cause leaking of tube-to-tubesheet and/or bolted flanged joints. Whitlock heat exchangers should not be subjected to abrupt temperature fluctuations. Hot fluid must not be introduced when the unit is cold, nor cold fluid introduced when the unit is hot.

Equipment must not be operated at conditions which exceed those for which the unit was designed.

START-UP OPERATION

1. **Eliminate Air** from the liquid and vapor spaces, by opening the vent cocks until all passages are completely filled. The most frequent cause of non-performance is improper venting and resultant air entrapment.
2. **Check Steam Traps** for proper draining the vapor space of steam-actuated heaters.
3. The first stream (liquid or vapor) admitted is the stream on the shell side. The heat exchanger should never be shocked by the sudden admission of extremely hot or cold fluids; repeated stresses set up by such a procedure cause metal fatigue. Thermal and physical shocks should be avoided whenever possible.
4. Sufficient circulation of the cold medium should be maintained at all times to prevent overheating, with subsequent depositing of scale, coke or sludge.

CAUTION!: The heat exchanger is a pressure vessel and its stated operational pressures and temperatures should NOT be exceeded.

SHUT-DOWN OPERATION

1. As a general rule, the hot stream should be gradually stopped first when shutting down the unit. If it is necessary to cut out the cold fluid circulation, the hot medium should first be bypassed to protect the tubes and tube expands from excessive temperatures, with the following exceptions:

   Fixed Tube Sheet Exchangers (Whitlock Types V and VI) having tubes and shells of the same class of material — steel, stainless steel, or copper alloy. The tubeside stream should be cut out first, to avoid an excessive temperature difference between tubes and shell that might result when the tubes are brought to tubeside stream temperature while the shell is insulated from the tubes by stagnant shellside fluids.

   Air Heaters, with air in the tubes. The blower should be turned off first, and then the steam valve — permitting the shell and tubes to cool down together gradually. If the blower were left on, the tubes would be cooled more rapidly than the shell; the resulting tube contraction would stress the tube-to-tube sheet joints. After several such shut downs, the tube expands might leak.
2. Drain all fluids from the unit after shut-down to prevent freezing, corrosion or sludging. In steam-actuated heaters, the condensate should be removed completely to prevent water hammer.

MAINTENANCE

Inspection of Whitlock heat transfer equipment at regular intervals, as frequently as experience indicates, can identify potential problems before any structural damage occurs. The inspection should include an examination of both the interior and exterior of the unit.

Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes which could cause severe thermal strains, leaking tube joints or structural damage to other components.

Temperatures and pressures of the fluid entering and leaving the equipment should be checked regularly to evaluate the function of the unit. For example, an increase in the pressure drop across the unit — with an accompanying decrease in the temperature range — usually indicates fouling or dirt in the unit. Whereas a decrease in the temperature range by itself denotes vapor or gas binding.

A slight sludge or scale coating on the tube greatly reduces the heat transfer efficiency. Therefore, exchangers subject to fouling or scaling should be cleaned periodically. A marked increase in pressure drop and/or reduction in performance usually indicates cleaning is necessary. The unit should first be checked for air or vapor entrapment to confirm that this is not the cause for the reduction in performance. Since the difficulty of cleaning increases rapidly as the scale thickness or deposit increases, the intervals between cleanings should not be excessive.

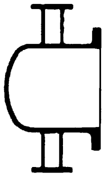
Disassembly and removal of the bundle for visual inspection and cleaning is desirable. The bundle must be checked for excessive corrosion. Regular examination and cleaning are even more necessary when the fluids handled are fouling, or highly corrosive.

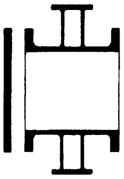
CAUTION!: Before disassembly, the user must ensure that the unit has been completely shut down and depressurized, vented, drained, and neutralized and/or purged of hazardous material.

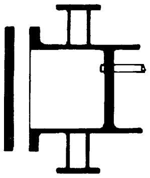
To clean or inspect a unit with a 2-piece head, it is only necessary to remove the channel covers. In the case of a 1-piece head, remove the head itself. In the case of a floating-head design, remove the shell cover and the floating head covers.

Care must be taken when "handling" the fouling material and the cleaning agent. Follow the chemical's "handling instructions" and wear all forms of eye, respiratory and body protection recommended.

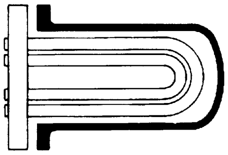
FRONT CLOSURES



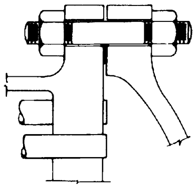




REAR CLOSURES



Type R



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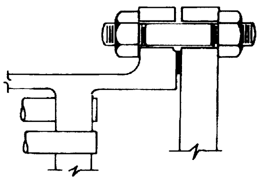

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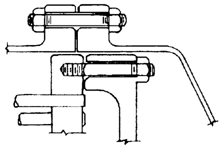

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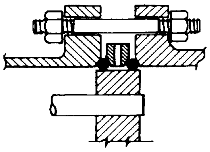
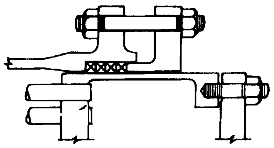


Type HTP



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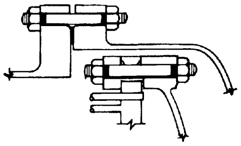
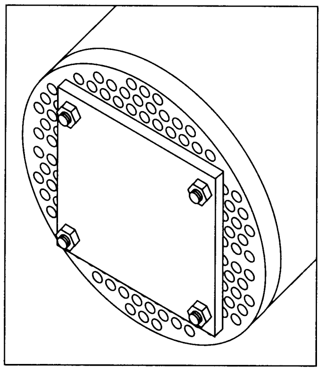


Type ST

Tube Joint Leaks can be located with the following procedures:

Fixed Tubesheet Exchangers — remove the channel covers and apply fluid pressure on the shell side.

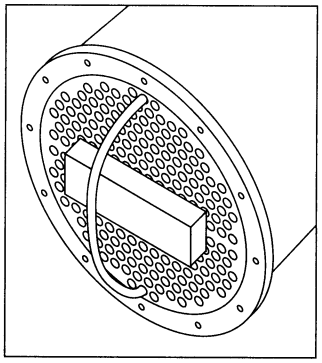
Floating Tubesheet Exchangers — remove the front channel and apply hydrostatic pressure on the shell side. Any leaks between the tubes and the front tube sheet will be evident immediately. Should a major leak occur in the rear tube sheet the fluid will shortly be seen running out the bottom row of tubes. If a test ring is purchased with the exchanger, remove the rear bonnet on the type HTP and the shell cover and the floating head cover on the type S & ST exchanger. Then attach the test ring. The pressure will show up any leaks in the floating tube sheet. Minor leaks may require the removal of the tube bundle and the application of a pressure test on the tubes.



U-Tube Exchangers — remove the bonnet or channel cover and test from the shell side. Be sure that all bolted contact surfaces are securely bolted, with all bolts in place and properly tightened.

Removal of the tube bundle requires the joint be first broken with a chisel, being careful not to injure the gasket surface, and then pried out using a chisel or crowbar.

Where the resistance to remove is great, a pair of hydraulic jacks — placed diametrically opposite on the periphery of the tube sheet — may be employed.



To remove a straight tube / floating tube sheet bundle, either of the above methods may be used or one of the following:

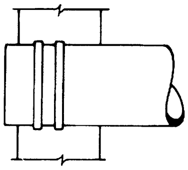
Steel cables may be threaded through eyebolts screwed into the tubesheet.

Cables may be threaded through several tubes (tube diameter permitting) and pulled. The cable must be passed over a wooden block at the tube ends to protect such tube ends from damage.

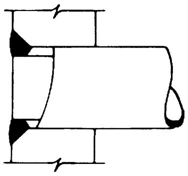
The bundle should be supported on the tubebaffles, supports or tubesheets to prevent damage to the tubes.

The gasket and packing contact surfaces should be protected.

Tube Expanding — a suitable tube expander can be used to tighten a leaking tube joint; however, care should be taken to insure that tubes are not over expanded. Proper care should be taken to prevent expanding the tube beyond the backside of the tube sheet.



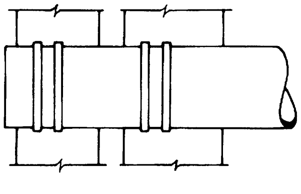
Tube expanded



Welded tube

CAUTION!: When removing the tube bundle...

- **Do not exceed stated load capacities of any piece of equipment or tools used.**
- **Wear and/or follow all recommended protective clothing and other safety practices.**



Double tube sheet design

Cleaning of Whitlock heat exchangers is important to keep the equipment providing satisfactory performance. Heat transfer equipment may be cleaned by either chemical or mechanical methods. The method selected must be the choice of the operator of the plant and will depend on the type of deposit and the facilities available in the plant. These are suggested methods:

Problem	Solution
Water-soluble deposits	Flush with warm water
Soft, water-insoluble deposits	Circulate hot wash oil or light distillate through the tube and shell at a good velocity, followed by thorough washing
Sludges or cokes	If neither of the methods described above produce satisfactory results, try chemical cleaning compounds such as Oakite
Hard scale	Should the scale not yield to the treatments mentioned above, then a chemical analysis of the scale is advisable. Such an analysis may indicate that careful washing with a dilute mineral acid and inhibitor, followed by thorough washing, will provide the required results. A mechanical cleaner, preferably a wire brush, can advantageously be employed, but care should be taken to prevent the cutting or scoring of the tube wall.

Frequent cleaning is important to prevent excessive deposits on the tubes, since these deposits may result in plugging the tubes. Resultant overheating may be followed by leakage of the expanded joints, or result in other damage, and certainly in a reduction of thermal capacity.

CAUTION!: CLEANING PRECAUTIONS

- **Be careful to avoid damaging the tubes when mechanically cleaning a tube bundle.**
- **Cleaning compounds must be compatible with the metallurgy of the exchanger.**

DO NOT:

- **Introduce steam into an individual tube, as such a practice causes differential expansion strains, with possible leakage at the tube joints.**
- **Introduce air into units handling inflammable fluids.**

WARNING!: Chemical disposal of the substances used in and to clean the heat exchangers are HAZARDOUS! Follow all local, state and federal ordinances in the removal and disposal of these substances.

Gaskets and gasket surfaces should be thoroughly cleaned and should be free of scratches and other defects. Gaskets should be properly positioned before attempting to retighten bolts. It is required that when a heat exchanger is dismantled for any cause, it be reassembled with new gaskets. This will tend to prevent future leaks and/or damage to the gasket seating surfaces of the heat exchanger. Composition gaskets become dried out and brittle so that they do not always provide an effective seal when reused. Metal or metal jacketed gaskets, when compressed initially, flow to match their contact surfaces. In so doing they are work hardened and, if reused, may provide an imperfect seal or result in deformation and damage to the gasket contact surfaces of the exchangers.

Bolted joints and flanges are designed for use with the particular type of gasket specified. Substitution of a gasket of different construction or improper dimensions may result in leakage and damage to gasket surfaces. Therefore, any gasket substitutions should be of compatible design.

Any leakage at a gasketed joint should be rectified and not permitted to persist as it may result in damage to the gasket surfaces.

Metal jacketed type gaskets are widely used. When these are used with a tongue and groove joint without a nubbin, the gasket should be installed so that the tongue bears on the seamless side of the gasket jacket. When a nubbin is used, the nubbin should bear on the seamless side.

Spare and Replacement Parts can be ordered directly from Ketema. When ordering parts please provide the name of the part needed, as well as the serial number, type, and size from the nameplate on the unit.

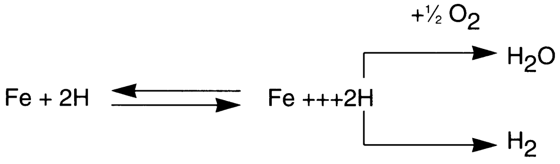
CORROSION

Since the corrosion of heat exchanger parts is of major interest when considering the maintenance of such equipment, it is appropriate that this subject be treated separately.

The generally-accepted conception of the mechanism of corrosion recognizes the tendency of common metals — being relatively unstable — to revert to a more stable form, as in oxides and salts.

This theory, known as the electrolytic theory, propounds that the iron (chosen here because we are concerned chiefly with this material) goes into solution as iron ions. For the iron to go into a solution, an equivalent number of positive ions of some other element must be displaced, in order that the solution may remain electrically neutral.

For example, a piece of iron immersed in a copper sulfate solution will go into solution, but at the same time, an equivalent amount of copper will be plated out. In the case of natural water, the element plated out is hydrogen, with hydrogen usually removed (1) by combination with oxygen to form water, or (2) gas, according to...



The tendency of hydrogen to come out of solution has been found to increase with the degree of acidity. This can be measured as the hydrogen-ion concentration.

Water is slightly dissociated into hydrogen and hydroxyl ions, with the product of the individual concentrations a constant 10-14. When these ions are present in equal quantities, with the concentrations 10-7, then the solution is neutral.

For convenience, such concentrations are e expressed as the negative log of the hydrogen-ion concentration . . . or the pH value. A pH of 7 indicates pure neutral water. A pH of less than 7 indicates acidic solutions. A pH of greater than 7 represents basic or alkaline solutions.

For all general purposes, the table at right represents the effect of pH on the rate of corrosion of iron or steel.

pH	**Rate of Corrosion**
Greater than 9.6	Slow
4.3 to 9.6	Medium
Less than 4.3	Rapid

It should be said of this summation (based on average inlet natural water temperatures) that the limits of the rapid corrosion zone are greatly expanded as the temperature increases.

It should also be pointed out that, while for the pH zone of 4.3 to 9.6 the corrosion has been indicated as being medium, the corrosion in this area can be particularly dangerous.

The principal factor influencing the rate of corrosion in the last group is the hydrogen-ion concentration. For the first two groups, the oxygen concentration is the dominant factor.

With the mechanism of corrosion and the important corrosive influence recognized, a few words on the prevention of corrosion are in order.

The first and foremost attack on the problem is, of course, pH control.

Should this treatment be impractical, then one of the two alternate methods should be considered:

1. Chemical treatment of the liquids, such as the addition of chemicals that facilitate the formation of a protective film on the metal surfaces.
2. Use of metals having the power to adapt themselves to the particular environment by forming self-protecting films.

KETEMA
HEAT TRANSFER DIVISION

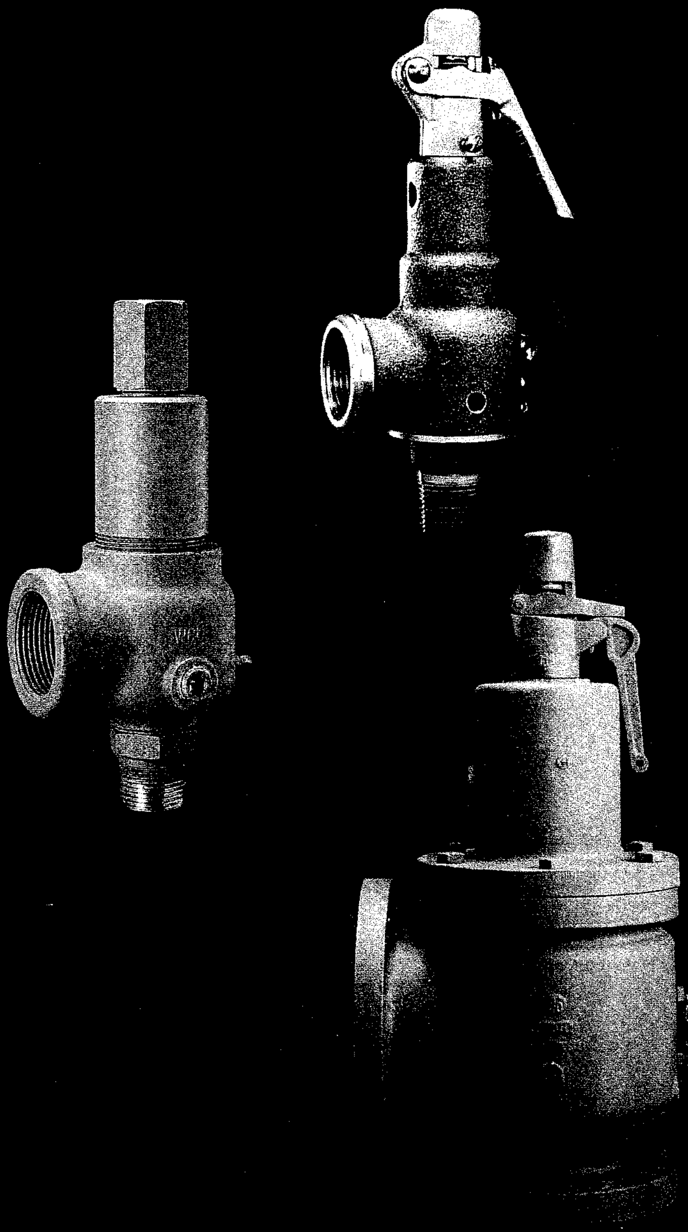
2300 West Marshall Drive, Grand Prairie, TX 75051

Mail: P.O. Box 534004, Grand Prairie, TX 75053-4004

(214)647-2626

FAX (214)641-1518

Safety and Relief Valve Products



KUNKLE®

An Anderson Greenwood Company

Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/Liquid, 'UV' National Board Certified. Also available for Vacuum Service

Pressure and Temperature Limits

Models 912, 913, 918, 919: – Steam
3 to 250 psig [-20 to 17 barg][1]
-60° to 406°F [-51° to 208°C]

Models 912, 918: – Air/Gas/Liquid
3 to 300 psig [-20 to 21 barg]
-60° to 406°F [-51° to 208°C]

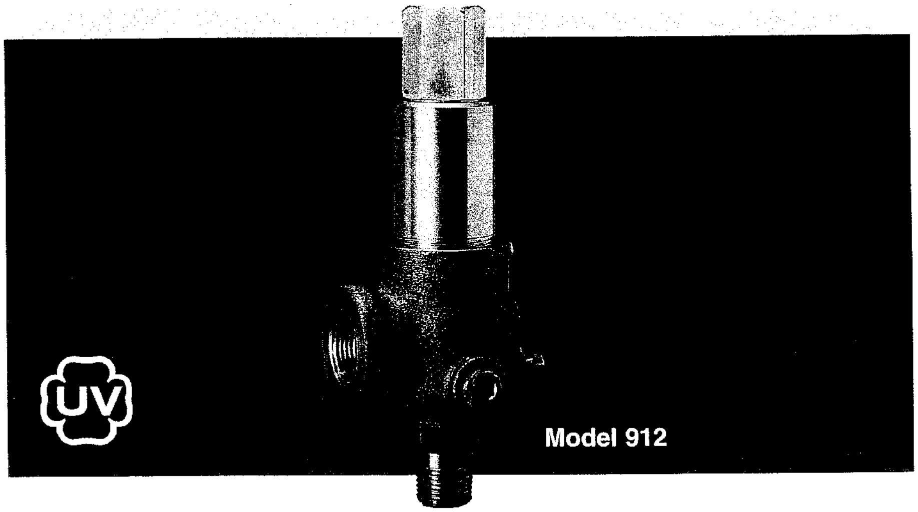
Models 913, 919: – Air/Gas/Liquid
3 to 900 psig [-20 to 62 barg]
-60° to 406°F [-51° to 208°C]

Vacuum – 6- through 29-inch HG
[200 through 1000 mbarg] – 300°F [149°C]

Maximum back pressure 50 psig [3 barg] - threaded cap and packed lever

Applications

- Air/gas compressors - intercoolers - aftercoolers.
- Liquid filled pressure vessels/systems - ASME Section VIII (UV).
- Pressure vessels - containing gas, air, liquid or steam. Including tanks and receivers.
- Vacuum systems including pumps, tanks and equipment.
- Optional materials for low temperature - cryogenic applications.
- Oil/gas separators.
- Overpressure relief and protection of pumps, tanks, lines and hydraulic systems.
- By-pass relief or pressure regulation.


Model 912

Features and Benefits

- **Available** with soft seat.
- **Threaded cap** is standard (back pressure tight).
- **Hex on valve nozzle** provides for easy installation.
- **Single control ring** offers easy adjustability of blowdown.
- **Pivoting disc design** corrects misalignment and offers exceptional performance.
- **Guide to nozzle ratio** reduces friction.
- **Full nozzle design** for optimum flow performance.
- **Threaded side outlet** for piped off discharge to eliminate fugitive emissions.

Model Descriptions

Model 912: Full nozzle design. SS warn ring and disc with brass/bronze base. Bronze/brass body and bonnet.

Model 913: Full nozzle design. Bronze/brass body and bonnet. 316 SS trim (base, disc and disc holder).

Model 918: Same as Model 912 except resilient seat/seal. Superior 'leak-free' performance.

Model 919: Same as Model 913 except resilient seat/seal. Superior 'leak-free' performance. Bronze body and bonnet. 316 SS trim (base, disc and disc holder).

Options

- Threaded cap. (Variation 01)
- Threaded cap with gag. (Variation 02)
- Plain lever. (Variation 03)
- Plain lever with gag. (Variation 04)
- Plain lever with vibration dampener. (Variation 05)
- Packed lever. (Variation 06)
- Packed lever with gag. (Variation 07)

Note

1. ASME standard valves for air or steam service must have lift lever. For steam boilers and generators.

Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, 'UV' National Board Certified. Also available for Vacuum Service

Service Recommendations for Resilient Seat/Seal Materials

Seat/Seal Materials[1]	Service Recommendation
BUNA-N (-40° to 200°F) [-40° to 93°C]	Air, Anhydrous Ammonia, Butane, Carbon Dioxide, Diesel Oil, Ethyl Chloride, Ethyl Ether, Freons #11 and 12, Fuel Oil, Gasoline, Helium, Hydrogen Sulphide, Kerosene, Lube Oil, Natural Gas, Nitrogen, Oxygen (Gas), Propane, Propylene, Sulphur Dioxide, Vinyl Chloride
Viton® A (-10° to 406°F) [-23° to 208°C]	Acetone, Air, Amyl Alcohol, Aniline, Benzine, Butane, Carbon Disulphide, Carbon Tetrachloride Dowtherm 'A' and 'E', Ethyl Chloride, Ethylene, Ethylene Glycol, Ethyl Alcohol, Gasoline, Hexane, Hydrogen Sulphide, Isobutyl Alcohol, JP - 4 Fuel, JP - 5 Fuel, Kerosene, Lube Oil, Natural Gas, Naphtha, Nitrogen, Propane, Propylene, Propyl Alcohol, Sulphur Dioxide, Toluene, Trichloroethylene, Turpentine, Water, Xylene
Silicone (-100° to 406°F) [-73° to 208°C]	Air, Helium, Nitrogen, Oxygen (Gas)
Ethylene Propylene (-70° to 400°F) [-57° to 205°C]	Steam, Hot Water
Neoprene (-45° to 300°F)[-43° to 149°C]	Air, Anhydrous Ammonia, Butane, Butyl Alcohol, Castor Oil Denatured Alcohol, Ethanol, Ethyl Alcohol, Freons (12, 13, 14 and 22), Glycols, Natural Gas and Silicate Esters

Note

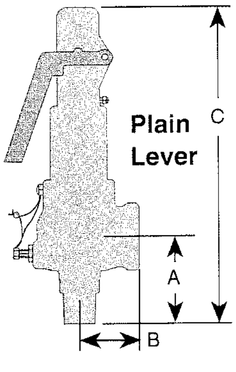
1. These recommendations are a guide only. For the final selection of the proper material, your experience with available elastomers of various lading fluids should be considered.

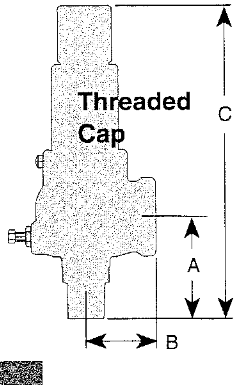
Specifications

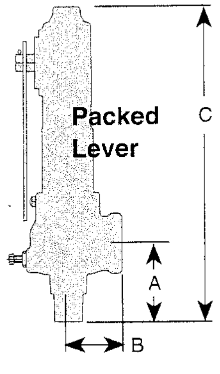
Model[2] Number	Orifice	Connections ANSI Standard Inlet		Connections ANSI Standard Outlet		Maximum Set Pressure psig [barg] 912-918[4]		Maximum Set Pressure psig [barg] 913-919[5]		Dimensions, in [mm] A		Dimensions, in [mm] B		Dimensions, in [mm] C Plain Lever		Dimensions, in [mm] C Threaded Cap		Dimensions, in [mm] C Packed Lever		Approx. Weight lb	[kg]
9*BDC	D	1/2"	[12.7]	3/4"	[19.0]	300	[20.7]	900	[62.1]	2 3/8	[60]	1 5/8	[41]	8 3/8	[213]	7 1/4	[184]	9	[229]	3	[1.4]
9*BDC	D	1/2"	[12.7]	1"	[25.4]	300	[20.7]	900	[62.1]	2 3/8	[60]	1 5/8	[41]	8 3/8	[213]	7 1/4	[184]	9	[229]	3	[1.4]
9*BDD[3]	D	3/4"	[19.0]	3/4"	[19.0]	—	—	900	[62.1]	2 3/8	[60]	1 5/8	[41]	8 3/8	[213]	7 1/4	[184]	9	[229]	3	[1.4]
9*BDE[3]	D	1"	[25.4]	1"	[25.4]	—	—	900	[62.1]	2 5/8	[67]	1 5/8	[41]	8 5/8	[219]	7 1/2	[191]	9 1/8	[232]	3	[1.4]
9*BED	E	3/4"	[19.0]	1 1/4"	[31.8]	300	[20.7]	900	[62.1]	2 5/8	[67]	2	[51]	8 3/4	[222]	7 5/8	[194]	9 3/8	[238]	4	[1.8]
9*BEF[3]	E	1 1/4"	[31.8]	1 1/4"	[31.8]	—	—	900	[62.1]	3	[76]	2	[51]	9 1/8	[232]	8	[203]	9 3/4	[248]	4	[1.8]
9*BFE	F	1"	[25.4]	1 1/2"	[38.1]	300	[20.7]	600	[41.4]	2 7/8	[73]	2 3/8	[60]	9 7/8	[251]	8 3/4	[222]	10 1/2	[267]	6	[2.7]
9*BFG[3]	F	1 1/2"	[38.1]	1 1/2"	[38.1]	—	—	600	[41.4]	3	[76]	2 3/8	[60]	10	[254]	8 7/8	[225]	10 5/8	[270]	6	[2.7]
9*BGF	G	1 1/4"	[31.8]	2"	[50.8]	300	[20.7]	600	[41.4]	3 1/4	[89]	2 5/8	[67]	11 1/4	[286]	10 1/8	[257]	11 3/4	[298]	8	[3.6]
9*BGH[3]	G	2"	[50.8]	2"	[50.8]	—	—	600	[41.4]	3 1/4	[89]	2 5/8	[67]	11 1/4	[286]	10 1/8	[257]	11 3/4	[298]	8	[3.6]
9*BHG	H	1 1/2"	[38.1]	2 1/2"	[63.5]	300	[20.7]	500	[34.5]	3 1/2	[89]	2 3/4	[70]	13	[330]	11 1/8	[283]	12 1/2	[318]	11	[5.0]
9*BJH	J[6]	2"	[50.8]	3"	[76.2]	300	[20.7]	500	[34.5]	4	[102]	3 1/4	[89]	14 1/2	[368]	12 1/2	[318]	15 1/8	[384]	15	[6.8]

Notes

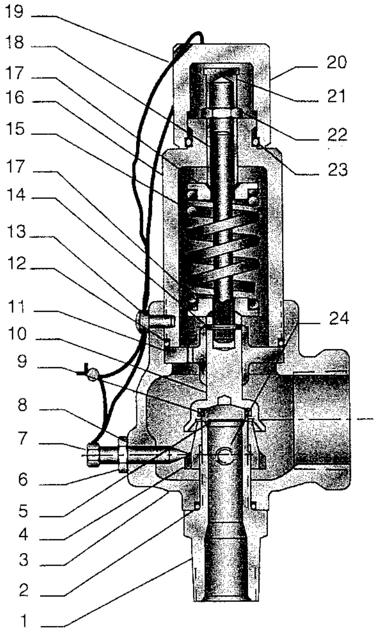
1. Maximum temperature controlled by resilient seat/seal material.
2. Replace asterisk with desired Model Number. Data applicable to all models.
3. Available with SS trim only.
4. Maximum pressure on steam is 250°F.
5. Maximum pressure on steam is 300°F.
6. For C dimensions: pressures above 200 psig [14 barg] add 1.25-inch [31.8 mm] to the overall height.







Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, 'UV' National Board Certified. Also available for Vacuum Service



Parts and Materials - Models 912, 913, 918, 919 Threaded Cap

No.	Part Name	Materials
1	Nozzle[1]	Brass, B21 Alloy 485, (SS, A351-CF8M[1] Models 913, 919 only)
2	O-ring Body	Teflon®
3	Body	Bronze, B584 Alloy 84400
4	Warn Ring	SS, A743-CF8M
5	Disc[2]	SS, A479-316
6	Set Screw Nut	Brass, B16
7	Set Screw	Brass, B16
8	Seal	Teflon®
9	Retainer Ring	SS, A313-316
10	Disc Holder	Brass, B16, (SS A351-CF8M Models 913, 919 only)
11	Guide[3]	Brass, B16
12	Bonnet O-ring	Teflon®
13	Screw	SS, Commercial 18-8
14	Coiled Spring Pin	SS, A313-302
15	Spring	Steel A231/A231M, Cadmium Plated SS: A313-302 SS: A313-316 Alloy steel: A681-H12
16	Bonnet[4]	Brass, B16
17	Spring Step	Brass, B16
18	Stem	Brass, B16
19	Wire and Seal	SS wire and Lead seal, Commercial
20	Cap	Brass, B16
21	Compression Screw	Brass, B16
22	Jam Nut	Brass, B16
23	Cap O-ring	BUNA-N
24	Body Plug[5]	Brass, B16
25	Guide Guide Locknut Shield	Brass, B16 Brass, B16 SS, A167-316
26	Disc Holder Spindle	Brass, B16 (Model 912 only) Brass, B16 (Model 912 only)

Notes

1. F through J orifice nozzle material is Bronze, B62.
2. Material / Letter Designation

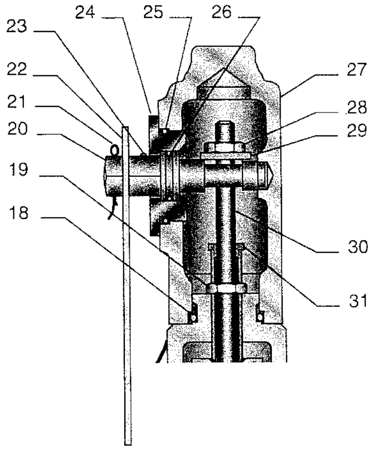
Material	Letter Designation
Viton®-A	A
BUNA-N	B
Silicone	S

3. G through J orifice guide material is Bronze, B584, Alloy 84400.
4. F through J orifice bonnet material is Bronze, B584, Alloy 84400.
5. Body plug and tapped hole not available for liquid service.

Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, 'UV' National Board Certified. Also available for Vacuum Service

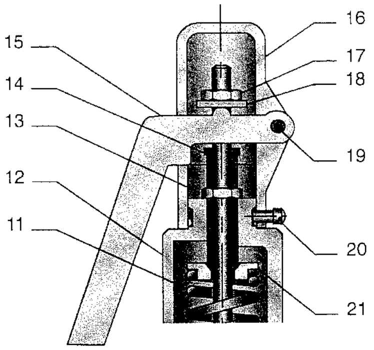
Parts and Materials - Model 912 Packed Lever

No.	Part Name	Materials
18	Cap O-ring	BUNA-N 70 Duro, Commercial
19	Jam Nut	Brass, B16
20	Lift Cam	SS, A743 CF8M
21	Cotter Pin	Steel, Commercial
22	Lever	Zinc Plated Steel, A108
23	Drive Screw	SS, Commercial
24	Retainer Nut	Brass, B16
25	Retainer O-ring	BUNA-N 70 Duro, Commercial
26	Lift Cam O-ring	BUNA-N 70 Duro, Commercial
27	Cap	Bronze, B584 Alloy 84400
28	Lift Nut	SS, A479 316
29	Lift Washer	SS, A479 316
30	Stem	Brass, B16
31	Compression Screw	Brass, B16
32	Coiled Spring Pin	SS, A313 302
33	Body Plug[4]	Brass, B16
34	Guide Guide Locknut Shield	Brass, B16 Brass, B16 SS, A167 316



Parts and Materials - Model 912 Plain Lever

No.	Part Name	Materials
11	Spring	Cadmium plated steel: A231/A231M SS: A313-302 SS: A313-316 Alloy steel: A681-H12
12	Bonnet[3]	Brass, B16
13	Jam Nut	Brass, B16
14	Compression Screw	Brass, B16
15	Lever	Steel Cadmium Plated, A109
16	Cap	Brass, B179
17	Lift Nut	SS, A479-316
18	LIft Washer	SS, A479-316
19	Rivet	Steel, Commercial
20	Screw	SS, Commercial GR. 18-8
21	Spring Step	Brass, B16
22	Disc Holder Spindle	Brass, B16 Brass, B16



Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, 'UV' National Board Certified. Also available for Vacuum Service

Model Number/Order Guide

Model Number Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Example	9	1	2	B	J	H	M	0	1	—	K	C	0	3	0	0

Model
912
913
918
919

Connection Model
B - Male x Female Threaded or NPT

Orifice
D
E
F
G
H
J

Inlet Size
C - 1/2-inch [15 mm]
D - 3/4-inch [18 mm]
E - 1-inch [25 mm]
F - 1 1/4-inch [32 mm]
G - 1 1/2-inch [40 mm]
H - 2-inch [50 mm]

Seat/Seal Material
M - Metal-to-metal
B - BUNA-N 200°F [93°C]
E - EPR 350°F [177°C]
S - Silicone 406°F [208°C]
V - Viton® 406°F [208°C]
N - Neoprene 300°F [149°C]

Variation (01 through 99)
Number provided only by manufacturer to cover specific feature or option.
01 - Threaded cap
02 - Threaded cap with gag
03 - Plain lever
04 - Plain lever with gag
05 - Plain lever with vibration dampener
06 - Packed lever
07 - Packed lever with gag

Design Revision
Indicates non-interchangeable revision. Dash (-) if original design.

Valve Service
J - Liquid ASME Section VIII (Standard Cap/Packed Lever only)
K - Air/Gas ASME Section VIII (Plain Lever/Packed Lever required for air)
L - Steam ASME Section VIII (Plain Lever/Packed Lever required)
M - Liquid (Standard Cap/Packed Lever only)
Q - Vacuum (Standard Cap/Packed Lever only)

Spring Material
E - SS

Set Pressure
3 psig [0.2 barg] (0003) through 900 psig [62 barg] (0900)
Vacuum 6-inch HG [200 mbarg] (0006) through 29-inch HG [1000 mbarg] (0029)

INSTALLATION & MAINTENANCE INSTRUCTIONS

ASCO®
BULLETIN
8320

3-WAY SOLENOID VALVES — NORMALLY OPEN, NORMALLY CLOSED, AND UNIVERSAL OPERATION 1/4" NPT — BRASS AND STAINLESS STEEL CONSTRUCTION

Form No.V5688R2

DESCRIPTION

Bulletin 8320 valves are small 3-way solenoid valves with all three connections located in the body. Valve bodies are made of brass or stainless steel.

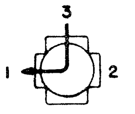
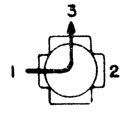
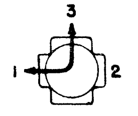
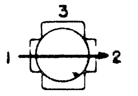
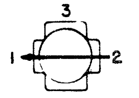
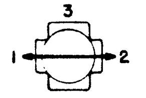
Standard valves have a Type 1, General Purpose Solenoid Enclosure. Valves may also be provided with an explosion-proof solenoid enclosure designed to meet Enclosure Type 3-Raintight, Type 7 (C & D)-Explosion-Proof Class I, Groups C & D and Type 9 (E, F, & G)-Dust Ignition-Proof Class II, Groups E, F, & G, and have a temperature range code of TC3. Installation and maintenance instructions for the explosion-proof solenoid enclosure are on Form No.V5380.

OPERATION

Normally Open (Pressure at 3)
Applies pressure when solenoid is de-energized; exhausts pressure when solenoid is energized. When solenoid is de-energized, flow is from Port "3" to Port "1." Port "2" is closed. When solenoid is energized, flow is from Port "1" to "2." Port "3" is closed.

Normally Closed (Pressure at 2)
Applies pressure when solenoid is energized; exhausts pressure when solenoid is de-energized. When solenoid is de-energized, flow is from Port "1" to Port "3." Port "2" is closed. When solenoid is energized, flow is from Port "2" to Port "1." Port "3" is closed.

Universal (Pressure at 1, 2, or 3)
For normally closed or normally open operation, selection or diversion of pressure can be applied to Ports "1", "2", or "3."

FLOW DIAGRAMS			
NORMALLY OPEN PRESS. AT 3	NORMALLY CLOSED PRESS. AT 2	UNIVERSAL-PRESS. AT ANY ORIFICE.	FORM
			SOL. DE-ENERGIZED
			SOL. ENERGIZED

Manual Operator (Optional)
Manual operator allows manual operation when desired or during an electrical power outage. Two types of manual operators are available - push type (Suffix MO) and screw type (Suffix MS). To operate valve manually with push type operator, push stem at base of valve body as far upward as possible. Valve will now be in the same position as when the solenoid is energized. Removing pressure from stem will release manual operator to original position. To operate valve with a screw type manual operator, rotate manual operator stem at base of valve body clockwise until it hits a stop. Valve will now be in the same position as when the solenoid is energized. Rotate manual operator stem fully counterclockwise before operating valve electrically.

INSTALLATION

Check nameplate for correct catalog number, pressure, voltage, frequency, and service.

Temperature Limitations

For maximum valve ambient and fluid temperatures, refer to chart below. Check catalog number prefix and watt rating on nameplate to determine the maximum temperatures. See example below chart.

Construction AC or DC	Catalog Number Prefix	Watts	Maximum Ambient Temp. °F	Maximum Fluid Temp. °F
AC	None, DA, or S	10.5	77	200
	DF, FT, or SF	10.5	122	200
	HT	10.5	140	200
	None, DP, or SP	16.7*	77	200
DC	None, FT, or HT	11.2*	77	150

*Catalog Nos. 8320A170, 8320A180, and 8320A190 are limited to 140 °F fluid temperature.

EXAMPLES: For Catalog No.HT8320A201, AC construction with a watt rating of 10.5, the maximum ambient temperature is 140°F with a maximum fluid temperature of 200°F. For Catalog No. 8320A204, AC construction with a watt rating of 10.5, the maximum ambient temperature is 77°F with a maximum fluid temperature of 200°F.

Positioning

This valve is designed to perform properly when mounted in any position. However, for optimum life and performance, the solenoid should be mounted vertically and upright to reduce the possibility of foreign matter accumulating in the solenoid base sub-assembly area.

Mounting

For mounting dimensions of body boss (brass) or mounting brackets (optional on brass construction), refer to Figures 1, 2, and 3.

Piping

Connect piping to valve according to markings on valve body. Refer to flow diagrams provided. Apply pipe compound sparingly to male pipe threads only. If applied to valve threads, the compound may enter the valve and cause operational difficulty. Avoid pipe strain by properly supporting and aligning piping. When tightening the pipe, do not use valve or solenoid as a lever. Locate wrenches applied to valve body or piping as close as possible to connection point. **IMPORTANT: To protect the solenoid valve, install a strainer or filter, suitable for the service involved in the inlet side as close to the valve as possible. Clean periodically depending on service conditions. See ASCO Bulletins 8600, 8601, and 8602 for strainers.**

Wiring

Wiring must comply with local codes and the National Electrical Code. Solenoid housings are provided with a 7/8" diameter hole to accommodate 1/2" conduit. On some constructions, a green grounding wire is provided. Use rigid metallic conduit to ground all enclosures not provided with a green grounding wire. To facilitate wiring, the enclosure may be rotated 360° by removing the retaining cap or clip. **WARNING: When metal retaining clip disengages, it will spring upward.** Rotate enclosure to desired position. Then replace retaining cap or clip before operating.

NOTE: Alternating current (AC) and direct current (DC) solenoids are built differently. To convert from one to the other, it is necessary to change the complete solenoid, including the solenoid base sub-assembly and core assembly.

ASCO Valves ASCO
Printed in U.S.A.
Automatic Switch Co. 50-60 Hanover Road, Florham Park, New Jersey 07932

Solenoid Temperature

Standard catalog valves are supplied with coils designed for continuous duty service. When the solenoid is energized for a long period, the solenoid enclosure becomes hot and can be touched by hand only for an instant. This is a safe operating temperature. Any excessive heating will be indicated by the smoke and odor of burning coil insulation.

MAINTENANCE

NOTE: It is not necessary to remove the valve from the pipeline for repairs.
WARNING: Turn off electrical power supply and depressurize valve before making repairs.

Cleaning

All solenoid valves should be cleaned periodically. The time between cleanings will vary depending on the medium and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive noise, or leakage will indicate that cleaning is required. Clean valve strainer or filter when cleaning the valve.

Preventive Maintenance

1. Keep the medium flowing through the valve as free from dirt and foreign material as possible.
2. While in service, the valve should be operated at least once a month to insure proper opening and closing.
3. Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. Replace worn or damaged parts. However, for best results, replace all parts as supplied with an ASCO Rebuild Kit.

Causes Of Improper Operation

1. **Faulty Control Circuits:** Check the electrical system by energizing the solenoid. A metallic "click" signifies that the solenoid is operating. Absence of the "click" indicates loss of power supply. Check for loose or blown fuses, open circuited or grounded coil, broken lead wires or splice connections.
2. **Burned-Out Coil:** Check for open-circuited coil. Replace coil as necessary. Check supply voltage; it must be the same as specified on nameplate.
3. **Low Voltage:** Check voltage across the coil lead. Voltage must be at least 85% of nameplate rating.
6. **Incorrect Pressure:** Check valve pressure. Pressure to valve must be within range specified on nameplate.
5. **Excessive Leakage:** Disassemble valve (see Maintenance) and clean all parts. Replace worn or damaged parts. However, for best results, replace all parts as supplied with an ASCO Rebuild Kit.

Coil Replacement (Refer to Figures 4 and 5)

WARNING: Turn off electrical power supply.

1. Disconnect coil lead wires.
2. Remove retaining cap or clip, nameplate and housing. **WARNING: When metal retaining clip disengages, it will spring upward.**
3. Remove spring washer, insulating washer, coil, insulating washer, ground wire terminal (if present) from solenoid base sub-assembly. Insulating washers are omitted when a molded coil is used.
4. Reassemble in reverse order of disassembly. Use exploded view provided for identification and placement of parts.

CAUTION: The solenoid must be fully reassembled because the housing and internal parts complete the magnetic circuit. Be sure to replace insulating washer at each end of the non-molded coil.

Valve Disassembly (Refer to Figures 4 and 5)

WARNING: Depressurize valve and turn off electrical power supply.

1. Disassemble valve in an orderly fashion. Use exploded views for identification and placement of parts.
2. If necessary, disconnect coil lead wires, grounding wire (if present), and rigid conduit from solenoid housing.
3. Remove retaining cap or clip and slip the entire solenoid enclosure off the solenoid base sub-assembly. **WARNING: When metal retaining clip disengages, it will spring upward.**
4. Unscrew solenoid base sub-assembly from valve body.
5. Remove core assembly, core spring, core guide (AC construction only), and solenoid base gasket.
6. Unscrew end cap (or manual operator assembly) and remove end cap gasket, disc holder spring, and disc holder sub-assembly.
7. All parts are now accessible to clean or replace. Replace worn or damaged parts. However, for best results, replace all parts as supplied with an ASCO Rebuild kit.

Valve Reassembly

1. Reassemble in reverse order of disassembly. Use exploded views for identification and placement of parts.
2. Lubricate all gaskets with DOW CORNING® 111 Compound lubricant or an equivalent high-grade silicone grease. For stainless steel valve constructions, apply a small amount of LOCTITE® PST® pipe sealant (ASCO No. 208-832-11) to male threads of end cap (or manual operator assembly). Pipe sealant supplied in ASCO Rebuild Kits.
3. Replace disc holder sub-assembly, disc holder spring, end cap gasket, and end cap (or manual operator assembly). For brass construction, torque end cap to 175 ± 25 inch-pounds (19,8 ± 2,8 newton-meters). For stainless steel, torque end cap to 90 ± 10 inch-pounds (10,2 ± 1,1 newton-meters).
4. Replace solenoid base gasket, core assembly, core spring, core guide (on AC construction only), and solenoid base sub- assembly. Torque solenoid base sub-assembly to 175 ± 25 inch-pounds (19,8 ± 2,8 newton-meters).
5. Replace solenoid enclosure and retaining cap or clip.
6. Restore line pressure and electrical power supply to valve.
7. After maintenance is completed, operate the valve a few times to be sure of proper operation. A metallic "click" signifies the solenoid is operating.

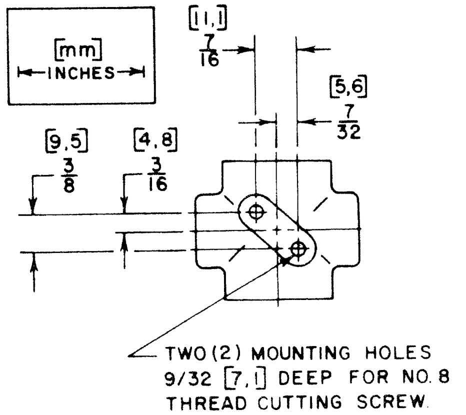
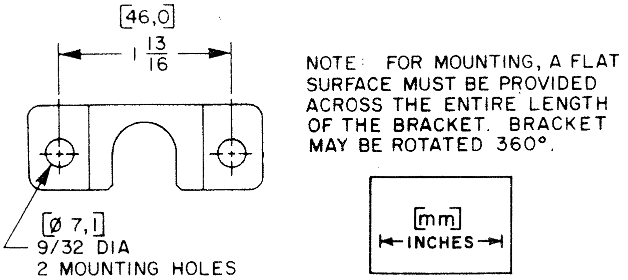


Figure 1. Brass Valve Body Mounting



NOTE: FOR MOUNTING, A FLAT SURFACE MUST BE PROVIDED ACROSS THE ENTIRE LENGTH OF THE BRACKET. BRACKET MAY BE ROTATED 360°.

Figure 2. Mounting Bracket for Stainless Steel

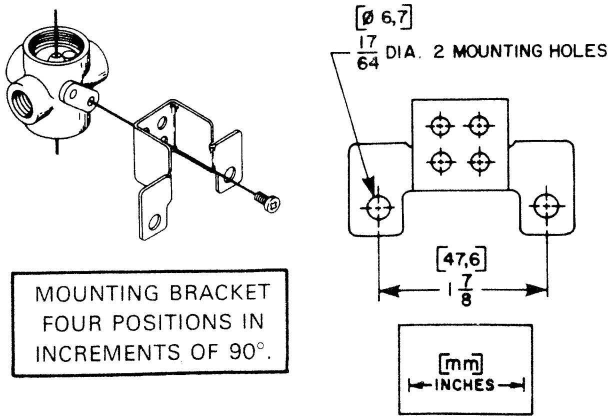


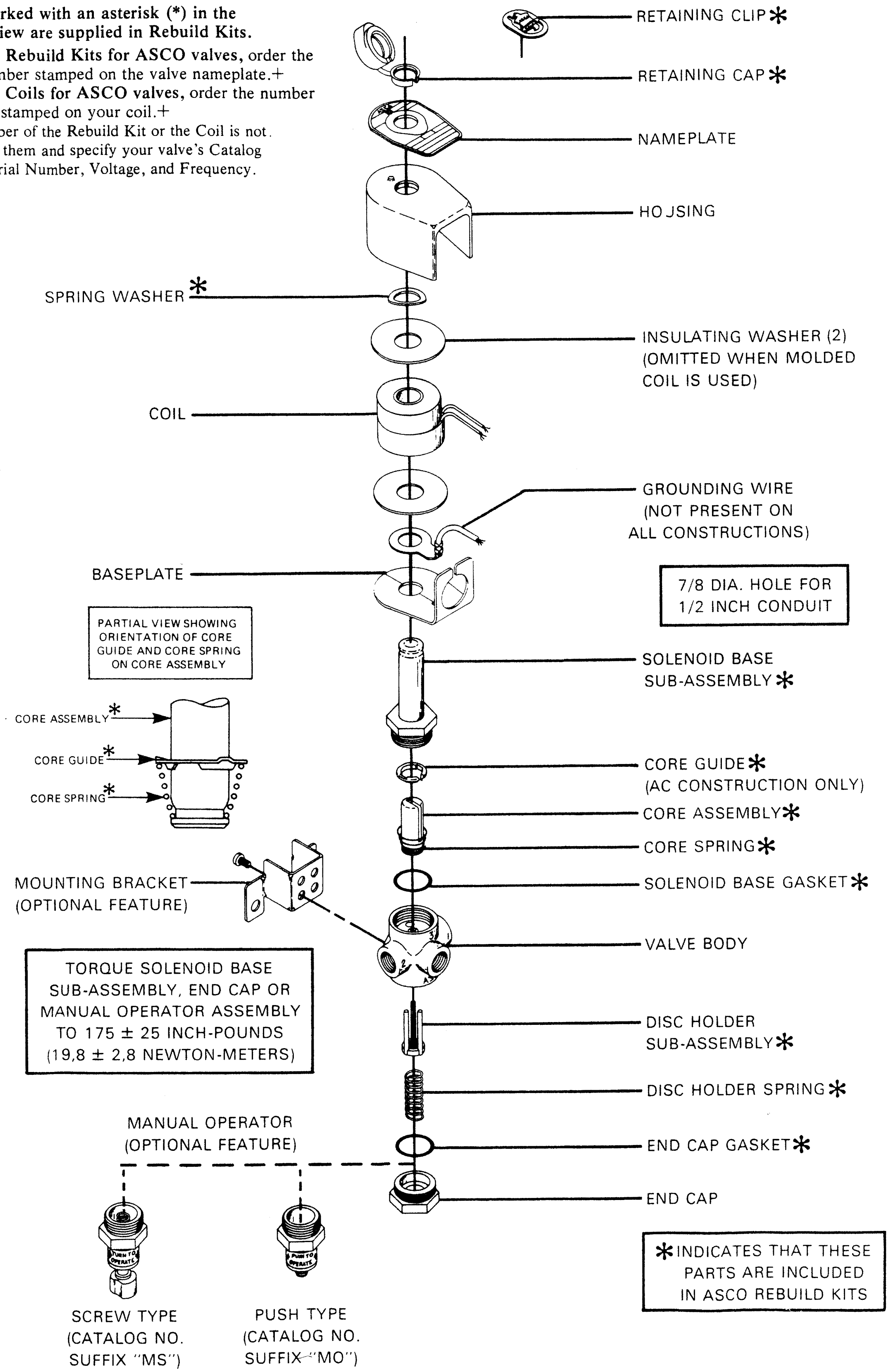
Figure 3. Optional Mounting Bracket for Brass

ORDERING INFORMATION FOR ASCO REBUILD KITS AND COILS

Parts marked with an asterisk (*) in the exploded view are supplied in Rebuild Kits.

- **When Ordering Rebuild Kits for ASCO valves,** order the Rebuild Kit number stamped on the valve nameplate.+
- **When Ordering Coils for ASCO valves,** order the number stamped on your coil.+

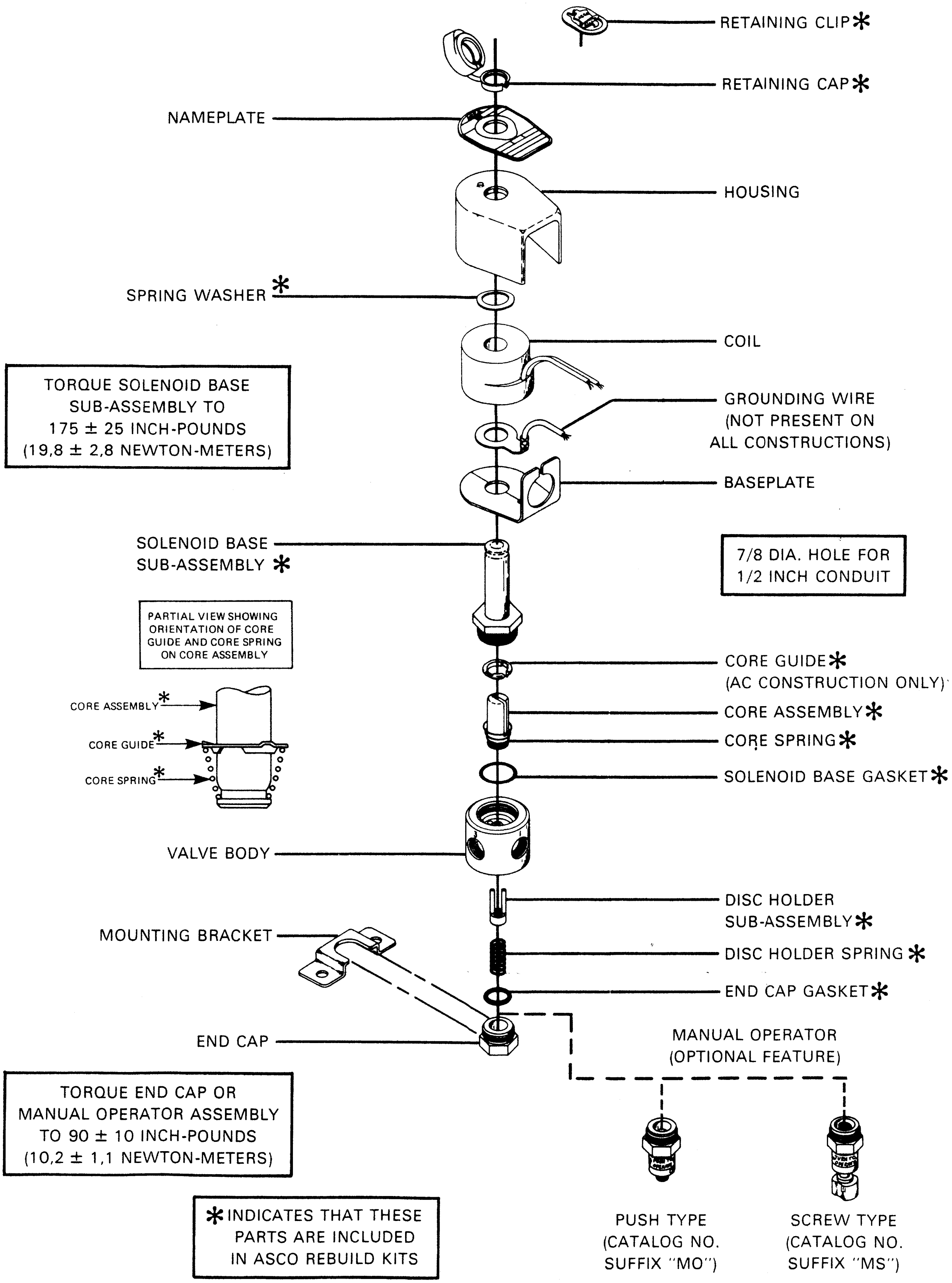
\+ If the number of the Rebuild Kit or the Coil is not visible, order them and specify your valve's Catalog Number, Serial Number, Voltage, and Frequency.



TORQUE SOLENOID BASE SUB-ASSEMBLY, END CAP OR MANUAL OPERATOR ASSEMBLY TO 175 ± 25 INCH-POUNDS (19,8 ± 2,8 NEWTON-METERS)

✱ INDICATES THAT THESE PARTS ARE INCLUDED IN ASCO REBUILD KITS

Figure 4. Bulletin 8320, Brass Construction With General Purpose Solenoid Enclosure Shown For Explosion-Proof Solenoid Enclosure, See Form No.V5380.



TORQUE SOLENOID BASE SUB-ASSEMBLY TO 175 ± 25 INCH-POUNDS (19,8 ± 2,8 NEWTON-METERS)

7/8 DIA. HOLE FOR 1/2 INCH CONDUIT

TORQUE END CAP OR MANUAL OPERATOR ASSEMBLY TO 90 ± 10 INCH-POUNDS (10,2 ± 1,1 NEWTON-METERS)

* INDICATES THAT THESE PARTS ARE INCLUDED IN ASCO REBUILD KITS

Figure 5. Bulletin 8320, Stainless Steel Construction With General Purpose Solenoid Enclosure Shown. For Explosion- Proof Solenoid Enclosure, See Form No.V5380.

Installation, Operation, Maintenance Instructions

Valtek Mark One and Mark Two Control Valves

GENERAL INFORMATION

The following instructions are designed to assist in unpacking, installing and performing maintenance as required on Valtek® Mark One and Mark Two control valves. Product users and maintenance personnel should thoroughly review this bulletin prior to installing, operating or performing any maintenance on the valve. Separate installation, operation, maintenance instructions cover additional features (such as special trim, diaphragm actuator, handwheel and extension bonnets).

This publication does not contain information on Valtek positioners. Refer to the appropriate Installation, Operation, Maintenance Instructions for installing, maintaining, troubleshooting, calibrating and operating Valtek positioners.

To avoid possible injury to personnel or damage to valve parts, WARNING and CAUTION notes must be strictly followed. Modifying this product, substituting non-factory parts or using maintenance procedures other than outlined could drastically affect performance and be hazardous to personnel and equipment and may void existing warranties.

WARNING: Standard industry safety practices must be adhered to when working on this or any other process control product. Specifically, personal protective and lifting devices must be used as warranted.

NOTE: *Selecting the proper fastener material is the responsibility of the customer. Typically, the supplier does not know what the valve service conditions or environment may be. Flowserve's standard body bolting material is B7/2H. B8 (stainless steel) is optional for applications more than 800° F / 425° C and with stainless steel or alloy body valves. The customer therefore must consider the material's resistance to stress corrosion cracking in addition to general corrosion. As with any mechanical equipment,* ***periodic inspection and maintenance is required****. For more information about fastener materials, contact your Flowserve representative.*

Unpacking

1. While unpacking the valve, check the packing list against materials received. Lists describing valve and accessories are in each shipping container.
2. When lifting the valve from shipping container, position the lifting straps through the yoke legs to avoid damage to the tubing and mounted accessories.

   WARNING: When lifting an actuator with lifting straps through the yoke legs, be aware that the center of gravity may be above the lifting point. Therefore, support must be given to prevent the actuator from rotating. Failure to do so can cause serious injury to personnel, damage to the valve or nearby equipment.

3. Contact your shipper immediately if there is shipping damage.
4. Should any problem arise, call your representative.

Installation

1. Before installing the valve, clean the line of dirt, welding chips, scale or other foreign material.
2. Whenever possible, the valve should be installed in an upright position. Vertical installation permits easier valve maintenance. This is also important for cryogenic applications to keep the packing isolated from the flowing medium, permitting the packing temperature to remain close to ambient temperature.

   CAUTION: Do not insulate extension bonnets that are provided for hot or cold services.

Table I: Overhead Clearance Requirement

Valve Size (inches)	Clearance (inches)	Valve Size (inches)	Clearance (inches)
1/2, 3/4, 1	3 / 76	6	10 / 254
1 1/2, 2	5 / 127	8	13 / 330
3	6 / 152	10	14 / 356
4	8 / 203	12	15 / 381

3. Be sure to provide proper overhead clearance for the actuator to allow for disassembly of the plug from the valve body. Refer to Table I for the necessary clearance needed for valve disassembly.
4. Double-check flow direction to be sure the valve is installed correctly. Flow direction is shown by the arrow attached to the body flange. Standard air-to-open valves close on air failure and should be installed so the flow tends to close the valve, except in rare circumstances that will be clearly indicated. Standard air-to-close valves open on air failure and should be installed with the flow tending to open the valve.
5. If welding the valve into the line, use extreme care to avoid excess heat buildup in the valve.
6. If the valve has separable end flanges, the half rings must be installed on the valve body before bolting the valve into the line to ensure a tight connection.

   WARNING: Failure to install half rings on the valve body can cause serious personal injury.

7. Connect air supply and instrument signal (air or mA) lines. Throttling control valves are equipped with a valve positioner. Two connections are marked: one for the air supply and the other for the instrument signal. Both the actuator and the positioner are suitable for 150 psi / 10.3 Bar air supply. An air regulator is not required unless the supply pressure exceeds 150 psi / 10.3 Bar. An air filter should be installed before the positioner unless supply air is clean and dry. All connections must be free of leaks.

   CAUTION: On valves equipped with air filters, the air filter must point down to perform properly.

   NOTE: *In some rare cases, the air supply must be limited to less than 150 psi / 10.3 Bar. This is indicated on a sticker found near the upper air port on the actuator cylinder. An air regulator should be installed to ensure the supply pressure does not exceed the line pressure indicated on the sticker.*

Table II: Common Lubricants

Lubricant	Manufacturer	Temperature Range	Description Applications
Krytox 206	E.I. DuPont	-5° to 550° F / -20° to 285° C	Fluorinated general purpose grease; handles common liquids and gases; good lubricity in harsh mediums; nonflammable, chemically inert; will not harm plastic or metal parts
GP 460	Graphite Products Co.	32° to 1000° F / 0° to 540° C	Graphite in petrolatum; high pressures; anti-galling, graphite remains above 600° F / 316° C
Aeroshell Grease 7	Shell Oil Co.	-100° to 300° F / -75° to 150° C	Synthetic oil based; low temperature applications
Garlock Luball	Garlock Inc.	32° to 500° F / 0° to 260° C	General purpose molybdenum disulfide lubricant economical; good in water, steam and common chemicals; not good in harsh mediums where Krytox 206 is recommended

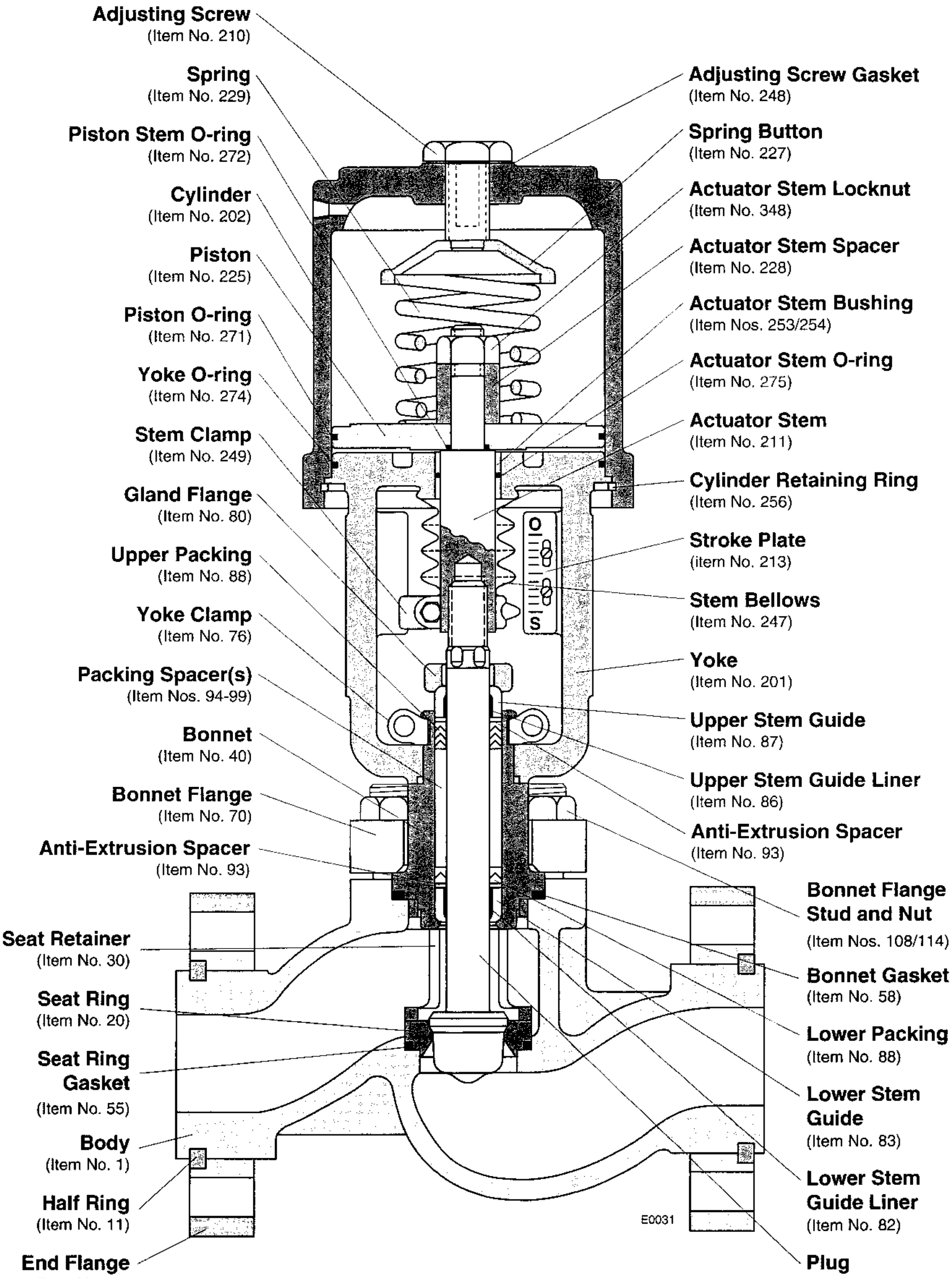


Figure 1: Mark One Control Valve

***NOTE:** Item numbers correspond directly to the valve's bill of material. Refer to it for specific part numbers.*

Quick-check

Prior to start-up, check the control valve by following these steps:

1. Stroke the valve and observe the plug position indicator on the stem clamp compared to the stroke indicator plate. The plug should change position in a smooth, linear fashion.
2. Check for full stroke by making appropriate instrument signal change: 3-15, 3-9, 9-15 psi / 0-1, 0-0.6, 0.6-1 Bar or associated split ranges for pneumatic positioners, 4-20 or 10-50 mA for electro-pneumatic positioners).
3. Check all air connections for leaks.
4. Adjust the packing nuts to slightly over finger-tight.

   CAUTION: Do not overtighten packing. This can cause excessive packing wear and high stem friction that may impede plug movement.
5. Make sure the valve fails in the correct direction in case of air failure. This is done by shutting off the air supply and observing the failure direction.
6. After temperature excursion has occurred, bonnet flange bolting should be retightened to ensure bonnet gaskets do not leak. See Table III.

VALVE MAINTENANCE

At least once every six months, check for proper operation by following the preventative maintenance steps outlined below. These steps can be performed while the valve is in-line and, in some cases, without interrupting service. If an internal problem is suspected, refer to the "Valve Disassembly and Reassembly" section.

1. Look for signs of gasket leakage through the end flanges and bonnet. Tighten flange and bonnet bolting (if required). See Table III.
2. Check for fluid leakage to the atmosphere through the pressure-balance sleeve, metal bellows seal and body drain plug.
3. Examine the valve for damage caused by corrosive fumes or process drippings.
4. Clean valve and repaint areas of severe oxidation.
5. Check packing box bolting for proper tightness. Packing nuts should be slightly over finger-tight; however, tighten only as necessary to prevent stem leakage.

   CAUTION: Do not overtighten packing. This can cause excessive packing wear and high stem friction that may impede stem movement.
6. If the valve is supplied with a lubricator fitting, check lubricant supply and add lubricant if necessary. See Table II for common lubricants.
7. If possible, stroke the valve and check for smooth, full-stroke operation. Unsteady stem movement could indicate an internal valve problem.

   NOTE: Jerky stem motion is normal whenever graphite packing is used.

   WARNING: Keep hands, hair and clothing away from all moving parts when operating the valve. Failure to do so can cause serious injury.
8. Make sure positioner linkage and stem clamp are securely fastened. If the stem clamp is loose, check plug thread engagement (refer to the "Reassembling the Actuator" section for the correct procedure on aligning the plug with the seat.)
9. Ensure all accessories, brackets and bolting are securely fastened.
10. If possible, remove air supply and observe actuator for correct fail-safe action.
11. Check rubber bellows for wear.
12. Spray a soap solution around the cylinder actuator retaining ring, adjusting screw and actuator stem guide to check for air leaks through the O-rings.
13. Clean any dirt and other foreign material from the plug stem.
14. If an air filter is supplied, check and replace cartridge if necessary.

VALVE DISASSEMBLY AND REASSEMBLY

Disassembling the Body

To disassemble the valve body, refer to Figures 1 and 4 then proceed as follows:

WARNING: Depressurize line to atmospheric pressure and drain all fluids before working on the valve. Failure to do so can cause serious injury.

1. If valve is air-to-open, apply air under the piston to lift the plug off the seat before taking the valve apart. If valve is air-to-close, proceed to step 2.
2. Remove the bonnet flange bolting and lift actuator, bonnet and plug out of the valve.

   CAUTION: Heavy actuators may require a hoist. Lift the valve with the yoke legs using a lifting strap and a hoist. Great care should be taken to lift the actuator and plug straight out of the body to avoid damage to the plug and seat.
3. Lift retainer, seat ring and gaskets free of the body.
4. Check to see the seating surfaces on both the seat ring and plug are free of damage to ensure tight shutoff. Make sure the gasket surfaces on the seat ring, bonnet and body are clean and undamaged.
5. To inspect the plug, remove by loosening the stem clamp and gland flange and by taking off the yoke clamps.

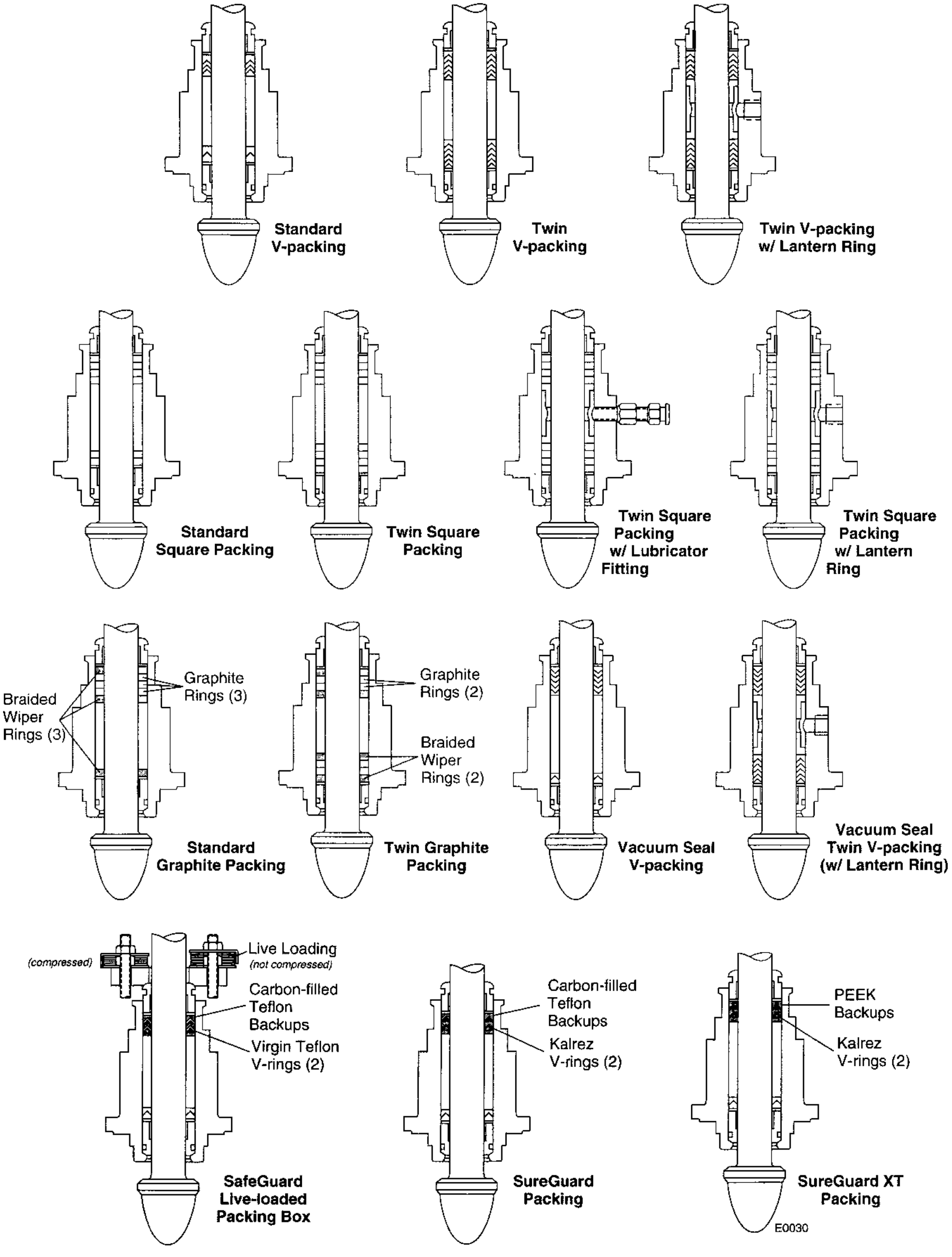


Figure 2: Typical Packing Configurations

NOTE: *See step 1 in "Reassembling the Body" section.*

NOTE: With air-to-close, fail-open valves, it may be necessary to apply a small amount of air to the top of the actuator to move the plug away from the bonnet. Otherwise, plug galling may occur.

Turn the actuator off the plug and bonnet without allowing the plug to rotate within the bonnet. Pull the plug carefully through the packing box.

CAUTION: To avoid scoring guides and plug stem, follow the above procedure exactly.

6. If the seat surfaces need remachining, both surfaces on plug and seat ring must be reworked. The seat angle on the plug is 30 degrees (36 degrees for CavControl and Channel Stream valves); the seat ring, 33 degrees. Lapping is not necessary if proper assembly procedures are followed.

   CAUTION: If remachining, protect the stem while turning. Ensure concentricity of the seat surface with the plug stem (or outside diameter of the seat ring, if machining the seat).

7. To replace packing or change the packing box configuration, from underneath the bonnet push out packing, spacer and guides with a dowel of the same approximate size as the plug stem.

   WARNING: For valves equipped with separable end flanges, do not machine body gasket surfaces. Machining could cause failure of the separable flange lip causing end gasket leakage and valve failure.

8. If separable end flanges need to be removed, file off tack welds or pull rivets behind the flanges.

   CAUTION: When using separable end flanges and spiral wound gaskets, use gaskets with outer backup rings. Failure to do so could result in excess stress in some applications.

   ***NOTE:** To prevent flanges from dropping off during shipping, a tack weld or stainless steel rivet has been installed behind the end flanges.*

Reassembling the Body

To reassemble the valve body, refer to Figures 1, 2 and 4 then proceed as follows:

1. If the packing has been removed, refer to Figure 2 and reinstall new packing exactly as shown. Make sure at least 1/8-inch is left at the top of packing box for the top guide to enter. Different spacer lengths permit a wide variety of packing configurations, such as twin seal and vacuum-pressure packing.

   WARNING: Valves with extended bonnets or metal bellows seals must not have lower packing installed. Instead, lower packing rings should be installed with the upper set. Lower packing installed in extended bonnets or metal bellows seal valves will diminish the integrity of the packing assembly.

   The graphite guide liners should be replaced each time the valve packing is replaced. Do not rebuild the valve without graphite liners in the guides.

2. Reinsert the plug stem into the packing box, being careful not to score the stem or the guides.

3. Turn actuator back onto the plug, without turning the plug inside the bonnet. Make sure the gland flange and bonnet flange are in place before engaging the plug stem and actuator stem threads.

   ***NOTE:** Do not allow the gland flange to contact and gall the polished plug stem.*

   Leave approximately three to four plug stem threads exposed. Attach yoke clamp and gland flange bolting. For valves with a 2-inch spud, be sure the half rings are in place between the yoke and bonnet. Firmly tighten yoke clamp bolting. The packing box nuts should be just over finger tight.

4. Install new bonnet and seat gaskets with the beveled edge up for Teflon gaskets.

5. Insert the seat ring into the body with the step side down. Place the seat retainer into the body with the thin end of the cathedral window down.

   ***NOTE:** For ANSI Class 900 and above valves with valve sizes 1/2- through 1 1/2-inch, the seat retainer window should be placed in the body with the window facing toward the valve ports. With valves 2-inches and larger, the retainer's bar should face toward the valve ports.*

6. Place air under the actuator piston on air-to-open valves to retract the plug.

7. Lower the plug and bonnet squarely into the body. Be careful not to scratch or gall the plug as it enters the body.

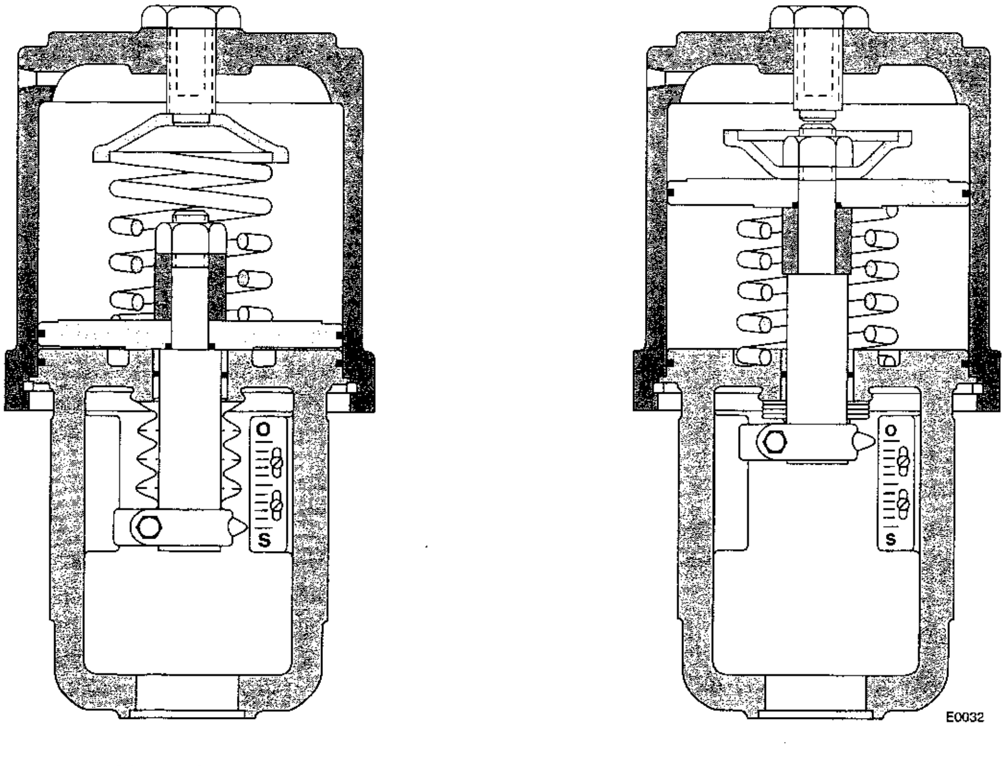
8. To properly align the seat ring and plug, first bring the bonnet bolting to finger-tightness.
   a. With pneumatic actuators, apply air pressure above the piston to seat the plug in the seat ring. Proceed to step 9.
   b. With electric or hydraulic actuators, move the actuator stem down until it is completely extended. Next, retract the actuator stem 1/8 inch / 3.175 mm. Install the stem clamp onto the plug stem / actuator stem and tighten the associated bolting. Move the actuator stem completely down. Adjust actuator limit switches according to the actuator's operating manual.

NOTE: *Step 9 applies only to valves with pneumatic actuators. If an electric or hydraulic actuator is used, return the plug to the midstroke position and proceed to tighten.*

CAUTION: Failure to return the plug to a midstroke position (electric or hydraulic operators only) will cause damage to the actuator and / or the valve during the bonnet tightening sequence. This is due to the inability of most electric / hydraulic actuators to accommodate the $^1/_{16}$ inch / 1.60 mm back-drive during the tightening sequence.

9. For air-to-close valves, skip this step and go to step 10. For air-to-open valves, check for proper plug seating as follows: When proper seating occurs, the bonnet flange will be forced up against the finger-tight body bolting with such force that it will be impossible to move the flange. If proper seating does not occur, the bonnet flange can be wiggled with light hand force. Should this occur, place air under the actuator piston and retract the actuator to approximate midstroke position. Turn the plug out of the actuator plug stem one additional thread and repeat above seating procedure. When the bonnet flange becomes tight against the finger-tight body bolting, the plug is properly seated. If necessary, repeat above procedure until proper seating occurs.
10. Move the plug to the extended (or closed) position for pneumatic actuators and to the midstroke position for electric, hydraulic or mechanical actuators. Begin tightening the bonnet flange bolting in a manner that will keep the bonnet flange square / parallel with the body. Tighten the first bolt $^1/_6$ turn, then tighten the bolt directly opposite $^1/_6$ turn and so on around the flange. Firmly tighten all bolts evenly and completely to compress the bonnet gasket and to seat the bonnet. Torque the bonnet bolts to the suggested torque values in Table III.
11. Apply air over the piston to seat the plug. For all throttling valves, adjust the stem clamp so that with full instrument signal to the positioner the full signal scribe line on the positioner cam points to the center of the cam roller bearing.

    NOTE: *For on / off valves, the bottom of the stem clamp should simply be lined up with the bottom of actuator stem (plus or minus $^1/_{16}$ inch / 1.60 mm).*



Air-to-Open **Air-to-Close**

Figure 3: Air-action Configurations

Tighten the stem clamp bolting. Proper tightness is important since this adjustment secures the actuator stem to the plug stem. Adjust the stroke plate so the stem clamp points to the "closed" position.

12. If the valve has been taken out of the line, make sure the flow arrow indicates proper flow direction upon reinstallation.

Table III: Suggested Bonnet Bolting Torque Values (ft-lbs / Nm, ±10 percent)

Bolt Size (inches)	**Bolt/Stud Material**	
	Carbon Steel	**Stainless Steel**
$^{5}/_{8}$	80 / 108	50 / 68
$^{3}/_{4}$	140 / 190	90 / 122
$^{7}/_{8}$	230 / 312	150 / 203
1	350 / 475	220 / 298
$1^{1}/_{8}$	510 / 690	330 / 447
$1^{1}/_{4}$	730 / 990	460 / 624
$1^{3}/_{8}$	990 / 1342	630 / 854
$1^{1}/_{2}$	1320 / 1790	840 / 1140
$1^{5}/_{8}$	1710 / 2318	1080 / 1484
$1^{3}/_{4}$	2170 / 2942	1400 / 1898
$1^{7}/_{8}$	2700 / 3660	1700 / 2305
2	3350 / 4542	2100 / 2847

Disassembling the Actuator

With air-to-open valves, the actuator may be disassembled while on the valve. With air-to-close valves, the actuator must be removed from the valve prior to disassembly. To disassemble the actuator, refer to Figures 1, 3 and 5 then proceed as follows:

***NOTE:** Steps 1 through 4 apply to removing the actuator from the valve. If disassembly is to take place with the actuator still attached to the valve, go on to step 5.*

1. Make sure the plug is neither seated on the seat ring nor back-seated against the bonnet by attaching an air hose on the appropriate side of the cylinder and release the pressure on the opposite side.

   CAUTION: Galling of critical surfaces may result if the plug is not positioned correctly between the seat ring and bonnet.

2. Loosen the stem clamp.
3. Remove packing box bolting and yoke clamps.
4. Completely turn the actuator off the plug and bonnet without rotating the plug inside the bonnet.

   CAUTION: Do not allow the plug to drop and impact against the seat after turning the actuator off the plug threads.

5. Disconnect tubing.
6. Remove the adjusting screw to relieve the spring compression.

   WARNING: The spring compression must be relieved before further disassembly; otherwise, serious personal injury can occur during disassembly.

7. Remove the retaining ring from the groove at the base of the cylinder by using two screwdrivers, inserting them in the ring's slot and prying the ring from the groove.
8. Pull the cylinder off of yoke and piston. Some O-ring resistance may be felt. Remove spring for cleaning and inspection (air-to-open configuration only).

   WARNING: Do not use air pressure to remove cylinder. Serious personal injury can occur.

9. To remove the spring on air-to-close configurations, remove the piston retaining nut and slide piston off of the actuator stem. The spring may now be removed.

   ***NOTE:** Step 10 can only be performed if the actuator has been removed from the valve.*

10. To inspect the actuator stem O-ring, remove the stem clamp and bellows. Push the actuator stem through the yoke, being careful not to gall the stem. The O-ring may now be removed for replacement.

    ***NOTE:** The actuator stem bushings are pressed into the yoke; it is not necessary to remove the bushing to replace the actuator stem O-ring.*

Reassembling the Actuator

To reassemble the actuator, refer to Figures 1, 3 and 5 then proceed as follows:

1. All O-rings should be replaced and the new ones lubricated with a silicone lubricant (Dow Corning 55M or equivalent). Silicone O-rings must be lubricated with Magnalube-G lubricant or equivalent. Do not use a silicone lubricant on silicone O-rings.
2. Make sure all internal parts are thoroughly cleaned and lubricated before beginning reassembly.
3. If the actuator stem has been removed, replace the piston stem O-ring and reassemble the piston and actuator spacer on the actuator stem according to the proper air-action (refer to Figures 3 and 5.) Air-to-close configurations require the spring button to be inserted under the actuator stem retaining nut. Tighten the retaining nut firmly.
4. For air-to-close configurations, place the spring under the piston and insert the actuator stem through the yoke, being careful to not gall the stem

or the bushings. Make sure the spring is retained in the groove provided in the top of the yoke. For air-to-open configurations, insert the actuator stem through the yoke and place the spring and spring button above the piston.

5. Install the cylinder, making sure the yoke is pushed deep enough into the cylinder to allow the retaining ring to be installed.
6. Reinsert the retaining ring by feeding it into the groove a little at a time until it snaps in place. Replace the stem bellows and stem clamp.
7. Using a new adjusting screw gasket, reinstall the gasket and adjusting screw. Tighten the adjusting screw only enough to provide an air seal with the gasket. Do not over tighten.

   ***NOTE:** On air-to-open configurations, make sure the hole in the spring button is directly centered under the adjusting screw hole.*
8. Apply air over the piston and place the actuator subassembly onto the valve, making sure the gland flange and bonnet flange are in place. For valves with a 2-inch spud, be sure the half rings are in place between the yoke and bonnet. Engage the plug stem and actuator stem threads. Carefully turn the actuator clockwise until the plug stem is engaged (three to four turns).

   CAUTION: To avoid possible stem and / or seat galling, do not allow the plug to turn on the seat.
9. Apply sufficient air under the piston (for air-to-open valves) or over the piston (for air-to-close valves) to prevent the plug head from touching either the seat or the bonnet. Continue turning the plug stem into the actuator stem until two to three plug stem threads remain exposed.

   CAUTION: Do not allow the gland flange to contact or gall the polished plug stem.

   CAUTION: To avoid possible stem and / or seat galling, do not allow the plug to turn on the seat.
10. Apply air over the piston. This will drive the plug into the seat and lift the yoke off the bonnet approximately 1/16 inch / 1.60 mm. If the space is not 1/16 inch / 1.60 mm, apply air under the piston to retract the actuator stem and screw the plug in or out as needed. Repeat this step until the 1/16 inch / 1.60 mm space is created.
11. Apply air under the piston and attach the yoke clamps and packing box bolting. Tighten the yoke clamp bolting firmly. The packing box nuts should be just over finger-tight.

    CAUTION: Do not overtighten packing. This can cause excessive packing wear and high stem friction that may impede plug movement.
12. Apply air over the piston to seat the plug. For all throttling valves, adjust the stem clamp so that with full instrument signal to the positioner the full signal scribe line on the positioner cam points to the center of the cam roller bearing.

    ***NOTE:** For on / off valves, the bottom of the stem clamp should simply be lined up with the bottom of the actuator stem (± 1/16 inch / 1.60 mm).*

    Tighten the stem clamp bolting. Proper tightness is important since this adjustment secures the actuator stem to the plug stem. Adjust the stroke plate so the stem clamp points to the "closed" position.
13. Reconnect the actuator / positioner tubing, supply and signal lines.

REVERSING THE AIR-ACTION

Changing to Air-to-Open

To change the air-action from air-to-close to air-to-open, refer to Figures 3 and 5 then proceed as follows:

1. Follow the instructions for disassembling the actuator (see "Disassembling the Actuator" section).
2. Reassemble the actuator with the spring, actuator stem spacer and spring button over the piston. For proper alignment, the center hole in the spring button should engage the end of the adjusting screw.
3. The positioner must also be changed. To do this, refer to the appropriate positioner Installation, Operation, Maintenance Instructions.

Changing to Air-to-Close

To change the air action from air-to-open to air-to-close, refer to Figures 3 and 5 then proceed as follows:

1. Follow the instructions for disassembling the actuator (see "Disassembling the Actuator" section).
2. Reassemble the actuator with spring and actuator stem spacer below the piston. The spring should sit in the spring groove on top of the yoke. The spring button is not used on air-to-extend configurations and is stored above the piston (the actuator stem retaining nut holds the spring button in place.)
3. The positioner must also be changed. To do this, refer to the appropriate positioner Installation, Operation, Maintenance Instructions.

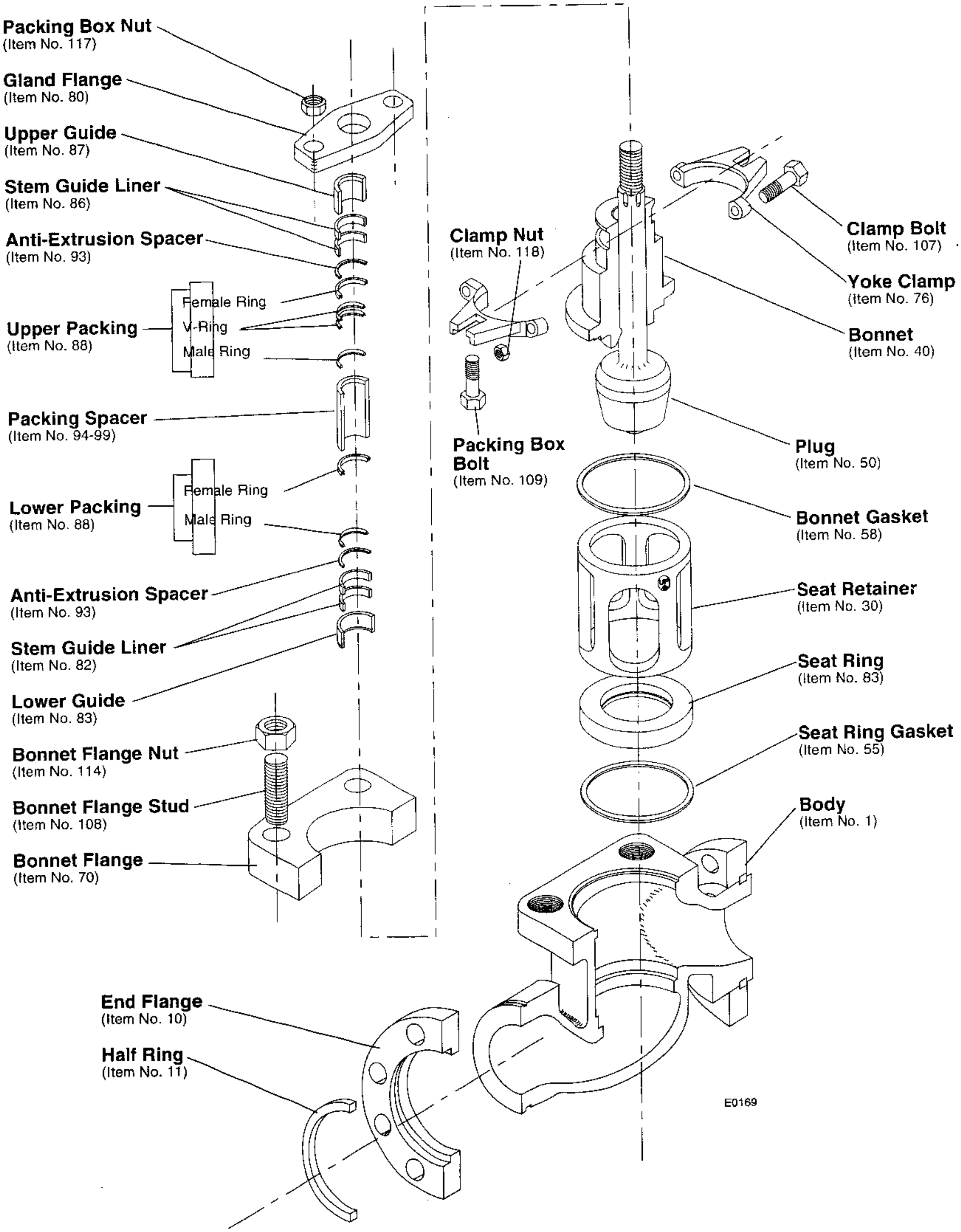


Figure 4: Exploded View – Body Assembly

NOTE: *Item numbers correspond directly to the valve's bill of material. Refer to it for specific part numbers.*

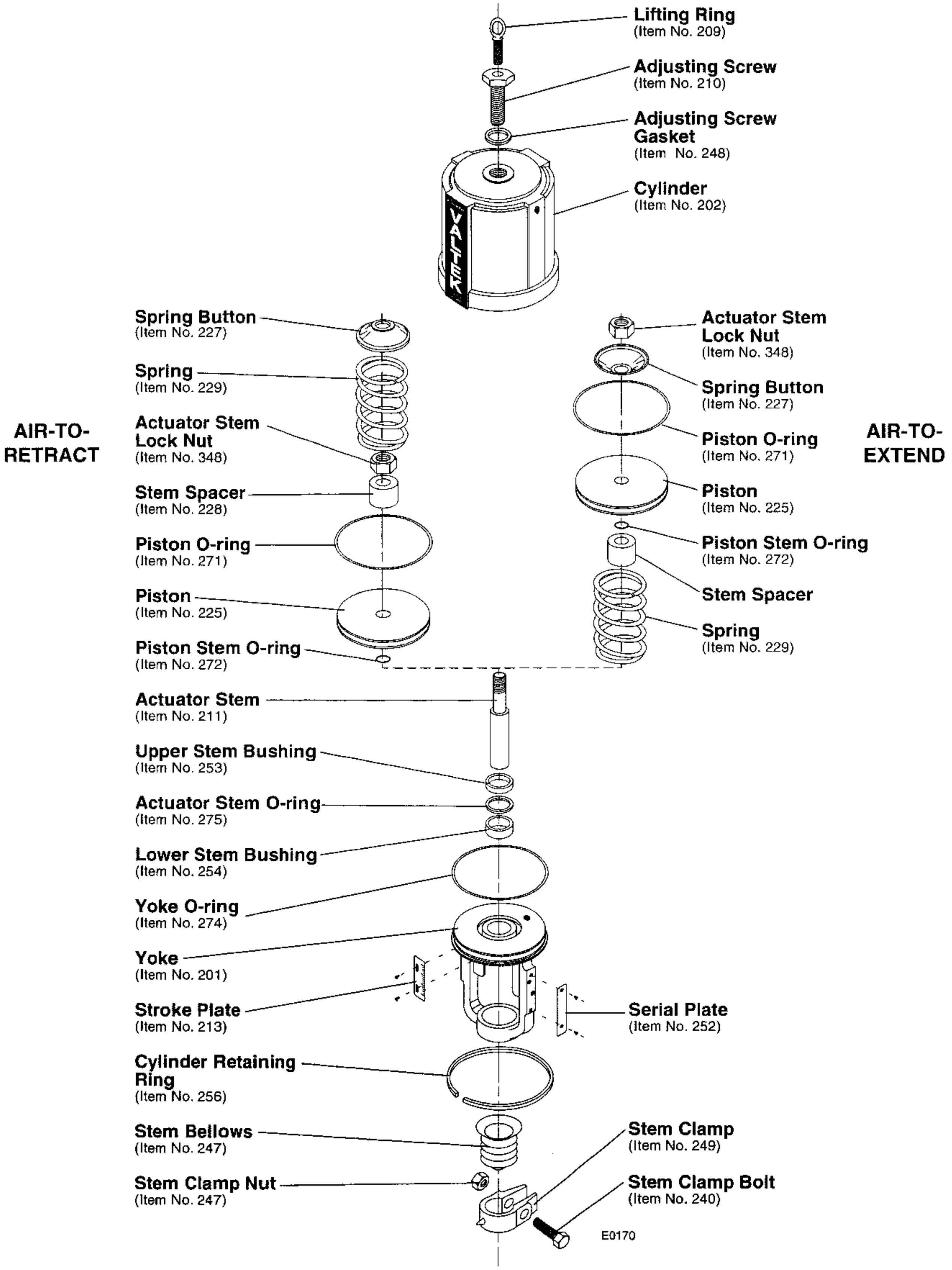


Figure 5: Exploded View – Actuator Assembly

NOTE: *Item numbers correspond directly to the valve's bill of material. Refer to it for specific part numbers.*

Troubleshooting Chart

Problem	Probable Cause	Corrective Action
Stem motion impeded	1. Overtightened packing 2. Service temperature is beyond operating limits of trim design 3. Inadequate air supply 4. Malfunctioning positioner	1. Adjust packing box nuts to slightly over finger-tight 2. Reconfirm service conditions and contact factory 3. Check for leaks in air supply or instrument signal system; tighten loose connections and replace leaky lines 4. Refer to positioner maintenance instructions
Excessive leakage	1. Improperly tightened bonnet flange bolting 2. Worn or damaged seat ring 3. Worn or damaged seat or bonnet gasket 4. Inadequate actuator thrust 5. Incorrectly adjusted plug 6. Improper flow direction 7. Improper handwheel adjustment acting as a limit-stop	1. Refer to step 3 of "Reassembling the Body" section for correct tightening procedure 2. Disassemble valve and replace or repair seat ring 3. Disassemble and replace gaskets 4. Check for adequate air supply to actuator; if air supply is adequate, reconfirm service conditions and contact factory 5. Refer to steps 8 - 10 of "Reassembling the Body" section for correct plug adjustment 6. Refer to original specifications or contact factory 7. Adjust handwheel until plug seats properly
Inadequate flow	1. Improper plug adjustment, limiting stroke 2. Malfunctioning positioner 3. Service conditions exceed trim design capacity	1. Refer to steps 8 - 10 of "Reassembling the Body" section for correct plug adjustment 2. Refer to positioner maintenance instructions 3. Verify service conditions and consult factory
Plug slams	1. Incorrect plug adjustment allowing improper cushion of air between actuator piston and yoke 2. Inadequate air supply 3. Trim sized too large for flow rate	1. Refer to steps 8 - 10 of "Reassembling the Body" section for correct plug adjustment 2. Check air supply to actuator; repair leaks and remove any restrictions in supply line 3. Install reduced trim
Valve does not fail in correct position	1. Incorrect flow direction	1. Reconfirm direction and, if necessary, correct flow direction through valve

For more information about Flowserve, contact www.flowserve.com or call USA 972 443 6500

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12, av. du Québec, B.P. 645
91965, Courtaboeuf Cedex,
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Phone (33 1) 60 92 32 51
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Facsimile 281 479 8511

104 Chelsea Parkway
Boothwyn, PA 19061 USA
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Facsimile 610 497 6680

1300 Parkway View Drive
Pittsburgh, PA 15205 USA
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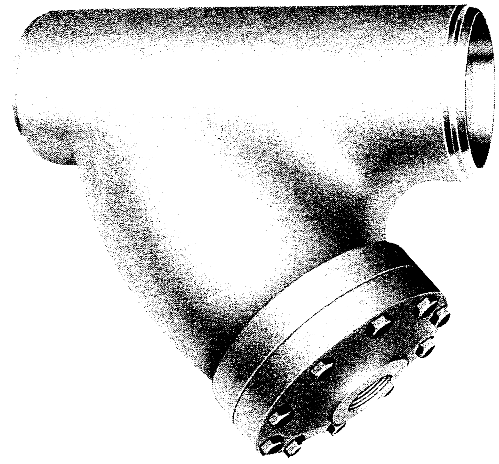
CAST STEEL BUTTWELD "Y" STRAINERS

CLASS 150, 300 & 500
531, 533, 550 SERIES

Size 2" through 8" buttweld "Y" strainers in carbon steel, stainless steel and chrome moly.



- **MATERIALS OF CONSTRUCTION:**

CARBON STEEL

No.	Part	Material	ASTM Spec	Remarks
1	Body	Cabon Steel	A216	Grade WCB
2	Cover (2")	Carbon Steel	A216	Grade WCB
2	Cover (2-1/2" & Up)	Carbon Steel	A515	
3	*Screen	Stainless Steel		Type 304
4	*Gasket 2" 304 SS/Spiral Wound, 2-1/2" & Up Grafoil®			
5	Bolting	Carbon Steel		Grade 5/B7

316 STAINLESS STEEL

No.	Part	Material	ASTM Spec	Remarks
1	Body	Stainless Steel	A351	CF8M (316)
2	Cover (2")	Stainless Steel	A276	Gr. 316
2	Cover (2-1/2" & Up)	Stainless Steel	A351	CF8M (316)
3	*Screen	Stainless Steel		Type 304
4	*Gasket 2" 304 SS/Spiral Wound, 2-1/2" & Up Grafoil®			
5	Bolting	Carbon Steel		Grade 5/B7

CHROME MOLY

No.	Part	Material	ASTM Spec	Remarks
1	Body	Chrome Moly	A217	Gr. WC6
2	Cover	Chrome Moly	A387	
3	*Screen	Stainless Steel		Type 304
4	*Gasket 2" 304 SS/Spiral Wound, 2-1/2" & Up Grafoil®			
5	Bolting	Carbon Steel		Grade 5/B7

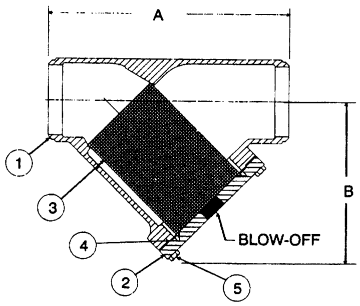
* Recommended Spare Parts

MODEL NUMBER/SELECTION INFORMATION

Model No.	Material	ANSI Class
531-15BW	Carbon Steel	150/SCH. 40
531-30BW	Carbon Steel	300/SCH. 40
531-60BW	Carbon Steel	600/SCH. 80
533-15BW	Stainless Steel	150/SCH. 40
533-30BW	Stainless Steel	300/SCH. 40
533-60BW	Stainless Steel	600/SCH. 80
550-15BW	Chrome Moly Steel	150/SCH. 40
550-30BW	Chrome Moly Steel	300/SCH. 40
550-60BW	Chrome Moly Steel	600/SCH. 80

PRESSURE & TEMPERATURE RATING

	Pressure Rating @ 100° F		
	Carbon Steel	Stainless Steel	Chrome Moly
Class 150	285	275	290
Class 300	740	720	750
Class 600	1480	1440	1500



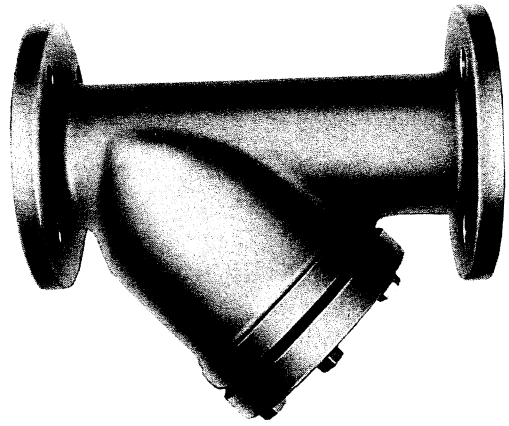
DIMENSIONAL DATA Note: Dimensions Shown are subject to change. Contact factory for certified prints (exact dimensions) when required.

Size	Class 150				Class 300				Class 600				Blow-Off NPT	Standard Screen	
	A	B	Screen Area In^2	Weight Lbs.	A	B	Screen Area In^2	Weight Lbs.	A	B	Screen Area In^2	Weight Lbs.		Steam	Liquid
2"	11	6	39.2	17	11	6	39.2	17	11	6	40.0	20	1	.045 Perf.	.045 Perf.
2-1/2"	12-5/8	7-5/8	61.0	42	12-5/8	7-1/2	61.0	42	12-5/8	7-1/2	63.0	47	1-1/4	.045 Perf.	.045 Perf.
3"	14-1/4	8-1/8	64.8	46	14-1/4	8-1/2	64.8	46	14-1/4	8-3/4	67.0	52	1-1/4	.045 Perf.	.045 Perf.
4"	16	10	160.0	64	14.000	10	160.0	64	21-1/8	14-3/8	217.0	143	1-1/4	.045 Perf.	.125 Perf.
5"	17-1/4	15	189.0	126	17-1/4	15	189.0	126	25-1/4	16	258.0	223	1-1/2	.045 Perf.	.125 Perf.
6"	19-3/4	16	270.0	190	19-3/4	16	270.0	190	27-1/2	18	370.0	250	1-1/2	.045 Perf.	.125 Perf.
8"	26	17-1/4	425.0	293	26	17-1/4	425.0	293	30-3/8	22	633.0	593	2	.062 Perf.	.125 Perf.

CAST STEEL FLANGED "Y" STRAINERS

CLASS 150, 300 & 600
531, 533, 550 SERIES

Choose carbon steel, stainless steel or chrome moly in class 150, 300 or 600 flanged body. Sizes 1/2" - 8".



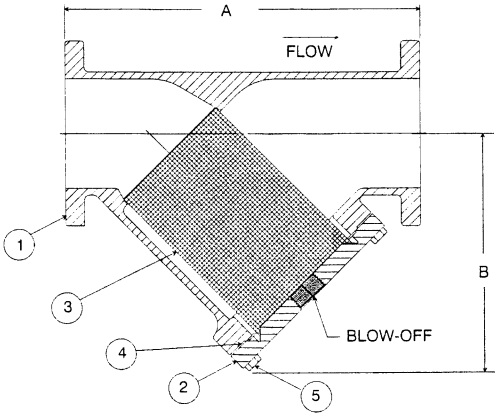
MATERIALS OF CONSTRUCTION

Carbon Steel

No.	Part	Material	ASTM Spec	Remarks
1	Body	Carbon Steel	A216	Grade WCB
2	Cover (1/2" to 2")	Carbon Steel	A216	Grade WCB
2	Cover (2-1/2" & Up)	Carbon Steel	A515	
3	* Screen	Stainless Steel		Type 304
4	* Gasket 1/2" - 1 1/2" Copper, 2" 304 SS/Spiral Wound, 2-1/2" & Up Grafoil®			
5	Bolting	Carbon Steel		Grade 5/B7

316 Stainless Steel

No.	Part	Material	ASTM Spec	Remarks
1	Body	Stainless Steel	A351	CF8M (316)
2	Cover (1/2" to 2")	Stainless Steel	A276	Gr. 316
2	Cover (2-1/2" & Up)	Stainless Steel	A351	CF8M (316)
3	* Screen	Stainless Steel		Type 304
4	* Gasket 1/2" - 2" 304 SS/Spiral Wound, 2-1/2" & Up Grafoil®			
5	Bolting	Carbon Steel		Grade 5/B7



Chrome Moly

No.	Part	Material	ASTM Spec	Remarks
1	Body	Chrome Moly	A217	Gr. WC6
2	Cover	Chrome Moly	A387	
3	*Screen	Stainless Steel		Type 304
4	*Gasket 1/2" - 2" 304 SS/Spiral Wound, 2-1/2" & Up Grafoil®			
5	Bolting	Carbon Steel		Grade 5/B7

* Recommended Spare Parts

PRESSURE & TEMPERATURE RATING

Pressure Rating @ 100° F

	Carbon Steel	Stainless Steel	Chrome Moly
Class 150	285	275	290
Class 300	740	720	750
Class 600	1480	1440	1500

MODEL NUMBERS/SELECTION INFORMATION

Model No.	Material	ANSI Class
531-15	Carbon Steel	150
531-30	Carbon Steel	300
531-60	Carbon Steel	600
533-15	Stainless Steel	150
533-30	Stainless Steel	300
533-60	Stainless Steel	600
550-15	Chrome Moly Steel	150
550-30	Chrome Moly Steel	300
550-60	Chrome Moly Steel	600

DIMENSIONAL DATA

Note: Dimensions Shown are subject to change. Contact factory for certified prints (exact dimensions) when required.

Size	Class 150				Class 300				Class 600				Blow-Off NPT	Standard Screen	
	A	B	Screen Area In²	Weight Lbs.	A	B	Screen Area In²	Weight Lbs.	A	B	Screen Area In²	Weight Lbs.		Steam	Liquid
1/2"	5-1/2	2-3/4	5.4	5-3/4	6	2-3/4	5.4	6	7	2-3/4	5.4	6-1/2	3/8	.045 Perf.	.045 Perf.
3/4"	6-3/4	3-1/2	8.7	6-3/4	7-1/16	3-1/2	8.7	8-1/2	8-9/16	3-1/2	8.7	9-3/4	3/8	.045 Perf.	.045 Perf.
1"	7-3/8	3-3/4	12.7	8	8-3/4	3-3/4	12.7	11	9-1/4	3-3/4	12.7	12-1/4	1/2	.045 Perf.	.045 Perf.
1-1/2"	9	5	25.3	15	9-7/8	5	25.3	22	10-1/2	5	25.3	24-3/4	3/4	.045 Perf.	.045 Perf.
2"	10	6	39.2	20	10-3/8	6	39.2	25	11	6	40.0	34	1	.045 Perf.	.045 Perf.
2-1/2"	12	7-5/8	61.0	52	12-1/2	7-1/2	61.0	56	13-1/4	7-1/2	63.0	73	1-1/4	.045 Perf.	.045 Perf.
3"	10-3/4	8-1/8	64.8	60	12-3/8	8-1/2	64.8	68	14-1/4	8-3/4	67.0	80	1-1/4	.045 Perf.	.045 Perf.
4"	14	10	160.0	94	16-3/4	10	160.0	108	21-1/8	14-3/8	217.0	204	1-1/4	.045 Perf.	.125 Perf.
5"	17-1/4	15	189.0	170	18-1/8	15	180.0	176	25-5/8	16	258.0	330	1-1/2	.045 Perf.	.125 Perf.
6"	18-7/8	16	270.0	174	19-3/4	16	270.0	204	27-1/2	18	370.0	376	1-1/2	.045 Perf.	.125 Perf.
8"	26	17-1/4	425.0	354	26-7/8	17-1/4	425.0	393	31-1/8	22	633.0	764	2	.062 Perf.	.125 Perf.

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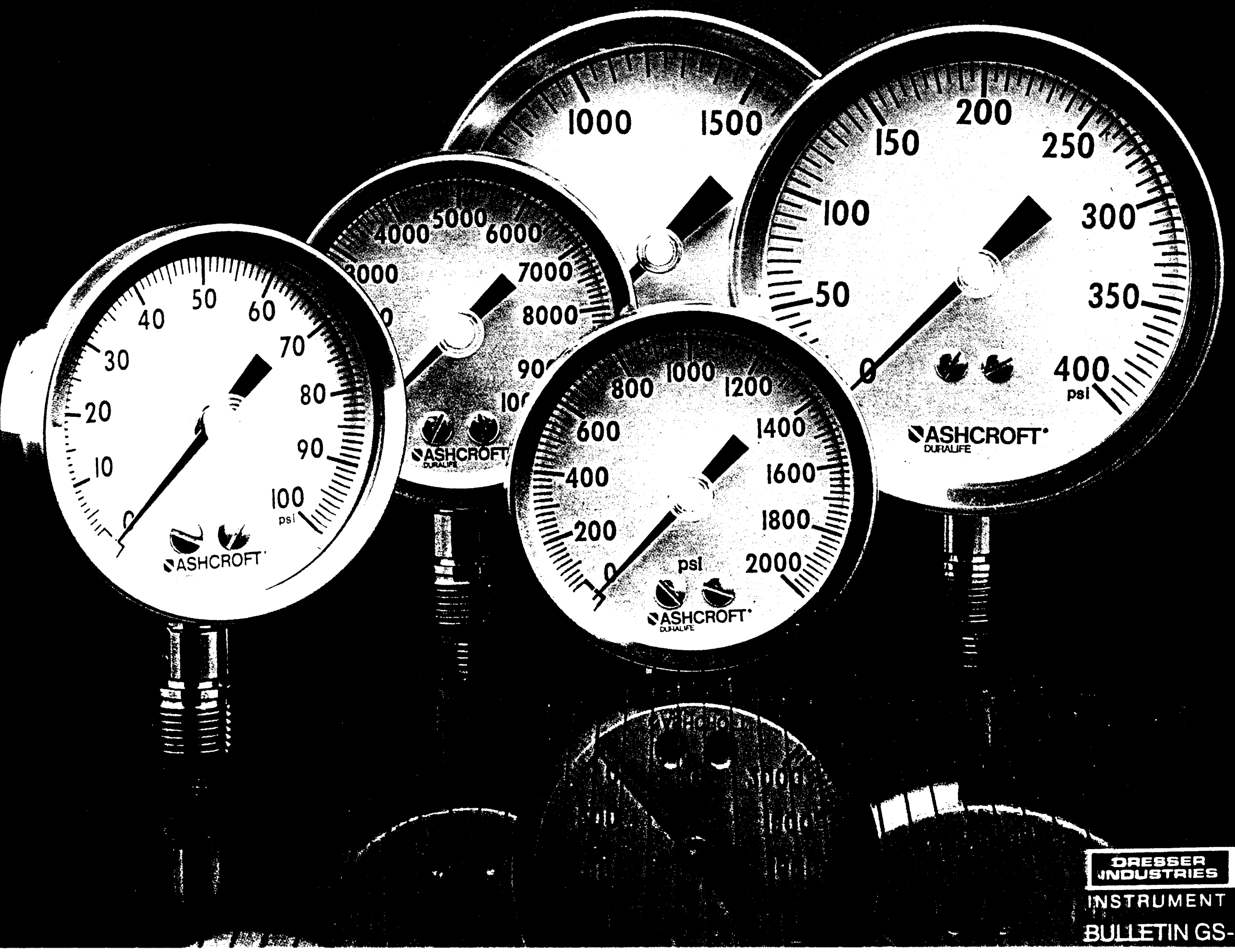


DRESSER INDUSTRIES DRESSER
INSTRUMENT DIVISION
BULLETIN GS-2

Dresser Industries' Instrument Division has, to its credit, a number of firsts and innovations in the field of gauge manufacture that spans more than 130 years. Since Edward Ashcroft first introduced the Bourdon tube to American Industry and Otto Heise developed the unique, "unitized" Bourdon tube, Dresser has been researching new methods and processes for pressure measurement to meet the needs of both foreign and domestic industry.

The Duralife system represents yet another technological breakthrough in gauge manufacture, offering the user significant features and benefits in conditions of severe vibration and pulsation where liquid filled gauges are often used. The Duralife system is well-named. This uniquely designed system consists of a spring-suspended movement and unitized Bourdon tube assembly that provides increased gauge life and stability, beyond that which is offered by conventional gauges.

Examination of the gauge interior shows a unique design.

The movement, which is all stainless steel, is suspended between the Bourdon tube and socket with a wire link. This spring-suspension significantly reduces the level of forces transmitted to the precision moving parts, greatly extending the wear life in applications where vibration and pulsation are constant factors. The movement in the Duralife system has a U-shaped frame with snap-in gearing as contrasted with conventional movements which are screwed together. There are no screws to be found in the Duralife system so nothing can loosen under conditions of vibration.

The combination of features offered in the 1009 gauge reflect the finest in gauge technology for vibration and pulsation applications.

The Bourdon tube is AISI 316 stainless steel, the preferred industrial material for applications where corrosion is a factor. All pressurized joints are welded. Cycle testing of the tubes in accordance with ANSI B40.1 (20/80% of range), has resulted in all tubes exceeding 1,000,000 cycles.

The Ashcroft Duralife socket, either stainless steel or bronze, is welded to the stainless steel case which results in a hermetically sealed unit for reliable, leak-tight liquid-filled gauges. This construction protects the gauge internals from ambient atmospheric contamination or corrosion.

The tip/tube and tube/socket joints are welded. The case/socket joint is also welded construction and provides a permanent seal in the event liquid filling is required. Both window gasket and case pressure relief plug are a nitrile compound, which is compatible with either glycerine or silicone when the 1009 is used as a liquid filled gauge. The standard fill is glycerine; however, silicone fill is available.

These 2½" and 3½" gauges feature the Duralife system with spring-suspended stainless steel movements. Movement parts are designed to reduce friction and extend wear life. Each movement is ultrasonically cleaned and lubricated. As a standard feature, the Duralife system has both an overload and underload stop built into the movement to prevent disengagement of the gears and to help maintain accuracy in the event of over or under pressure.

All Duralife gauges are manufactured to ANSI Grade 1A accuracy (1% over entire dial arc).

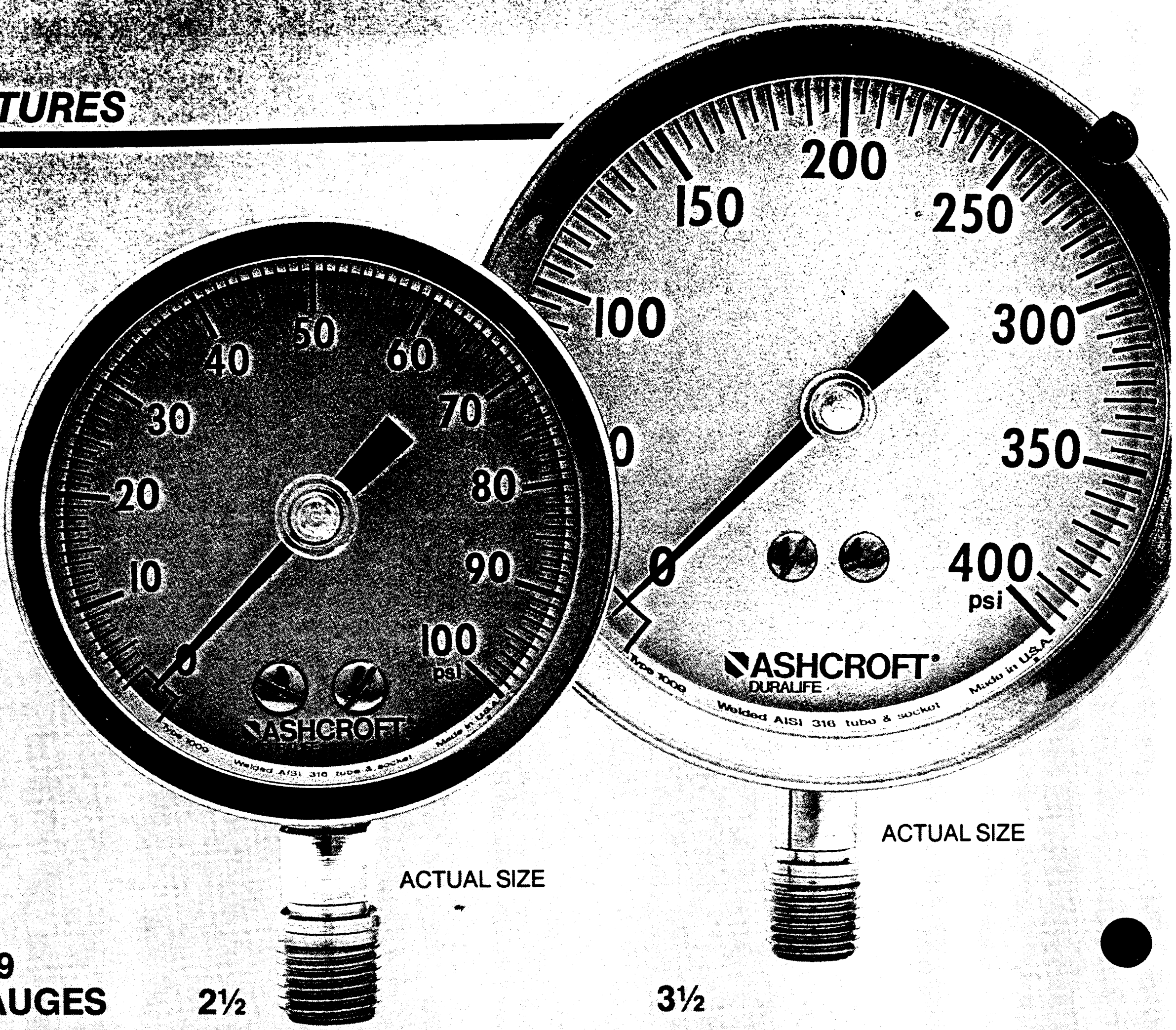
Ashcroft Duralife gauges are available in 2½" and 3½" sizes, lower or back connected, with panel, flange and u-clamp mounting adaptors available for field installation. Pressure ranges from 0-15 psi through 0-15,000 psi including vacuum and compound are available. Metric ranges are also offered.

Polycarbonate window is standard, however, plain glass is available for environments where solvents are present. Laminated safety glass is also offered for those applications where this feature may be required. Gauges with glass windows cannot be liquid filled.

The dial is a brushed aluminum design with uniformly graduated black markings and numerals, making the dial easier to read in sunlight. The pointer is friction adjustable and painted black.

All 1009 Duralife gauges have a limited 5 year warranty.

STANDARD FEATURES



ASHCROFT 1009 INDUSTRIAL GAUGES

	2½	3½
Accuracy: 1% Full Scale Grade 1A	STANDARD	STANDARD
Duralife System: Stainless Steel spring suspended movement, AISI 316 Stainless steel bourdon tube	STANDARD	STANDARD
Connection:(1)		
¼ NPT Lower	STANDARD	STANDARD
¼ NPT Center Back	STANDARD	STANDARD
⅛ NPT Lower (SW only)	OPTIONAL	OPTIONAL
Socket Material: AISI 316 Stainless Steel or bronze	VAC – 15,000 psi VAC – 1000 psi	VAC – 15,000 psi VAC – 1000 psi
Case Type:		
Polished Stainless Steel	STANDARD	STANDARD
Field fillable	STANDARD	STANDARD
Liquid filled	OPTIONAL (glycerine fill standard)	OPTIONAL (glycerine fill standard)
Windows:		
Polycarbonate	STANDARD	STANDARD
Plain glass	OPTIONAL	OPTIONAL
Laminated safety glass	OPTIONAL	OPTIONAL
Pointers:		
Friction adjustable	STANDARD	STANDARD
Knurled hub adjustable	OPTIONAL	OPTIONAL
Minimum/Maximum	OPTIONAL	OPTIONAL

(1) ½" Lower NPT see Bulletin GS-3.

Standard Metric Ranges

RANGE		DIAL GRADUATIONS		Outer scale when dual range specified psi
kg/cm² (Kilograms per sq. cm.)	bar	figure interval	minor graduation	
pressure				
0/1	0/1	0.1	0.01	0/14
0/1.6	0/1.6	0.2	0.02	0/22
0/2.5	0/2.5	0.5	0.05	0/35
0/4	0/4	0.5	0.05	0/55
0/6	0/6	0.5	0.1	0/85
0/10	0/10	1	0.1	0/140
0/16	0/16	2	0.2	0/220
0/25	0/25	5	0.5	0/350
0/40	0/40	5	0.5	0/550
0/60	0/60	5	1	0/850
0/100	0/100	10	1	0/1400
0/160	0/160	20	2	0/2200
0/250	0/250	50	5	0/3500
0/400	0/400	50	5	0/5500
0/600	0/600	50	10	0/8500
0/1000	0/1000	100	10	0/14,000
vacuum				
-1/0	-1/0	0.1	0.01	30/0" Hg
compound				
-1/0/1.5	-1/0/1.5	0.5	0.05	30/0" Hg/0/20
-1/0/3	-1/0/3	0.5	0.05	30/0" Hg/0/40
-1/0/5	-1/0/5	0.5	0.1	30/0" Hg/0/70
-1/0/9	-1/0/9	1	0.1	30/0" Hg/0/125
-1/0/15	-1/0/15	2	0.2	30/0" Hg/0/215
-1/0/24	-1/0/24	5	0.5	30/0" Hg/0/340
kPa (kilopascal)		figure interval	minor graduation	Outer scale when dual range specified psi
pressure				
0/100		10	1	0/14
0/160		20	2	0/22
0/250		50	5	0/35
0/400		50	5	0/55
0/600		50	10	0/85
0/1000		100	10	0/140
0/1600		200	20	0/220
0/2500		500	50	0/350
0/4000		500	50	0/550
0/6000		500	100	0/850
0/10000		1000	100	0/1400
0/16000		2000	200	0/2200
0/25000		5000	200	0/3500
0/40000		5000	500	0/5500
0/60000		5000	500	0/8500
0/100000		10000	1000	0/14,000
vacuum				
-100/0		10	1	30/0" Hg
compound				
-100/0/150		50	5	30/0" Hg/0/20
-100/0/300		50	5	30/0" Hg/0/40
-100/0/500		50	10	30/0" Hg/0/70
-100/0/900		100	10	30/0" Hg/0/125
-100/0/1500		200	20	30/0" Hg/0/215
-100/0/2400		500	20	30/0" Hg/0/340

Special logos and scales available upon request. Consult factory.

Standard Ranges

RANGE	DIAL GRADUATIONS			
psi	figure interval		minor graduation	
pressure				
0/15	1		0.2	
0/30	5		0.5	
0/60	5		1	
0/100	10		1	
0/160	20		2	
0/200	20		2	
0/300	30		5	
0/400	50		5	
0/600	50		10	
0/800	100		10	
0/1000	100		10	
0/1500	200		20	
0/2000	200		20	
0/3000	300		50	
0/4000	100		50	
0/5000	500		50	
0/6000	1000		100	
0/7500	1000		100	
0/10,000	1000		100	
0/15,000	2000		200	
vacuum 30-0 inches Mercury	5 inches		0.5	
compound	"Hg	psi	"Hg	psi
30" Hg Vac/ 0/15 psi	5	3	1	0.5
30" Hg Vac/ 030 psi	10	5	1	1
30" Hg Vac/ 0/60 psi	10	10	2	1
30" Hg Vac/ 0/100 psi	10	10	2	1
30" Hg Vac/ 0/150 psi	10	20	5	2
30" Hg Vac/ 0/300 psi	30	25	5	5

Ammonia (NH_3) Service – XR5
Standard Ranges (temperature scale in red in °F)

pressure	"Hg	psi	"Hg	psi
30" Hg Vac/ 0/150 psi[1]	10	20	5	2
30" Hg Vac/ 0/300 psi[2]	30	25	5	5

[1] Temp. Scale, 0°F, -60/0/+84°
[2] Temp. Scale, 0°F, -60/0/+125°

Type 1009SW gauges may be ordered with metric single scale dial: kPa, bar or kg/cm².

Dual scale dials will be supplied with standard metric inner scale and equivalent psi outer scale or with standard psi inner scale and equivalent metric outer scale.

Retard scales not available with a Duralife system.

HOW TO ORDER

Ordering Example Below

35	1009	SWL	02B	UXC	100 PSI (See Page 5)

Case Size		Gauge Type		Tube & Socket Material		Connection Size & Location(2)		Variations	
Code		Code		Code		Code		Code	
25	2½	1009	Duralife System Polished St. St. Case Bayonet Lock Ring Lexan Window 1% F. S. Accuracy Welded Construction	AW	Welded AISI 316 tube, bronze socket Vacuum thru 1000 psi	02L	¼ Lower	XFW	Wall Mount Back Flange
								XFE	Front Flange Welded to Case (Back Connection)
35	3½					02B	¼ Center Back	XFF	Front Flange Mount
								XUC	"U" Clamp Mount
								XWN	White Dial Background
				AWL	With glycerine fill	RWL*	SAE J-514 7/16 - 20	XGV	Silicone Liquid Fill
								XLJ	Dry Liquid Fillable
								XR5	Ammonia Scale Dial
				SW	Welded AISI 316 tube and socket Vacuum thru 15,000 psi			XR1/R7	Refrigerant Scales
						01L	⅛ NPT Lower only SS only	XTS	Throttle Device
								XGX	Halocarbon Fill
								X6B(1)	Cleaned for Gaseous Oxygen Service
				SWL	With glycerine fill			XAP(1)	Adjustable Pointer
								XEP(1)	Min/Max Pointer
								XRG(1)	Plain Glass Window
								XSG	Laminated Safety Glass
								XSH(1)	Set Hand
								XPR(1)	Receiver Range 3/15 psi
								XHR(1)	Easily Removable Ring
								XMP	3½" Micrometer Adj. Pointer

(2) ½" NPT Lower see Bulletin GS-3. *2½ 1009SW/SWL only. (1) Not available liquid filled.

Warning: All gauge components should be selected considering media and operating conditions, to prevent mis-application. Improper application can cause gauge failure and possible personal injury or property damage. The information contained in this catalog is offered as a guide to assist in making the proper selection of a pressure gauge. Additional information is available from Dresser Instrument Division. Consult ANSI B40.1 for guidance in gauge selection.

Pressure Range — Select a gauge with a full scale pressure range of approximately twice the normal operating pressure. The maximum operating pressure should not exceed approximately 75% of the full scale range. Failure to select a gauge range within these criteria may ultimately result in fatigue failure of the Bourdon tube.

Ambient Temperature — The temperature to which a gauge will be subjected should not exceed 150°F. Temperature affect on accuracy of a dry gauge will be 0.2% for each 10°F change from ambient temperature. For liquid filled gauges the error will be 0.2 PSI (regardless of pressure range) for each 10°F change from ambient temperature.

Cases — Cases are AISI 304 stainless steel with a bright annealed finish. The case has a pressure relief plug to relieve case pressure build up in the event a slow leak develops in the pressure element.

Pressure Elements — Materials include: AISI 316 stainless steel tube and either AISI 316 stainless steel socket or bronze socket. Proper selection of the Bourdon system and socket material is dependent upon the process fluid to which the system will be subjected. If a standard material is not suitable, the use of a diaphragm seal may be necessary.

Movements — The 1009 AW(L) and SW(L) models feature the Duralife system with spring-suspended stainless steel movement. Movement parts are designed to reduce friction and extend wear life. Each movement is ultrasonically cleaned and lubricated.

Dials — Dials are uniformly graduated and have highly legible black markings on brushed aluminum backgrounds with black numerals.

Pointers — Friction adjustable pointers are standard and are black painted aluminum.

Cleaning — Gauges cleaned for gaseous oxygen or other strong oxidizing agents cannot be supplied with glycerine or silicone liquid fill. Consult factory if liquid filling is required on strong oxidizing media.

Throttle Devices — All 1009 Duralife gauges can be provided with throttle devices. For applications where liquid filled gauges are required (where vibration and/or pulsation normally exist), throttle devices may be indicated. A typical application for throttle devices is high pressure hydraulic pumps. However, if a process contains dirt or has certain suspended particles, the use of a throttle device may cause plugging in the socket. When determining the need for throttle devices, be aware of the application.

The **1009 AWL** (300 PSI and above) is equipped with a push in brass throttle plug with a 0.013" diameter orifice. **1009 SWL** (300 PSI and above) is equipped with the Ashcroft annular orifice device with an orifice equivalent to .013" by 2¼" length. This device will attenuate up to 70% of excess pulsation.

Windows — The standard is polycarbonate, however, a plain glass window or laminated safety glass window are available.

Rings — The ring is polished stainless steel with a bayonet type lock.

Liquid Fill — 1009 gauges may be factory or field-filled with glycerine or optional silicone or halocarbon fill.

Weights

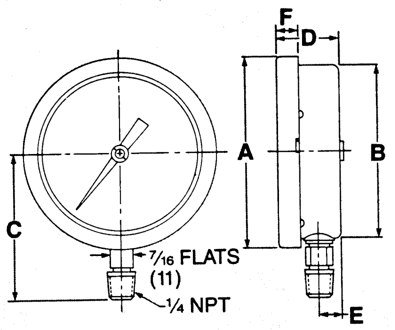
Size	Dry	L.F.	Add For	
			XUC	XFF
2½	4.2 oz. 119g	8.0 oz. 227g	1.0 oz. 28g	1.5 oz. 42g
3½	7.0 oz. 198g	14.0 oz. 397g	1.5 oz. 42g	2.0 oz. 57g

Field Mounting Hardware Kits

	"U" Clamp - XUC	Front Flange - XFF
2½	A-3520	A-3522
3½	A-3521	A-3523

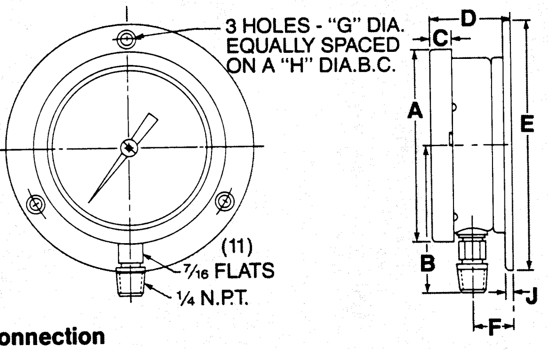
	Wall Mounting Back Flange - XFW
2½	A-3527
3½	A-3528

CASE DIMENSIONS



Lower Connection

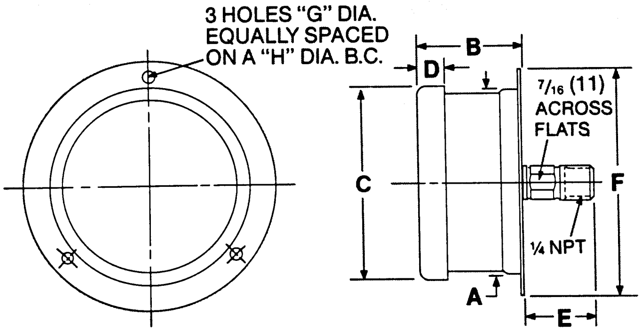
GAUGE SIZE		A	B	C	D	E	F
2½	INCH	2 7/8	2 21/32	2 9/16	1 5/32	13/32	3/8
	MM	73	67	65	29	10	10
3½	INCH	3 31/32	3 19/32	3	1 7/32	13/32	15/32
	MM	101	91	76	31	10	12



Lower Connection w/Wall Mtg. Back Flange (XFW)

2½" Kit #3527, 3½" Kit #3528.

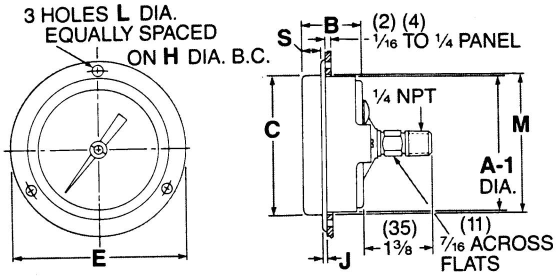
GAUGE SIZE		A	B	C	D	E	F	G	H	J
2½	INCH	2 7/8	2 9/16	3/8	1 5/8	3 11/16	23/32	5/32	3 1/8	5/32
	MM	73	65	10	41	96	18	4	79	4
3½	INCH	3 31/32	3	15/32	1 19/32	5 7/32	25/32	1/4	4 9/16	5/32
	MM	101	76	12	40	133	20	6	116	4



Back Connection w/Wall Mtg. Back Flange (XFW)

2½" Kit #3527, 3½" Kit #3528.

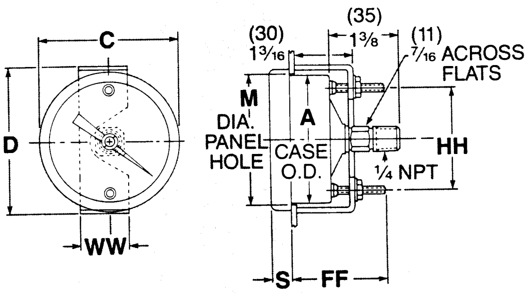
GAUGE SIZE		A	B	C	D	E	F	G	H
2½	INCH	2 3/4	1 15/32	2 7/8	3/8	7/8	3 11/16	5/32	3 1/8
	MM	70	37	73	10	22	96	4	79
3½	INCH	3 5/8	1 23/32	3 31/32	15/32	1 3/32	5 7/32	7/32	4 9/16
	MM	92	44	101	12	28	133	6	116



Back Connection w/3 Hole Front Flange Panel Mount (XFF)

2½" Kit #3522, 3½" Kit #3523.

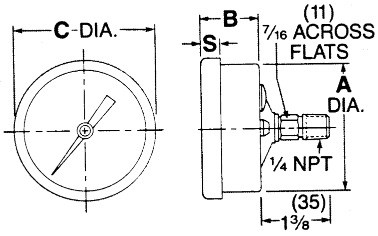
GAUGE SIZE		B	C	E	A-1	H	J	L	M	S
2½	INCH	1 5/32	2 7/8	3 11/16	2 23/32	3 1/8	1/16	5/32	2 13/16	3/8
	MM	29	73	94	69	79	2	4	70	10
3½	INCH	1 7/32	3 31/32	5 7/32	3 11/16	4 9/16	5/32	7/32	3 13/16	15/32
	MM	31	101	133	94	116	4	6	95	12



Back Connection w/"U" Clamp Panel Mount (XUC)

2½" Kit #3520, 3½" Kit #3521.

GAUGE SIZE		A	C	D	M	S	HH	FF	WW
2½	INCH	2 21/32	2 7/8	2 15/16	2 11/16	3/8	2 1/16	1 25/32	1 1/8
	MM	67	73	74	68	10	52	45	29
3½	INCH	3 19/32	3 31/32	4 3/16	3 21/32	15/32	2 13/32	1 3/4	1 1/16
	MM	91	101	106	93	12	61	44	27



Back Connection

GAUGE SIZE		A	B	C	S
2½	INCH	2 21/32	1 5/32	2 7/8	3/8
	MM	67	29	73	10
3½	INCH	19/32	1 7/32	3 31/32	15/32
	MM	91	31	101	12

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DRESSER INDUSTRIES DRESSER
INSTRUMENT DIVISION

6/90 20M

INSTRUCTIONS FOR THE SELECTION, INSTALLATION AND USE OF THE TYPE 91 SERIES ADAPTER SET

The Type 91 series adapter sets were designed to provide a simple means of installing a Bi-metal Dial Thermometer into an existing Industrial Glass Thermometer well.

The adapter set consists of:

1. A metal liner and spring assembly.
2. An adapter nut.
3. A small supply of heat conducting medium.

METHOD OF SELECTING THE SET

The adapter sets are available in four different sizes, to cover various depths of wells. The "Selection Chart" shows the adapter set number and the Bi-metal Dial Thermometer stem length to use for any well depth from 3⅝" up to 25⅛".

To select the proper adapter set and Bi-metal Dial Thermometer stem length, measure first the well depth by inserting a pencil, or any small diameter rod or stiff wire until it reaches the bottom. (See Figure 1). Be sure the rod does not hang up on any shoulder inside the well. Using your thumb as an index, withdraw the rod and measure the distance from the end of the rod to the index point. (See Figure 2).

Then use the chart to select the adapter set and the Bi-metal Dial Thermometer stem length to fit the well.

Note that one stem length of thermometer covers several different well depths by using the correct adapter set.

For example, a thermometer with a 9" long stem can be used for all well depths between 7⅛" and 10⅛", by choosing the correct adapter set.

The liner is tapped with a 5⁄16"—18 machine thread so it can be removed from the well if desired.

INSTALLATION

Assemble the adapter nut into the well and tighten securely. (See Figure 3).

Before installing the Bi-metal Dial Thermometer into the adapter and well, coat the lower 3" section of the thermometer stem with a layer of heat conducting medium. This will improve the temperature response of the thermometer.

The metal liner is then slipped over the end of the thermometer stem and a coating of heat conducting medium is applied to the outside wall of the liner.

The thermometer and liner are then inserted into the well and tightened in position. Do not tighten more than is necessary to prevent the thermometer from turning.

Where service temperatures exceed 350°F the heat conducting medium may smoke when first subjected to a high temperature. This is caused by the vehicle, in the heat conducting medium, vaporizing and leaving the dry solids behind. This should not be cause for alarm. The dry solids will act equally well as a heat conducting medium for temperatures up to 1000°F.

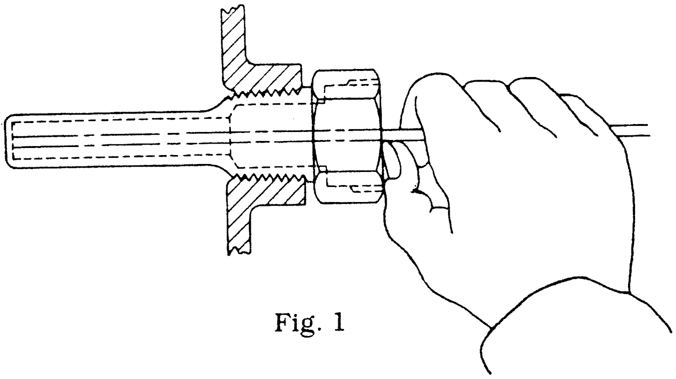


Fig. 1

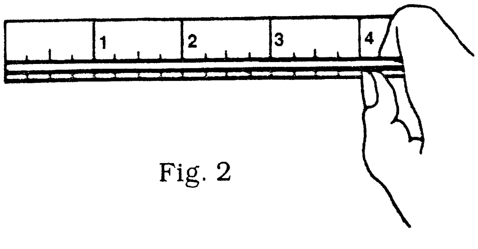


Fig. 2

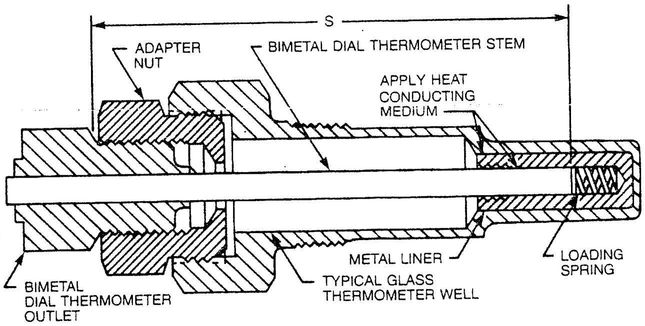
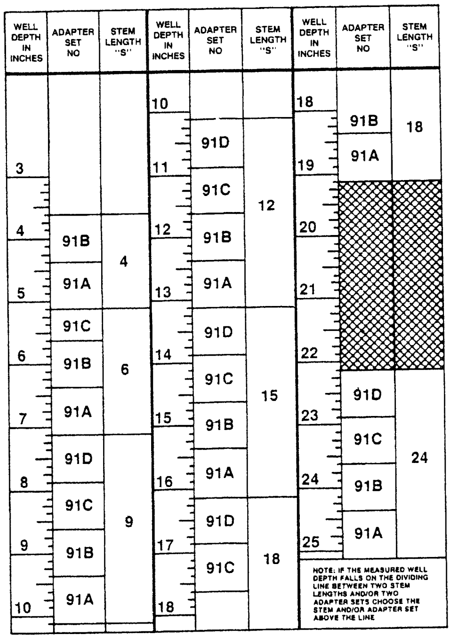


Fig. 3

SELECTION CHART



WELL DEPTH IN INCHES	ADAPTER SET NO	STEM LENGTH "S"	WELL DEPTH IN INCHES	ADAPTER SET NO	STEM LENGTH "S"	WELL DEPTH IN INCHES	ADAPTER SET NO	STEM LENGTH "S"
3	91B	4	10	91D	12	18	91B	18
4	91A		11	91C		19	91A	
5	91C	6	12	91B		20	▨	▨
6	91B		13	91A		21		
7	91A		14	91D	15	22		
8	91D	9	15	91C		23	91D	24
9	91C		16	91B		24	91C	
10	91B		17	91A		25	91B	
	91A		18	91D	18		91A	
				91C				

NOTE: IF THE MEASURED WELL DEPTH FALLS ON THE DIVIDING LINE BETWEEN TWO STEM LENGTHS AND/OR TWO ADAPTER SETS CHOOSE THE STEM AND/OR ADAPTER SET ABOVE THE LINE

INSTRUCTIONS FOR THE INSTALLATION AND USE OF ASHCROFT® BI-METAL DIAL THERMOMETERS

GENERAL

In removing the thermometer out of the packing box, handle it by the case or case outlet. Avoid handling it by the stem.

INSTALLATION OF THERMOMETERS

The thermometer should be mounted at any convenient location where it will be subjected to the average temperature variations to be indicated.

Avoid bending the stem as this will cause misalignment of the internal parts, resulting in undue frictional errors.

To tighten the thermometer to the apparatus, use a wrench applied to the hexagon head of the threaded connection located just outside of the case.

INSTALLATION

Locate the stem so that at least the last two inches will be subjected to the average temperature to be measured.

Exposing the stem to a temperature in excess of the highest dial reading should be avoided.

The thermometer is normally provided with a threaded connection. To tighten the thermometer to the apparatus or into the well, use an open-end wrench applied to the hexagon head of the threaded connection. Turn until reasonably tight, then tighten still further in the same manner as a pipe elbow or similar pipe fitting until the scale is in the desired position for reading. DO NOT TIGHTEN BY TURNING THE THERMOMETER CASE. *Install the thermometer so that the maximum case temperature is kept below 200°F at all times.*

When a thermometer is equipped with a well, the well should be installed onto the apparatus first. The stem of the thermometer should then be coated with a heat conducting medium (a mixture of glycerine and graphite or vaseline or any other heavy lubricant may be used), after which the thermometer stem is inserted, and tightened into the well.

CAUTION: Thermowells should be used on all pressurized applications, to protect the thermometer stem from corrosion or physical damage, and to facilitate removal of thermometer without disturbing the process.

TESTING

Ashcroft Bi-metal Dial Thermometers are carefully calibrated at the factory and under most operating conditions will retain their accuracy indefinitely. However, as in the case of all instruments, it is well to make periodic checks for accuracy against known standards.

ADJUSTMENT

If it is necessary to make an adjustment to the thermometer, proceed as follows:

On thermometers fitted with an "External Adjustment"—Use a small wrench, small screwdriver or a coin to turn the slotted hexagon head in the back of the case until the pointer indicates the proper temperature on the dial.

MAINTENANCE OF DIAL THERMOMETERS

Aside from occasional testing, little or no maintenance is required.

Be sure that the gasketed glass cover is on the case at all times, as moisture and dirt inside the case will eventually cause the thermometer to lose its accuracy. (See caution note below).

If the thermometer is used for measuring the temperature of a material that may harden and build up an insulating layer on the stem, the thermometer should be removed from the apparatus occasionally, and the stem cleaned. Observe this precaution to insure the sensitivity of the instrument.

CAUTION: Bi-metal Thermometers operating below freezing must have a perfectly tight case to prevent entrance of moisture which eventually will condense and freeze inside the stem. This condition shows up as a failure of the thermometer to read accurately below 32°F or 0°C. For this reason it is important to avoid damage to the glass front, while the stem temperature is at freezing or below.

Thermometers fitted with the non-removable ring are hermetically sealed in a dry atmosphere at the factory and require no further maintenance.

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INSTRUMENT DIVISION
DRESSER INDUSTRIES INC.
STRATFORD, CONNECTICUT 06497

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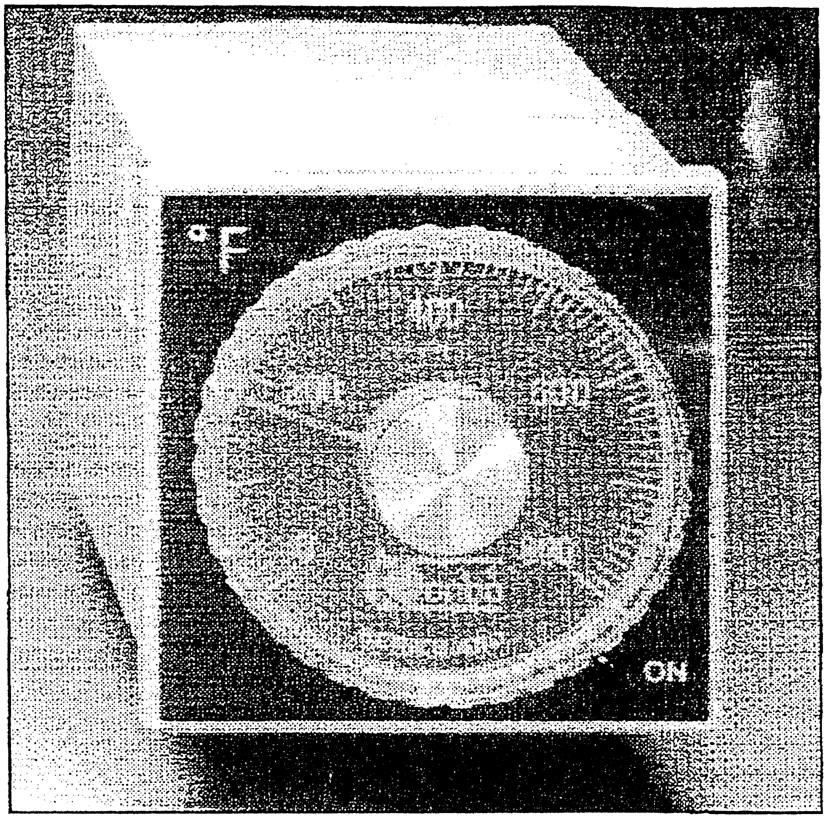


The economical Konbo 480 is a great choice when expensive, advanced features aren't needed. The controller has widespread use in a variety of industrial applications.

The Low Cost, Easy Controller

480

The Konbo 480 1/16 DIN temperature controller

The Konbo 480 is our most economical general purpose controller. It offers a simple-to-operate dial indicator and features both on/off and time-proportional controls. The 480 is perfect for applications where more expensive advanced features aren't needed and for OEM applications which call for easy installation. Industrial control applications for the 480 include plastics and rubber molding, textile processing, food baking, hot stamping, and control of flow ordering machinery.

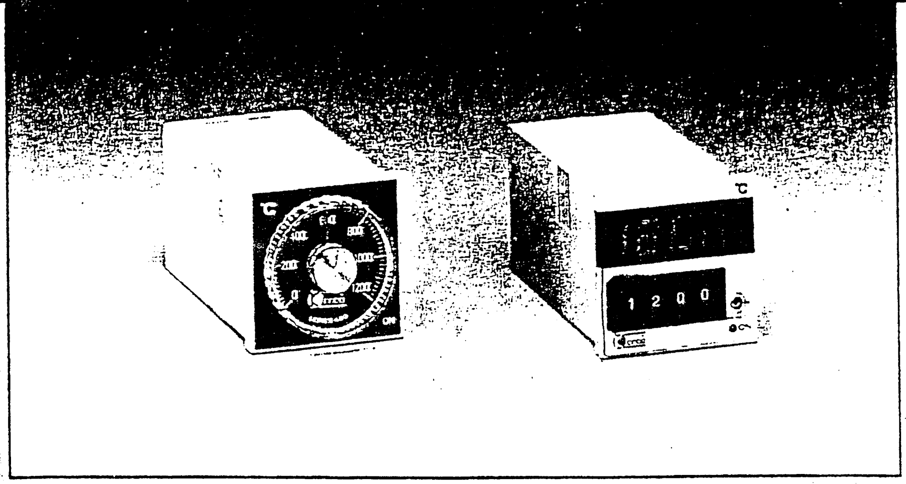
A number of features make this controller an excellent choice. The 480 offers automatic thermocouple cold junction compensation to provide accurate control regardless of ambient conditions. Open sensor protection prevents your system from overheating in the event of sensor failure. The controller operates at either 110 or 220V AC, and can be ordered in either Fahrenheit or Celsius configurations. The 480 accepts input from thermocouple (J or K) or RTD sensors.

And what else? There's more! A list of some of the key features and how they'll benefit you is shown on the following page.

Temperature Controllers

Series 480/486

1/16 DIN Controllers



Features

- Cost and space savings
- Thermocouple or RTD input
- Up to 3½-digit set/indicating ranges
- Choice of °C or °F scale
- Bright, easy-to-read LED digits on indicating units
- Automatic thermocouple cold junction compensation
- Open sensor protection
- Easy front-of-panel or DIN rail mounting
- Convenient plug-in connection via universal sockets
- Solid state reliability and high-accuracy performance

Typical Applications

- Plastics and rubber molding
- Food and bakery processes
- Textile processing
- Hot stamping machines
- Flow soldering machinery
- Limit control

Ordering Information

To order, please identify your specific requirements using the controller type number codes given below, which also serve as your check list.

☐☐☐ - ☐☐ - ☐ - ☐ - ☐

Series
480: Control only
486: Digital setting, Digital indicating

Input & Range

Set Range	Range Code		
	J	K	PT100*
-100 to +100°C	01		
-50 to +50°C			17
0 to 100°C	02		18
0 to 400°C	04	09	20
0 to 1000°C		11	
0 to 1200°C		12	
-160 to +240°F			21
0 to 200°F	05		22
0 to 600°F		13	24
0 to 1000°F	08	14	
600 to 1600°F		15	

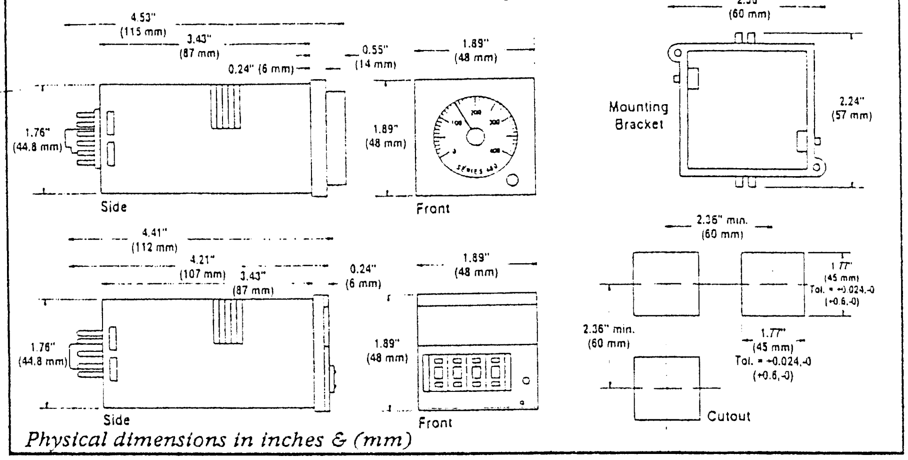
*PT100 (α = 0.00385 ohm/ohm/°C)

Output
1: Relay
2: Unisolated 12 VDC
3: Unisolated 0-5 VDC
4: Unisolated 4-20 mA (Series 486 only)

Control Action
1: ON-OFF
2: P
3: PD
4: ON-OFF/P (Series 480 only)
5: ON-OFF/PD (Series 480 only)

Options
0: None
1: Hi/Lo Limit Alarm (Series 486 only)

Series 480/486



Physical dimensions in inches & (mm)

Specifications

Series	480	486
[illegible]		
Thermocouple	Type J or K	
RTD	PT100Ω, DIN coefficient (α=0.00385Ω/Ω/°C)	
Break Protection	Output OFF on open sensor	Blinking LED or "1" and output OFF on open sensor
Input Impedance	10M ohms	
[illegible]		
Contact	SPDT relay, 5 A at 120 VAC or 3 A at 240 VAC, resistive load Service Life: Mechanical - 10,000,000 operations min., Electrical - 100,000 operations min.	
Voltage	SSR Drive Voltage 12 VDC or Proportional Voltage 0-5 VDC	
Current	N/A	Unisolated 4-20 mA (max. load 300 Ω)
Alarm	N/A	Optional ± 10% F.S. Hi/Lo limit, adjustable from front
[illegible]		
Mode	ON-OFF/P or ON-OFF/PD, field selectable	ON-OFF, P or PD
ON - OFF	Differential: 0.5% F.S., symmetrical around setpoint	
Proportional	Prop. Band: 2.5% F.S., symmetrical around setpoint Prop. Cycle: Approx. 20 sec. (relay output) or 2 sec. (SSR drive output)	
Manual Reset	N/A	± 3% F.S., adjustable from front
INDICATION		
Process Temperature	N/A	Up to 3½ digits, 0.4" red LED display
Accuracy	N/A	± 1% F.S. (T/C) or ± 0.5% F.S. (RTD)
A/D Converter	N/A	Dual slope
Output	ON red LED indicator	
[illegible]		
Mode	Analog via wire-wound potentiometer	Digital via push-push switches
Scale Length	Approx. 82mm	N/A
Resolution	0.4% F.S.	Least significant digit
Accuracy	± 2% F.S. (T/C) or ± 1% F.S. (RTD)	± 0.1% F.S. or ± 1 digit (whichever is greater)
Repeatability	± 0.2% F.S.	± 0.1% F.S.
[illegible]		
Supply Voltage	110/220 VAC, 50/60 Hz, user selectable at connector	
Voltage Variation	90 to 110% of rated voltage	
Consumption	Less than 2 VA	Less than 3 VA
[illegible]		
Insulation	20M ohms min. (500 VDC)	
Breakdown	1,500 VAC, 50/60 Hz for 1 minute	
Operating Temperature	0-50°C	
Operating Humidity	45-85% RH	
Vibration	10-55 Hz, amplitude 0.5mm	
Connections	Via 11-pin connector	
Mounting	Panel or DIN rail mounting	
Net Weight	Approx. 200g	Approx. 250g

The TOTAL policy is one of continuous development and improvement. Therefore, specifications are subject to change without prior notice.

TEMPERATURE CONTROLLERS

Configuration	1/16 DIN		1/8 DIN		1/4 DIN			Sub-Panel
Series	480	486	492	496	962	964	967	906
Page Number	10-11		12-13		14-15			16-17
[illegible]								
Thermocouple	Type J or K					Types J, K, R, S or B		Type J or K
RTD	PT100 Ω, DIN							N/A
[illegible]								
Minimum to Maximum °C	-100 to 1200°C		-99 to 999°C		-100 to 1200°C	-100 to 1600°C		-100 to 1200°C
°F	-160 to 1600°F		-99 to 999°F		-160 to 1999°F			0 to 1600°F
[illegible]								
Relay	●	●	●	●	●	●	●	●
Voltage	●	●	●	●		●	●	●
Current		●				●	●	
Limit Alarm		●		●		●		
[illegible]								
ON-OFF	●	●	●	●	●	●		●
Proportional	●	●	●	●	●	●		●
PD	●	●	●	●	●	●		
PID							●	
[illegible]								
Analog			●		●			
Digital		● 3 ½-Digit		● 3-Digit		● 3½-Digit	● 3½-Digit	
Control Only, No Indication	●							●
[illegible]								
Analog	●				●	●		●
Digital		●	●	●			●	

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Telephone 612/935-4400 • Facsimile 612/935-8782
Toll Free 800/328-3871

PRT INSTRUCTION SHEET

HANDLING

Platinum Resistance Thermometers (PRTs) are precision instruments and should be handled accordingly. Extensive service life can be expected in the absence of high vibration, extreme temperature, and rough handling. Unless specifically ordered, PRTs are not bendable.

INSPECTION – PHYSICAL

Examine the sheath and mounting surfaces for compliance with the order and for signs of shipping damage. Whenever type C or K PRTs are ordered without thermowells, they are shipped unassembled to prevent damage during shipment. Install the thermowell, extension, and connection head prior to installing the PRT to prevent leadwire damage.

INSPECTION – ELECTRICAL

Element Resistance: Figure 1
Check element resistance using an ohmmeter with a test current of no more than 5 milliamps. Do not use an insulation resistance meter as these devices use voltage/current levels that may permanently damage the PRT.

Type 2 PRTs – Measure the resistance between the leadwires. This resistance should approximately equal the resistance given in the Resistance vs. Temperature Tables at ambient temperatures.

Type 3 and 4 PRTs – Element resistance is determined by subtracting the compensating loop resistance (R1) from the element loop resistance (R2). The resulting resistance should approximately equal the resistance given in the Resistance vs. Temperature Tables at ambient temperatures.

Insulation Resistance – Using a meter capable of measuring resistances in the range of 5 to 500 megohms (10 6 ohms), measure the insulation resistance between the leadwires and the sheath when the PRT is at room temperature. The insulation resistance should be at least 500 megohms.

FIELD WIRING

PRTs should be connected to the recorder, controller, transmitter, or computer with copper wires. Do not use Thermocouple extension wire. Long lead lengths (even several hundred feet) do not affect accuracy if Type 3, 4, or type 5 sensors and appropriate signal conditioners are used. It is recommended that shielded wire be used wherever possible. Make sure that the field wiring and sensor lead style comply with the schematic for the signal conditioner in use. Lead wire resistance should not exceed the limitations of the signal conditioner. Typical wire gage is 18 AWG.

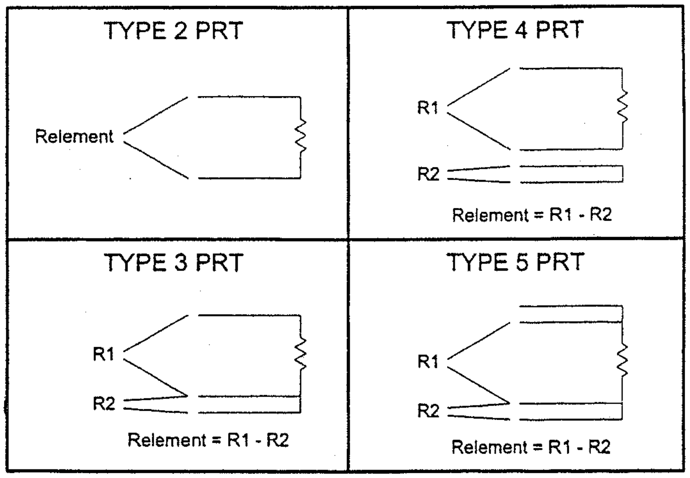
OUTPUT

Refer to Resistance vs. Temperature Tables. Be sure to use the appropriate table for your sensor (Tables are given for each combination of temperature coefficient and temperature scale).

ADDITIONAL INFORMATION

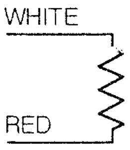
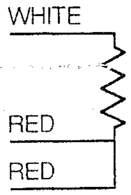
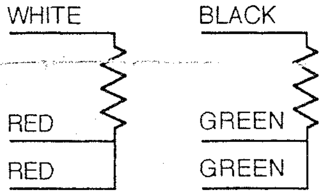
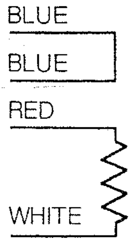
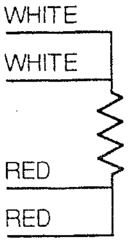
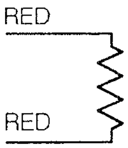
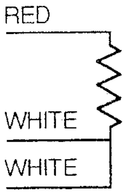
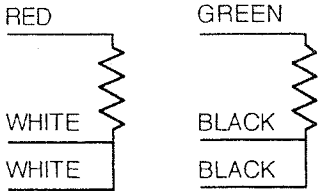
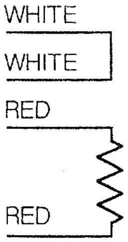
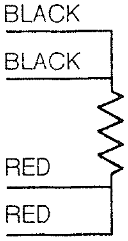
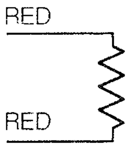
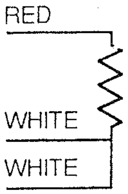
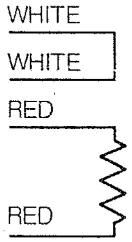
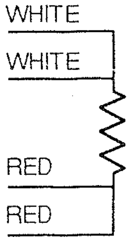
Burns Engineering is available to answer your questions regarding PRT and Thermocouple applications. Call toll free 1-800-328-3871.

Figure 1. Element resistance check diagram



prtinstruction/mw

PRT Color Codes

	TYPE 2	TYPE 3	TYPE 3 DUAL	TYPE 4	TYPE 5
$\alpha = .00385$ CURVE 21					
$\alpha = .003902$ CURVE 1					
$\alpha = .00392$ CURVE 11					

PRT types are designated not only by the wire color code, but also by a label etched onto the sheath of the sensor. The labels correspond to the sensor Resistance vs. Temperature curve as follows:

	100 ohm	**200 ohm**	**500 ohm**
Curve 21	385-1	385-2	385-5
Curve 1	3902-1	3902-2	3902-5
Curve 11	392-1	392-2	392-5

For assistance call 1-800-328-3871

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Resistance vs. Temperature tables (Deg Celcius)

Burns Curve 21 (DIN PRTs - 100 ohm, alpha = .0038500)

	0	-10	-20	-30	-40	-50	-60	-70	-80	-90
-200	18.493									
-100	60.254	56.190	52.106	47.999	43.869	39.714	35.531	31.320	27.078	22.803
0	100.000	96.086	92.160	88.222	84.271	80.307	76.328	72.335	68.325	64.299

	0	10	20	30	40	50	60	70	80	90
0	100.000	103.902	107.793	111.672	115.539	119.395	123.239	127.072	130.893	134.702
100	138.500	142.286	146.061	149.824	153.575	157.315	161.043	164.760	168.465	172.158
200	175.840	179.510	183.168	186.815	190.451	194.074	197.686	201.287	204.876	208.453
300	212.019	215.573	219.115	222.646	226.166	229.673	233.169	236.654	240.127	243.588
400	247.038	250.476	253.902	257.317	260.720	264.112	267.492	270.860	274.217	277.562
500	280.896									

Burns Curve 1 (100 ohm PRTs, alpha = .0039020)

	0	-10	-20	-30	-40	-50	-60	-70	-80	-90
-200	17.073									
-100	59.679	55.551	51.399	47.220	43.012	38.769	34.490	30.173	25.820	21.443
0	100.000	96.031	92.050	88.056	84.049	80.028	75.992	71.940	67.872	63.785

	0	10	20	30	40	50	60	70	80	90
0	100.000	103.956	107.901	111.833	115.753	119.660	123.556	127.440	131.312	135.172
100	139.020	142.856	146.681	150.493	154.294	158.083	161.860	165.626	169.380	173.122
200	176.853	180.572	184.279	187.975	191.659	195.332	198.992	202.642	206.279	209.906
300	213.520	217.123	220.714	224.294	227.862	231.419	234.963	238.496	242.018	245.528
400	249.026	252.512	255.987	259.450	262.901	266.341	269.769	273.184	276.588	279.981
500	283.361									

Burns Curve 11 (100 ohm PRT, alpha = .0039220)

	0	-10	-20	-30	-40	-50	-60	-70	-80	-90
-200	17.082									
-100	59.516	55.381	51.227	47.050	42.847	38.617	34.356	30.063	25.742	21.405
0	100.000	96.014	92.013	88.000	83.973	79.934	75.880	71.813	67.730	63.631

	0	10	20	30	40	50	60	70	80	90
0	100.000	103.976	107.941	111.893	115.833	119.760	123.676	127.580	131.472	135.353
100	139.221	143.078	146.922	150.755	154.576	158.386	162.184	165.970	169.745	173.508
200	177.259	180.999	184.727	188.443	192.148	195.841	199.523	203.194	206.852	210.499
300	214.135	217.759	221.371	224.972	228.562	232.139	235.706	239.260	242.803	246.334
400	249.854	253.362	256.858	260.343	263.816	267.277	270.726	274.164	277.590	281.004
500	284.406									

Resistance vs. Temperature tables (Deg Fahrenheit)

Burns Curve 21 (DIN PRTs - 100 ohm, alpha = .0038500)

	0	-20	-40	-60	-80	-100	-120	-140	-160	-180
-200	48.457	43.869	39.250	34.598	29.910	25.182	20.413	15.599		
0	93.034	88.660	84.271	79.865	75.442	71.000	66.538	62.054	57.547	53.015

	0	20	40	60	80	100	120	140	160	180
0	93.034	97.392	101.736	106.065	110.380	114.681	118.967	123.239	127.497	131.740
200	135.969	140.184	144.385	148.571	152.742	156.900	161.043	165.172	169.286	173.386
400	177.472	181.544	185.601	189.644	193.672	197.686	201.686	205.672	209.643	213.600
600	217.542	221.471	225.385	229.284	233.169	237.040	240.897	244.739	248.567	252.381
800	256.180	259.965	263.736	267.492	271.234	274.962	278.675	282.374		

Burns Curve 1 (100 ohm PRTs, alpha = .0039020)

	0	-20	-40	-60	-80	-100	-120	-140	-160	-180
-200	47.668	42.994	38.278	33.516	28.717	23.858	18.996	14.174		
0	92.919	88.484	84.032	79.563	75.076	70.569	66.040	61.489	56.912	52.306

	0	20	40	60	80	100	120	140	160	180
0	92.919	97.339	101.760	106.149	110.523	114.883	119.227	123.556	127.871	132.171
200	136.456	140.726	144.982	149.224	153.450	157.663	161.860	166.044	170.213	174.367
400	178.507	182.633	186.744	190.841	194.924	198.992	203.047	207.086	211.112	215.123
600	219.120	223.102	227.070	231.024	234.963	238.888	242.799	246.695	250.577	254.444
800	258.297	262.136	265.959	269.769	273.563	277.343				

Burns Curve 11 (100 ohm PRT, alpha = .0039220)

	0	-20	-40	-60	-80	-100	-120	-140	-160	-180
-200	47.456	42.788	38.085	33.344	28.564	23.754	18.937	14.177		
0	92.847	88.389	83.916	79.427	74.920	70.396	65.852	61.289	56.703	52.093

	0	20	40	60	80	100	120	140	160	180
0	92.847	97.289	101.769	106.180	110.577	114.958	119.325	123.676	128.013	132.336
200	136.643	140.936	145.215	149.479	153.728	157.963	162.184	166.390	170.582	174.759
400	178.922	183.071	187.206	191.326	195.432	199.523	203.601	207.664	211.712	215.747
600	219.767	223.773	227.765	231.742	235.706	239.654	243.589	247.509	251.414	255.306
800	259.183	263.045	266.893	270.726	274.545	278.349				

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INSTRUCTION MANUAL 740

RESISTANCE THERMOMETER ELEMENT ASSEMBLIES

PRINCIPLE OF OPERATION

The sensing element is composed of a precision, non-inductively wound, strain-free coil of reference grade platinum.

The resistance of each coil of wire changes with temperature in a highly reproducible manner (see Resistance Temperature Tables).

HIGH ACCURACY

Platinum Resistance Thermometer Element Assemblies provide the most accurate method of temperature measurement. The National Bureau of Standards utilizes this instrument to define the International Practical Temperature Scale between the triple point of hydrogen /(-434.812°F) and the melting point of antimony (1167.332°F).

SHORT SENSITIVE PORTION

The temperature sensitive portion of the element is located in the first 1/2" to 1" of the tip depending on element resistance. This short sensitive length permits measurements at specific locations rather than average temperature over an extended length.

SPRING LOADING

Spring loading insures positive metal-to-metal contact between the resistance element and well providing improved heat transfer and vibration endurance. The element is easily installed or removed through the head without disconnecting head or well.

LINEARITY

Platinum resistance thermometer elements have a nearly linear output well known for stability and dependability.

LEAD WIRES

No special alloy lead wires are required. Regular copper conductors may be used from remotely located elements to the control room. Lead wire resistance is compensated for within the instrument to which the element is connected. Consult the instrument specifications for proper lead wire selection. Shielded 18 GA lead wires are generally used. Extra long lead wire lengths may require special attention.

NO REFERENCE JUNCTION REQUIRED

Resistance thermometers do not use reference junctions which are required on thermocouple systems. All connections are made without regard to polarity.

MATERIALS

Type 316 stainless steel is standard for temperatures from -325°F to 900°F.

Inconel tubing is used for temperatures above 900°F.

Hastaloy "C" is stocked for applications requiring unusual corrosion resistance.

DURABLE CONSTRUCTION

A heavy wall stainless steel sheath provides improved protection over the sensitive position of the element without sacrifice to speed of response. All joints are heliarc welded. The element and lead wires are enclosed in the sheath in a special way to insure years of dependable service. All element assemblies are considered "heavy duty".

INSPECTION

Each element assembly is carefully inspected prior to shipment. A thorough visual inspection should be made upon receipt to determine if damage occurred during shipment. Look for bends in the sheath or broken lead wires.

A serial number is impression stamped or engraved on each element assembly as well as tag numbers when specified. These identifying numbers should be used in any future correspondence or re-orders.

NOTE: Whenever type C or K PRTs are ordered without thermowells, they are shipped unassembled to prevent damage during shipment. Install the thermowell, extension, and connection head prior to installing the PRT to prevent leadwire damage.

TESTING

To determine that the resistance element is operational, the following tests may be run:

CONTINUITY -

With a digital multimeter, check the resistance of the element at room temperature (20°C) by measuring the resistance across any two different colored leadwires. The resistance of the element should be approximately 107-110 ohms for a 100 ohm RTD and 214-220 ohms for a 200 ohm RTD. The Current used to measure the resistance of the element should not exceed 10 milliamps.

Check the resistance between any two like-colored leadwires. The resistance should be no more than 2 ohms (some RTDs with very long leadwires may have a larger resistance across the like colored leadwires).

INSULATION RESISTANCE -

With dry external surfaces, the insulation resistance between any lead wire and the metal sheath should be greater than 200 megohms. If insulation resistance appears to be low, or the element has become wet, place it in an oven at approximately 250°F for 3 hours or until dry, and repeat the test.

CALIBRATION

INDUSTRIAL PRTs

Burns Engineering's standard temperature vs. resistance temperature curves were developed over the period of several years. The standard interpolation equations used to describe the resistance vs. temperature relationship of industrial PRTs is known as the Calander-Van Dusen equation. The equation describes the nominal resistance of each calibration curves at any temperature within the operating range of the PRT.

The coefficients given below give the nominal resistance vs. temperature relationship for each of the standard curves. Using these coefficients you can expect an interpolation error no worse than the standard interchangeability error for the accuracy grade of the sensor you have purchased. If greater accuracy is required, each individual PRT can be calibrated and have its own unique set of calibration coefficients determined. In this case, the interpolation error is reduced to approximately the accuracy of the calibration itself. This typically results in a 10-fold improvement in the accuracy of the interpolation.

The Calander-Van Dusen interpolation equation for the temperature range of 0 to 850 deg. C is:

$$R(t) = R0\ (1 + At + Bt^2)$$

For the temperature range of -200 to 0 deg. C:

$$R(t) = R0\ (1 + At + Bt^2 + C(t-100)t3)$$

Where

$R(t)$ = the resistance of the PRT at the temperature t

t = temperature in deg. C

$R0$ = the nominal resistance of the PRT at 0 deg. C

A, B, C = calibration coefficients

The nominal calibration coefficients for Burns Engineering's standard curves are:

CURVE #	Ro	A	B	C
1	100	3.959626919e-3	-5.84880952e-7	-5.81230159e-12
2	200	3.959626919e-3	-5.84880952e-7	-5.81230159e-12
21	100	3.90806061e-3	-5.8030303e-7	-4.26906566e-12
22	200	3.90806061e-3	-5.8030303e-7	-4.26906566e-12

To determine the temperature from a measured resistance, a different set of equations and calibration coefficients are required. For temperatures greater than 0 deg. C (measured resistances greater than the known ice point resistance of the PRT):

$$t(^{o}C) = ((Rt-Ro)/(Alpha^{*}Ro)) + Delta((t/100)-1)(t/100)$$

For temperatures less than 0 deg. C (measured resistances less than the known ice point resistance of the PRT):

$$t(^{o}C) = ((Rt-Ro)/(Alpha^{*}Ro)) + Delta((t/100)-1)(t/100) + Beta((t/100)-1)(t/100)3$$

where

t = temperature to be calculated

Rt = measured resistance at unknown temperature

Ro = Resistance of the sensor at 0 deg. C

Alpha, Delta, Beta = coefficients

To correctly determine the temperature from a given resistance, you must iterate the equations a minimum of 5 times. After each calculation, the new value of Temperature (t) is plugged back into the equations. The calculated temperature value will converge on its true value. After 5 iterations, the calculated temperature should be within ±.001 deg. C of the true value.

The coefficients for Burns Engineering's standard curves are:

CURVE #	Ro	ALPHA	DELTA	BETA
1	100	.003901138	1.49925724	.14898990
2	200	.003901138	1.49925724	.14898990
21	100	.0038500	1.50726873	.11088395
22	200	.0038500	1.50726873	.11088395

PRIMARY AND SECONDARY STANDARD PRTs

The temperature scales and interpolation equations used with Primary and Secondary standard PRTs are very different than those used for the industrial type probes. The interpolation equations are significantly more complex. Computer programs are typically used to resolve the equations.

The current temperature scale is known as the ITS-90 (International Temperature Scale of 1990). It was adopted on January 1, 1990, as a replacement to the previous scale IPTS-68. The use of the ITS-90 and IPTS-68 scales are typically reserved for the laboratory. Industrial control equipment is not set up to use these scales.

Burns Engineering has a computer program available for performing the ITS-90 calculations. Please call for more information.

Burns Engineering also publishes technical articles on the use of the IPTS-68 and ITS-90 equations. To obtain a copy of these articles, please request Burns Engineering Form # 0793268 for the IPTS-68 guide, and Form # 0990243 for the ITS-90 guide.

SELF-HEATING RESISTANCE THERMOMETERS

Self-heating is caused by electric current used to determine element resistance. The error is typically 50 milliwatts per degree centigrade for 1/4 inch diameter resistance thermometers in water moving at 3 feet per second.

Example:

Water moving at 3 feet per second.
Current of 2 milliamps.
Element resistance of 110 ohms

$$\begin{aligned}\text{Power} &= I^2R\\ &= (2 \times 10^{-3}\ \text{Amps})^2\ (110\ \text{ohms})\\ &= .044\ \text{milliwatts}\end{aligned}$$

$$\begin{aligned}\text{Temperature error} &= \frac{\text{Power}}{\text{Self-heating Coefficient}}\\ &= \frac{.044\ \text{Milliwatts}}{50\ \text{milliwatts / deg. C.}}\\ &= .0088\ \text{deg. C.}\\ &= .0158\ \text{deg. F. (Insignificant)}\end{aligned}$$

Example:

Same conditions except current is 5 milliamps

$$\begin{aligned}\text{Power} &= (5 \times 10^{-3}\ \text{Amps})^2\ (110\ \text{ohms})\\ &= 2.75\ \text{milliwatts}\end{aligned}$$

$$\begin{aligned}\text{Temperature error} &= \frac{2.75\ \text{milliwatts}}{50\ \text{milliwatts / deg. C.}}\\ &= .055\ \text{deg. C.}\\ &= .099\ \text{deg. F.}\end{aligned}$$

Factors that affect self-heating error are thermal conductivity and velocity of the process medium being measured. These are the same factors that affect time response.

Most instrumentation produced today supplies 1 Ma source current to the RTD. When calibrating the RTD, we do the same. Therefore, under most circumstances, error from self-heating will be insignificant.

man740

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BURNS CURVE #21

Resistance vs. Temperature table for DIN PRTs (alpha = .0038500 Ω/Ω-°C)
Ro = 100.000 ohms
Temperatures (in bold) in Deg. Fahrenheit

°F	**0**	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**	
-350	13.175										**-350**
-300	25.182	23.994	22.803	21.609	20.413	19.214	18.012	16.807	15.599	14.389	**-300**
-250	36.929	35.764	34.598	33.429	32.258	31.085	29.910	28.731	27.551	26.368	**-250**
-200	48.457	47.313	46.167	45.019	43.869	42.717	41.564	40.408	39.250	38.090	**-200**
-150	59.804	58.676	57.547	56.417	55.284	54.151	53.015	51.878	50.739	49.599	**-150**
-100	71.000	69.886	68.771	67.655	66.538	65.419	64.299	63.177	62.054	60.930	**-100**
-50	82.071	80.969	79.865	78.761	77.656	76.550	75.442	74.333	73.223	72.112	**-50**
0	93.034	91.942	90.849	89.755	88.660	87.565	86.468	85.370	84.271	83.171	**0**
	0	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**	

°F	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	
0	93.034	94.125	95.215	96.304	97.392	98.479	99.566	100.651	101.736	102.819	**0**
50	103.902	104.984	106.065	107.145	108.224	109.303	110.380	111.457	112.532	113.607	**50**
100	114.681	115.754	116.826	117.897	118.967	120.037	121.105	122.173	123.239	124.305	**100**
150	125.370	126.434	127.497	128.559	129.620	130.681	131.740	132.799	133.857	134.914	**150**
200	135.969	137.024	138.079	139.132	140.184	141.236	142.286	143.336	144.385	145.432	**200**
250	146.479	147.526	148.571	149.615	150.658	151.701	152.742	153.783	154.823	155.862	**250**
300	156.900	157.937	158.973	160.009	161.043	162.077	163.109	164.141	165.172	166.202	**300**
350	167.231	168.259	169.286	170.313	171.338	172.363	173.386	174.409	175.431	176.452	**350**
400	177.472	178.491	179.510	180.527	181.544	182.559	183.574	184.588	185.601	186.613	**400**
450	187.624	188.634	189.644	190.652	191.660	192.666	193.672	194.677	195.681	196.684	**450**
500	197.686	198.688	199.688	200.688	201.686	202.684	203.681	204.677	205.672	206.666	**500**
550	207.659	208.651	209.643	210.634	211.623	212.612	213.600	214.587	215.573	216.558	**550**
600	217.542	218.526	219.508	220.490	221.471	222.450	223.429	224.407	225.385	226.361	**600**
650	227.336	228.311	229.284	230.257	231.228	232.199	233.169	234.138	235.107	236.074	**650**
700	237.040	238.006	238.970	239.934	240.897	241.859	242.820	243.780	244.739	245.697	**700**
750	246.655	247.611	248.567	249.522	250.476	251.429	252.381	253.332	254.282	255.231	**750**
800	256.180	257.128	258.074	259.020	259.965	260.909	261.852	262.794	263.736	264.676	**800**
850	265.616	266.554	267.492	268.429	269.365	270.300	271.234	272.167	273.099	274.031	**850**
900	274.962	275.891	276.820	277.748	278.675	279.601	280.526	281.450	282.374	283.296	**900**
	0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	

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BURNS CURVE #21

Resistance vs. Temperature table for DIN PRTs (alpha = .0038500 Ω/Ω-°C)

Ro = 100.000 ohms

Temperatures (in bold) in Deg. Celsius

°C	**0**	**-2**	**-4**	**-6**	**-8**	**-10**	**-12**	**-14**	**-16**	**-18**	
-200	18.493										**-200**
-180	27.078	26.226	25.372	24.517	23.661	22.803	21.944	21.083	20.221	19.358	**-180**
-160	35.531	34.691	33.850	33.008	32.165	31.320	30.474	29.627	28.779	27.929	**-160**
-140	43.869	43.040	42.210	41.379	40.547	39.714	38.879	38.044	37.208	36.370	**-140**
-120	52.106	51.286	50.466	49.645	48.822	47.999	47.175	46.350	45.524	44.697	**-120**
-100	60.254	59.443	58.631	57.818	57.005	56.190	55.375	54.559	53.742	52.924	**-100**
-80	68.325	67.521	66.717	65.911	65.105	64.299	63.491	62.683	61.874	61.065	**-80**
-60	76.328	75.531	74.733	73.934	73.135	72.335	71.534	70.733	69.931	69.128	**-60**
-40	84.271	83.479	82.687	81.894	81.101	80.307	79.512	78.717	77.921	77.125	**-40**
-20	92.160	91.374	90.587	89.799	89.011	88.222	87.433	86.643	85.853	85.063	**-20**
0	100.000	99.218	98.436	97.653	96.870	96.086	95.302	94.517	93.732	92.946	**0**
	0	**-2**	**-4**	**-6**	**-8**	**-10**	**-12**	**-14**	**-16**	**-18**	

°C	**0**	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	
0	100.000	100.781	101.562	102.343	103.123	103.902	104.681	105.460	106.238	107.016	**0**
20	107.793	108.570	109.346	110.122	110.897	111.672	112.446	113.220	113.994	114.767	**20**
40	115.539	116.311	117.083	117.854	118.625	119.395	120.165	120.934	121.703	122.471	**40**
60	123.239	124.007	124.774	125.540	126.306	127.072	127.837	128.602	129.366	130.130	**60**
80	130.893	131.656	132.418	133.180	133.941	134.702	135.463	136.223	136.982	137.741	**80**
100	138.500	139.258	140.016	140.773	141.530	142.286	143.042	143.797	144.552	145.307	**100**
120	146.061	146.814	147.567	148.320	149.072	149.824	150.575	151.326	152.076	152.826	**120**
140	153.575	154.324	155.072	155.820	156.568	157.315	158.061	158.808	159.553	160.298	**140**
160	161.043	161.787	162.531	163.274	164.017	164.760	165.501	166.243	166.984	167.724	**160**
180	168.465	169.204	169.943	170.682	171.420	172.158	172.895	173.632	174.368	175.104	**180**
200	175.840	176.575	177.309	178.043	178.777	179.510	180.242	180.975	181.706	182.437	**200**
220	183.168	183.899	184.628	185.358	186.087	186.815	187.543	188.271	188.998	189.724	**220**
240	190.451	191.176	191.901	192.626	193.350	194.074	194.798	195.520	196.243	196.965	**240**
260	197.686	198.407	199.128	199.848	200.568	201.287	202.006	202.724	203.442	204.159	**260**
280	204.876	205.592	206.308	207.024	207.739	208.453	209.167	209.881	210.594	211.307	**280**
300	212.019	212.731	213.442	214.153	214.863	215.573	216.282	216.991	217.700	218.408	**300**
320	219.115	219.822	220.529	221.235	221.941	222.646	223.351	224.055	224.759	225.463	**320**
340	226.166	226.868	227.570	228.272	228.973	229.673	230.373	231.073	231.772	232.471	**340**
360	233.169	233.867	234.565	235.261	235.958	236.654	237.349	238.044	238.739	239.433	**360**
380	240.127	240.820	241.513	242.205	242.897	243.588	244.279	244.969	245.659	246.349	**380**
400	247.038	247.726	248.414	249.102	249.789	250.476	251.162	251.848	252.533	253.218	**400**
420	253.902	254.586	255.269	255.952	256.635	257.317	257.999	258.680	259.360	260.040	**420**
440	260.720	261.399	262.078	262.757	263.434	264.112	264.789	265.465	266.141	266.817	**440**
460	267.492	268.167	268.841	269.514	270.188	270.860	271.533	272.204	272.876	273.547	**460**
480	274.217	274.887	275.557	276.226	276.894	277.562	278.230	278.897	279.564	280.230	**480**
500	280.896										**500**

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BURNS CURVE #1
Resistance vs. Temperature table for 3902 PRTs
According to the IPTS-68 (alpha = .0039020 Ω/Ω-°C)
Ro = 100 ohms
Temperatures (in bold) in Deg Celsius

°C	**0**	**-2**	**-4**	**-6**	**-8**	**-10**	**-12**	**-14**	**-16**	**-18**	
-200	17.073										**-200**
-180	25.820	24.946	24.071	23.195	22.319	21.443	20.567	19.692	18.817	17.944	**-180**
-160	34.490	33.630	32.768	31.904	31.039	30.173	29.305	28.436	27.565	26.693	**-160**
-140	43.012	42.166	41.319	40.471	39.621	38.769	37.917	37.062	36.207	35.349	**-140**
-120	51.399	50.566	49.731	48.895	48.058	47.220	46.381	45.541	44.699	43.856	**-120**
-100	59.679	58.855	58.030	57.205	56.378	55.551	54.723	53.893	53.063	52.231	**-100**
-80	67.872	67.056	66.239	65.422	64.604	63.785	62.965	62.145	61.324	60.502	**-80**
-60	75.992	75.183	74.373	73.563	72.752	71.940	71.128	70.315	69.501	68.687	**-60**
-40	84.049	83.246	82.442	81.638	80.833	80.028	79.222	78.415	77.608	76.800	**-40**
-20	92.050	91.253	90.454	89.655	88.856	88.056	87.256	86.455	85.654	84.852	**-20**
0	100.000	99.207	98.414	97.620	96.826	96.031	95.236	94.440	93.644	92.847	**0**
	0	**-2**	**-4**	**-6**	**-8**	**-10**	**-12**	**-14**	**-16**	**-18**	

°C	**0**	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	
0	100.000	100.792	101.584	102.375	103.166	103.956	104.746	105.536	106.324	107.113	**0**
20	107.901	108.688	109.475	110.261	111.047	111.833	112.618	113.402	114.186	114.970	**20**
40	115.753	116.535	117.317	118.099	118.880	119.660	120.441	121.220	121.999	122.778	**40**
60	123.556	124.334	125.111	125.888	126.664	127.440	128.215	128.990	129.765	130.539	**60**
80	131.312	132.085	132.857	133.629	134.401	135.172	135.942	136.713	137.482	138.251	**80**
100	139.020	139.788	140.556	141.323	142.090	142.856	143.622	144.387	145.152	145.917	**100**
120	146.681	147.444	148.207	148.970	149.732	150.493	151.254	152.015	152.775	153.535	**120**
140	154.294	155.053	155.811	156.569	157.326	158.083	158.839	159.595	160.351	161.106	**140**
160	161.860	162.614	163.368	164.121	164.874	165.626	166.378	167.129	167.880	168.630	**160**
180	169.380	170.129	170.878	171.627	172.375	173.122	173.869	174.616	175.362	176.108	**180**
200	176.853	177.598	178.342	179.086	179.829	180.572	181.341	182.056	182.798	183.539	**200**
220	184.279	185.019	185.759	186.498	187.237	187.975	188.713	189.450	190.187	190.923	**220**
240	191.659	192.394	193.129	193.864	194.598	195.332	196.065	196.797	197.529	198.264	**240**
260	198.992	199.723	200.454	201.183	201.913	202.642	203.370	204.098	204.826	205.553	**260**
280	206.279	207.006	207.731	208.456	209.181	209.906	210.629	211.353	212.076	212.798	**280**
300	213.520	214.242	214.963	215.683	216.403	217.123	217.842	218.561	219.279	219.997	**300**
320	220.714	221.431	222.148	222.863	223.579	224.294	225.009	225.723	226.436	227.149	**320**
340	227.862	228.574	229.286	229.997	230.708	231.419	232.128	232.838	233.547	234.255	**340**
360	234.963	235.671	236.378	237.085	237.791	238.496	239.202	239.907	240.611	241.315	**360**
380	242.018	242.721	243.423	244.125	244.827	245.528	246.228	246.929	247.628	248.327	**380**
400	249.026	249.724	250.422	251.119	251.816	252.512	253.208	253.904	254.599	255.293	**400**
420	255.987	256.681	257.374	258.066	258.759	259.450	260.141	260.832	261.522	262.212	**420**
440	262.901	263.590	264.279	264.967	265.654	266.341	267.027	267.713	268.399	269.084	**440**
460	269.769	270.453	271.136	271.820	272.502	273.184	273.866	274.547	275.228	275.909	**460**
480	276.588	277.268	277.947	278.625	279.303	279.981	280.658	281.334	282.010	282.686	**480**
500	283.361										**500**
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	

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10201 Bren Road East *Minnetonka, Minnesota 55343*
Telephone 612/935-4400 • Facsimile 612/935-8782
Toll Free 800/328-3871

BURNS CURVE #1

Resistance vs. Temperature table for 3902 PRTs
According to the IPTS-68 (alpha = .0039020 Ω/Ω-°C)
Ro = 100 ohms
Temperatures (in bold) in Deg Farhenheit

°F	**0**	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**	
-350	11.821										**-350**
-300	23.858	22.642	21.425	20.208	18.993	17.780	16.571	15.369	14.174	12.991	**-300**
-250	35.903	34.711	33.516	32.318	31.117	29.914	28.717	27.498	26.287	25.073	**-250**
-200	47.668	46.503	45.336	44.166	42.994	41.819	40.641	39.461	38.278	37.092	**-200**
-150	59.204	58.059	56.912	55.763	54.613	53.460	52.306	51.150	49.991	48.831	**-150**
-100	70.569	69.439	68.307	67.174	66.040	64.905	63.768	62.629	61.489	60.347	**-100**
-50	81.800	80.682	79.563	78.443	77.322	76.199	75.076	73.951	72.825	71.697	**-50**
0	92.919	91.812	90.703	89.594	88.484	87.372	86.260	85.146	84.032	82.916	**0**
	0	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**	

°F	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	
0	92.919	94.025	95.131	96.235	97.339	98.441	99.543	100.660	101.760	102.859	**0**
50	103.956	105.053	106.149	107.244	108.338	109.431	110.523	111.615	112.705	113.794	**50**
100	114.883	115.970	117.057	118.142	119.227	120.311	121.393	122.475	123.556	124.636	**100**
150	125.715	126.794	127.871	128.947	130.023	131.097	132.171	133.243	134.315	135.386	**150**
200	136.456	137.525	138.593	139.660	140.726	141.792	142.856	143.920	144.982	146.044	**200**
250	147.105	148.165	149.224	150.282	151.339	152.395	153.450	154.505	155.558	156.611	**250**
300	157.663	158.713	159.763	160.812	161.860	162.908	163.954	164.999	166.044	167.087	**300**
350	168.130	169.172	170.213	171.253	172.292	173.330	174.367	175.403	176.439	177.474	**350**
400	178.507	179.540	180.572	181.603	182.633	183.662	184.690	185.718	186.744	187.770	**400**
450	188.795	189.818	190.841	191.863	192.884	193.905	194.924	195.942	196.960	197.977	**450**
500	198.992	200.007	201.021	202.034	203.047	204.058	205.068	206.078	207.086	208.094	**500**
550	209.101	210.107	211.112	212.116	213.119	214.121	215.123	216.123	217.123	218.122	**550**
600	219.120	220.117	221.113	222.108	223.102	224.095	225.088	226.079	227.070	228.060	**600**
650	229.049	230.037	231.024	232.010	232.995	232.980	234.963	235.946	236.928	237.908	**650**
700	238.888	239.867	240.845	241.823	242.799	243.774	244.749	245.723	246.695	247.667	**700**
750	248.638	249.608	250.577	251.545	252.512	253.479	254.444	255.409	256.373	257.335	**750**
800	258.297	259.258	260.218	261.177	262.136	263.073	264.049	265.005	265.959	266.913	**800**
850	267.866	268.818	269.769	270.719	271.668	272.616	273.563	274.510	275.455	276.400	**850**
900	277.343										**900**
	0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	

Resistance
Thermometers
for
Space
Science
Industry

BURNS ENGINEERING INC.

10201 Bren Road East   Minnetonka, Minnesota 55343

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TEMPERATURE CONVERSIONS

THE NUMBERS IN BOLD FACE TYPE REFER TO THE TEMPERATURE IN DEGREES CENTIGRADE OR FAHRENHEIT WHICH IT IS DESIRED TO CONVERT INTO THE OTHER SCALE

-100 TO 100

C.		F.
-73.3	**-100**	-148
-67.8	**-90**	-130
-62.2	**-80**	-112
-56.7	**-70**	-94
-51.1	**-60**	-76
-45.6	**-50**	-58
-40.0	**-40**	-40
-34.4	**-30**	-22
-28.9	**-20**	-4
-23.3	**-10**	14
-17.8	**0**	32
-17.2	**1**	33.8
-16.7	**2**	35.6
-16.1	**3**	37.4
-15.6	**4**	39.2
-15.0	**5**	41
-14.4	**6**	42.8
-13.9	**7**	44.6
-13.3	**8**	46.4
-12.8	**9**	48.2
-12.2	**10**	50
-11.7	**11**	51.8
-11.1	**12**	53.6
-10.6	**13**	55.4
-10.0	**14**	57.2
-9.44	**15**	59
-8.89	**16**	60.8
-8.33	**17**	62.6
-7.78	**18**	64.4
-7.22	**19**	66.2
-6.67	**20**	68
-6.11	**21**	69.8
-5.56	**22**	71.6
-5.00	**23**	73.4
-4.44	**24**	75.2
-3.89	**25**	77
-3.33	**26**	78.8
-2.78	**27**	80.6
-2.22	**28**	82.4
-1.67	**29**	84.2
-1.11	**30**	86
-.56	**31**	87.8
.00	**32**	89.6
.56	**33**	91.4
1.11	**34**	93.2
1.67	**35**	95
2.22	**36**	96.8
2.78	**37**	98.6
3.33	**38**	100.4
3.89	**39**	102.2
4.44	**40**	104
5.00	**41**	105.8
5.56	**42**	107.6
6.11	**43**	109.4
6.67	**44**	111.2
7.22	**45**	113
7.78	**46**	114.8
8.33	**47**	116.6
8.89	**48**	118.4
9.44	**49**	120.2
10.0	**50**	122
10.6	**51**	123.8
11.1	**52**	125.6
11.7	**53**	127.4
12.2	**54**	129.2
12.8	**55**	131
13.3	**56**	132.8
13.9	**57**	134.6
14.4	**58**	136.4
15.0	**59**	138.2
15.6	**60**	140
16.1	**61**	141.8
16.7	**62**	143.6
17.2	**63**	145.4
17.8	**64**	147.2
18.3	**65**	149
18.9	**66**	150.8
19.4	**67**	152.6
20.0	**68**	154.4
20.6	**69**	156.2
21.1	**70**	158
21.7	**71**	159.8
22.2	**72**	161.6
22.8	**73**	163.4
23.3	**74**	165.2
23.9	**75**	167
24.4	**76**	168.8
25.0	**77**	170.6
25.6	**78**	172.4
26.1	**79**	174.2
26.7	**80**	176
27.2	**81**	177.8
27.8	**82**	179.6
28.3	**83**	181.4
28.9	**84**	183.2
29.4	**85**	185
30.0	**86**	186.8
30.6	**87**	188.6
31.1	**88**	190.4
31.7	**89**	192.2
32.2	**90**	194
32.8	**91**	195.8
33.3	**92**	197.6
33.9	**93**	199.4
34.4	**94**	201.2
35.0	**95**	203
35.6	**96**	204.8
36.1	**97**	206.6
36.7	**98**	208.4
37.2	**99**	210.2
37.8	**100**	212

100 TO 1000

C.		F.
38	**100**	212
43	**110**	230
49	**120**	248
54	**130**	266
60	**140**	284
66	**150**	302
71	**160**	320
77	**170**	338
82	**180**	356
88	**190**	374
93	**200**	392
99	**210**	410
104	**220**	428
110	**230**	446
116	**240**	464
121	**250**	482
127	**260**	500
132	**270**	518
138	**280**	536
143	**290**	554
149	**300**	572
154	**310**	590
160	**320**	608
166	**330**	626
171	**340**	644
177	**350**	662
182	**360**	680
188	**370**	698
193	**380**	716
199	**390**	734
204	**400**	752
210	**410**	770
216	**420**	788
221	**430**	806
227	**440**	824
232	**450**	842
238	**460**	860
243	**470**	878
249	**480**	896
254	**490**	914
260	**500**	932
266	**510**	950
271	**520**	968
277	**530**	986
282	**540**	1004
288	**550**	1022
293	**560**	1040
299	**570**	1058
304	**580**	1076
310	**590**	1094
316	**600**	1112
321	**610**	1130
327	**620**	1148
332	**630**	1166
338	**640**	1184
343	**650**	1202
349	**660**	1220
354	**670**	1238
360	**680**	1256
366	**690**	1274
371	**700**	1292
377	**710**	1310
382	**720**	1328
388	**730**	1346
393	**740**	1364
399	**750**	1382
404	**760**	1400
410	**770**	1418
416	**780**	1436
421	**790**	1454
427	**800**	1472
432	**810**	1490
438	**820**	1508
443	**830**	1526
449	**840**	1544
454	**850**	1562
460	**860**	1580
466	**870**	1598
471	**880**	1616
477	**890**	1634
482	**900**	1652
488	**910**	1670
493	**920**	1688
499	**930**	1706
504	**940**	1724
510	**950**	1742
516	**960**	1760
521	**970**	1778
527	**980**	1796
532	**990**	1814
538	**1000**	1832

1000 TO 3000

C.		F.
538	**1000**	1832
543	**1010**	1850
549	**1020**	1868
554	**1030**	1886
560	**1040**	1904
566	**1050**	1922
571	**1060**	1940
577	**1070**	1958
582	**1080**	1976
588	**1090**	1994
593	**1100**	2012
599	**1110**	2030
604	**1120**	2048
610	**1130**	2066
616	**1140**	2084
621	**1150**	2102
627	**1160**	2120
632	**1170**	2138
638	**1180**	2156
643	**1190**	2174
649	**1200**	2192
654	**1210**	2210
660	**1220**	2228
666	**1230**	2246
671	**1240**	2264
677	**1250**	2282
682	**1260**	2300
688	**1270**	2318
693	**1280**	2336
699	**1290**	2354
704	**1300**	2372
710	**1310**	2390
716	**1320**	2408
721	**1330**	2426
727	**1340**	2444
732	**1350**	2462
738	**1360**	2480
743	**1370**	2498
749	**1380**	2516
754	**1390**	2534
760	**1400**	2552
766	**1410**	2570
771	**1420**	2588
777	**1430**	2606
782	**1440**	2624
788	**1450**	2642
793	**1460**	2660
799	**1470**	2678
804	**1480**	2696
810	**1490**	2714
816	**1500**	2732
821	**1510**	2750
827	**1520**	2768
832	**1530**	2786
838	**1540**	2804
843	**1550**	2822
849	**1560**	2840
854	**1570**	2858
860	**1580**	2876
866	**1590**	2894
871	**1600**	2912
877	**1610**	2930
882	**1620**	2948
888	**1630**	2966
893	**1640**	2984
899	**1650**	3002
904	**1660**	3020
910	**1670**	3038
916	**1680**	3056
921	**1690**	3074
927	**1700**	3092
932	**1710**	3110
938	**1720**	3128
943	**1730**	3146
949	**1740**	3164
954	**1750**	3182
960	**1760**	3200
966	**1770**	3218
971	**1780**	3236
977	**1790**	3254
982	**1800**	3272
988	**1810**	3290
993	**1820**	3308
999	**1830**	3326
1004	**1840**	3344
1010	**1850**	3362
1016	**1860**	3380
1021	**1870**	3398
1027	**1880**	3416
1032	**1890**	3434
1038	**1900**	3452
1043	**1910**	3470
1049	**1920**	3488
1054	**1930**	3506
1060	**1940**	3524
1066	**1950**	3542
1071	**1960**	3560
1077	**1970**	3578
1082	**1980**	3596
1088	**1990**	3614
1093	**2000**	3632
1099	**2010**	3650
1104	**2020**	3668
1110	**2030**	3686
1116	**2040**	3704
1121	**2050**	3722
1127	**2060**	3740
1132	**2070**	3758
1138	**2080**	3776
1143	**2090**	3794
1149	**2100**	3812
1154	**2110**	3830
1160	**2120**	3848
1166	**2130**	3866
1171	**2140**	3884
1177	**2150**	3902
1182	**2160**	3920
1188	**2170**	3938
1193	**2180**	3956
1199	**2190**	3974
1204	**2200**	3992
1210	**2210**	4010
1216	**2220**	4028
1221	**2230**	4046
1227	**2240**	4064
1232	**2250**	4082
1238	**2260**	4100
1243	**2270**	4118
1249	**2280**	4136
1254	**2290**	4154
1260	**2300**	4172
1266	**2310**	4190
1271	**2320**	4208
1277	**2330**	4226
1282	**2340**	4244
1288	**2350**	4262
1293	**2360**	4280
1299	**2370**	4298
1304	**2380**	4316
1310	**2390**	4334
1316	**2400**	4352
1321	**2410**	4370
1327	**2420**	4388
1332	**2430**	4406
1338	**2440**	4424
1343	**2450**	4442
1349	**2460**	4460
1354	**2470**	4478
1360	**2480**	4496
1366	**2490**	4514
1371	**2500**	4532
1377	**2510**	4550
1382	**2520**	4568
1388	**2530**	4586
1393	**2540**	4604
1399	**2550**	4622
1404	**2560**	4640
1410	**2570**	4658
1416	**2580**	4676
1421	**2590**	4694
1427	**2600**	4712
1432	**2610**	4730
1438	**2620**	4748
1443	**2630**	4766
1449	**2640**	4784
1454	**2650**	4802
1460	**2660**	4820
1466	**2670**	4838
1471	**2680**	4856
1477	**2690**	4874
1482	**2700**	4892
1488	**2710**	4910
1493	**2720**	4928
1499	**2730**	4946
1504	**2740**	4964
1510	**2750**	4982
1516	**2760**	5000
1521	**2770**	5018
1527	**2780**	5036
1532	**2790**	5054
1538	**2800**	5072
1543	**2810**	5090
1549	**2820**	5108
1554	**2830**	5126
1560	**2840**	5144
1566	**2850**	5162
1571	**2860**	5180
1577	**2870**	5198
1582	**2880**	5216
1588	**2890**	5234
1593	**2900**	5252
1599	**2910**	5270
1604	**2920**	5288
1610	**2930**	5306
1616	**2940**	5324
1621	**2950**	5342
1627	**2960**	5360
1632	**2970**	5378
1638	**2980**	5396
1643	**2990**	5414
1649	**3000**	5432

$C=5/9(F-32)$ **$F=9/5\,C+32$**

TC2000

two phase control

Thyristor Units

EUROTHERM

User Manual

Thyristor power units
and
Solid state contactors

TC2000
series

Two-phase control of a three-phase load or control of two single-phase loads

User Manual

Part No HA 174757 ENG Issue 1 Printed in France 10/96

CE

EUROPEAN DIRECTIVES

SAFETY

The **TC2000** products installed and used in accordance with this User Manual are designed to comply with the essential protection requirements of the European Low Voltage Directive 73/23/EEC dated 19/02/73 (amended by Directive 93/68/EEC dated 22/07/93).

CE MARK

The CE Mark of **TC2000** products implies that the essential protection requirements of the European Low Voltage Directive are observed.

The **TC2000** Technical Construction File is approved by a Notified Body, **LCIE** (Laboratoire Central des Industries Électriques).

CE DECLARATION OF CONFORMITY

A CE Declaration of Conformity is available on request.
For further information on CE Mark, please contact your nearest Eurotherm office.

ELECTROMAGNETIC COMPATIBILITY (EMC)

For industrial environments, excluding residential environments

The **TC2000** products are considered as components without any direct function as defined in the EMC Directive. The system or installation in which these products are incorporated must complies with the essential protection requirements of the EMC Directive.

However, Eurotherm certifies that the **TC2000** products, when installed and used in accordance with their User Manual, meets the following EMC test standards and enables the system or installation in which there are installed to comply with the EMC Directive in regards to the **TC2000** products.

EMC STANDARDS

Immunity Generic Standard : EN 50082-2
Test Standards : EN 61000-4-2, EN 61000-4-4,
ENV 50140, ENV 50141
Emissions Generic Standard : EN 50081-2
Test Standard : EN 55011
Product Standard : IEC1800-3

The choice of the Conducted Emission applicable standard depends on the application

- EN 50081-2 :
  With a internal standard filter for 60 A and 75 A nominal
  With a internal optional filter (FILT option) for 100 A and 150 A nominal
- IEC 1800-3 :
  Without filter. Applies for the second environment.

EMC FILTER

To reduce the conducted emissions that occur when using thyristor units, the EMC internal filter is added (standard for 60 A and 75 A; optional for 100 A and 150 A).

VALIDATION BY COMPETENT BODY

In order to guarantee the best service, Eurotherm has validated the compliance of the **TC2000** products with EMC test standards through design and laboratory tests that have been validated with a Technical Construction File by a Competent Body, **LCIE** (Laboratoire Central des Industries Électriques).

EMC INSTALLATION GUIDE

In order to help you reduce risks related to the effects of electromagneticinterference depending on the installation of the product, Eurotherm can supply you with the "**EMC Installation Guide**" (Part No. HA025464).
This guide gives the rules generally applicable for Electromagnetic compatibility.

MANUALS IN USE

This **TC2000 User Manual Part No HA 174757 ENG** intended for the TC2000 series power thyristor units manufactured beginning **September 1996.**

The TC2000 User Manual (Part No HA174758) is valid for products manufactured from November 1995 to September 1996.

The TC2000 User Manual (Part No HA174514) is valid for products manufactured before November 1995.

PRECAUTIONS

Important precautions and special information are indicated in the manual by two symbols:

⚠ DANGER

This symbol means that failure to take note of the information may have serious consequences for the safety of personnel and may even result in the risk of electrocution.

⚠ ATTENTION

This symbol means that failure to take note of the information may

- **have serious consequences for the installation**
- **result in the incorrect functioning of the power unit.**

These marks must indicate specific points. The entire manual remains applicable.

PERSONNEL

The installation, configuration, commissioning and maintenance of the power unit must only be performed by a person **qualified and authorised to perform work in an industrial low voltage electrical environment.**

INDEPENDENT SAFETY

It is the responsibility of the user and it is highly recommended, given the value of the equipment controlled using TC2000, to install **independent safety** devices. This alarm must be tested regularly.
Eurotherm can supply suitable equipment.

FURTHER INFORMATION

For any further information and if in doubt, please contact your EUROTHERM office where technicians are at your disposal should you require advice or assistance with the commissioning of your installation.

TC2000 USER MANUAL

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Chapter 7 MAINTENANCE

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Chapter 1

IDENTIFYING THE UNIT

Chapter 1 IDENTIFYING THE UNIT

GENERAL INTRODUCTION TO THE TC2000 SERIES

The **TC2000** thyristor unit series is designed for the electrical power control of industrial three-phase or single-phase loads.

Depending on the type of operation, the **TC2000** series is composed of two types of unit:

- **Solid state contactors** (**logic** operation).
  Units driven by a logic signal, operating in **ON/OFF** mode, emitting the maximum power to the load during the presence of the control signal.

- **Power thyristor units** (**analogue** operation).
  Units driven by an analogue signal emitting an output power proportional to the input signal for thyristor firing and in **Burst firing** mode including a whole number of alternations.

For the solid state contactors and the power thyristor units, the thyristor firing and non-firing are synchronised at zero voltage for each phase, eliminating the steep current fronts which generate supply interference.

TC2000 series units are composed of **two thyristor channels**, which allows the following two types of configuration:

- three-phase configuration
- single-phase configuration.

In the **three-phase configuration,** the TC2000 series units control **two phases** of a three-phase load connected in a closed delta or a star without neutral (3-wire configuration).
In this configuration, **only one** control signal is used.

In the **single-phase configuration,** the **TC2000** series units behave in the same way as two single-phase units incorporated in the same unit, controlling **two** independent single-phase **loads** by two different control signals.

By simply modifying the positions of the jumpers on the driver board, the **TC2000** series unit can be configured to control a three-phase in a three-wire configuration or to control two single-phase loads.

The range of nominal currents of the **TC2000** series power units is from **60** to **500 A** (in **3** unit models) at nominal voltages of **120** to **500 V**.

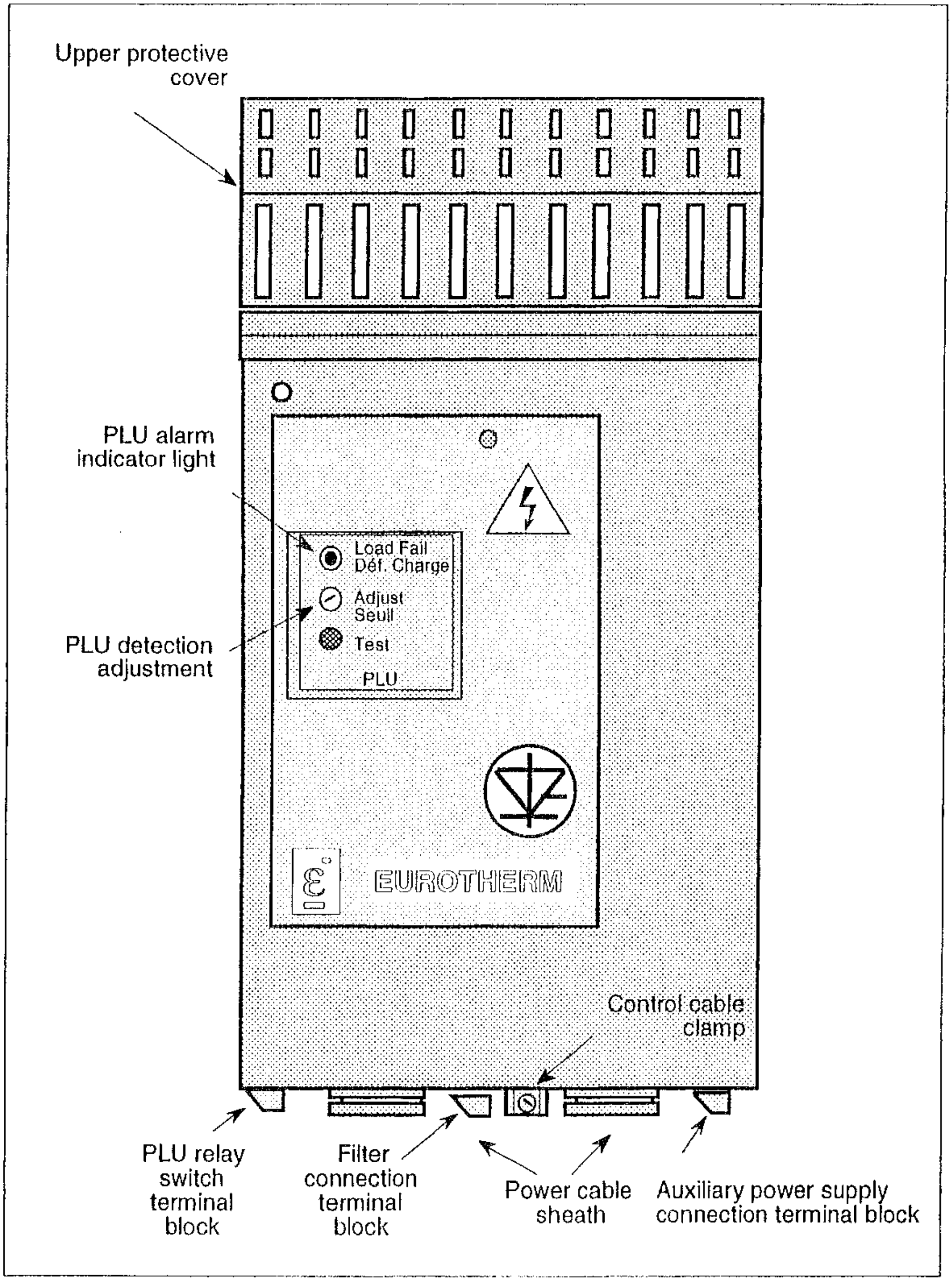


Figure 1-1 Overall view of the TC2000 power unit (PLU or IPU option)

The standard version of the TC2000 series unit (**basic version**) is equipped with a **driver board** which performs the feedback, measurement and thyristor firing functions.

As an **option,** a TC2000 unit in a three-phase configuration is equipped with a partial load unbalance board ("**PLU board**"), which can be plugged into the driver board. With the PLU/ IPU, options, TC2000 series units in a three-phase configuration detect any current unbalance greater than **10%**.

The partial load **unbalance** detection is signalled by the indicator light on the front fascia and by a **PLU alarm relay** switch (switch N/O or N/C depending on, the control code).
The user terminal block of the alarm relay switch is located below the unit, to the left.
In the PLU / IPU options, the front fascia of the unit comprises:

- a "**Load Fail**" indicator light when the partial load unbalance of the three-phase load is detected
- an "**Adjust**" potentiometer to adjust the detection
- a "**Test**" push button.

The partial load unbalance detection system also triggers the alarm for the following cases:

- non-firing of a thyristor
- blowing of a fuse of one of the phases
- absence of a phase or significant drop in voltage of the phases of the three-phase supply.

The simultaneous failure of the 2 fuses, installed inside the unit on the controlled phases, is detected by the fuse blown indication micro-switches (optional).

The **supply** side power cables pass through the **opening of the protective cover**.
The power cables to the **load** pass through the **cable sheath** under the unit.

The control wires are connected on the user terminal block of the driver board.
They must be **shielded** and grounded at **both ends**.

The control cable passes through the **cable clamp** which **secures** the cable and **grounds** the shielding simultaneously.

The thermal switch inhibits the fan-cooled unit (from **100 A** of the nominal current) in the event of thyristor **overheating.**

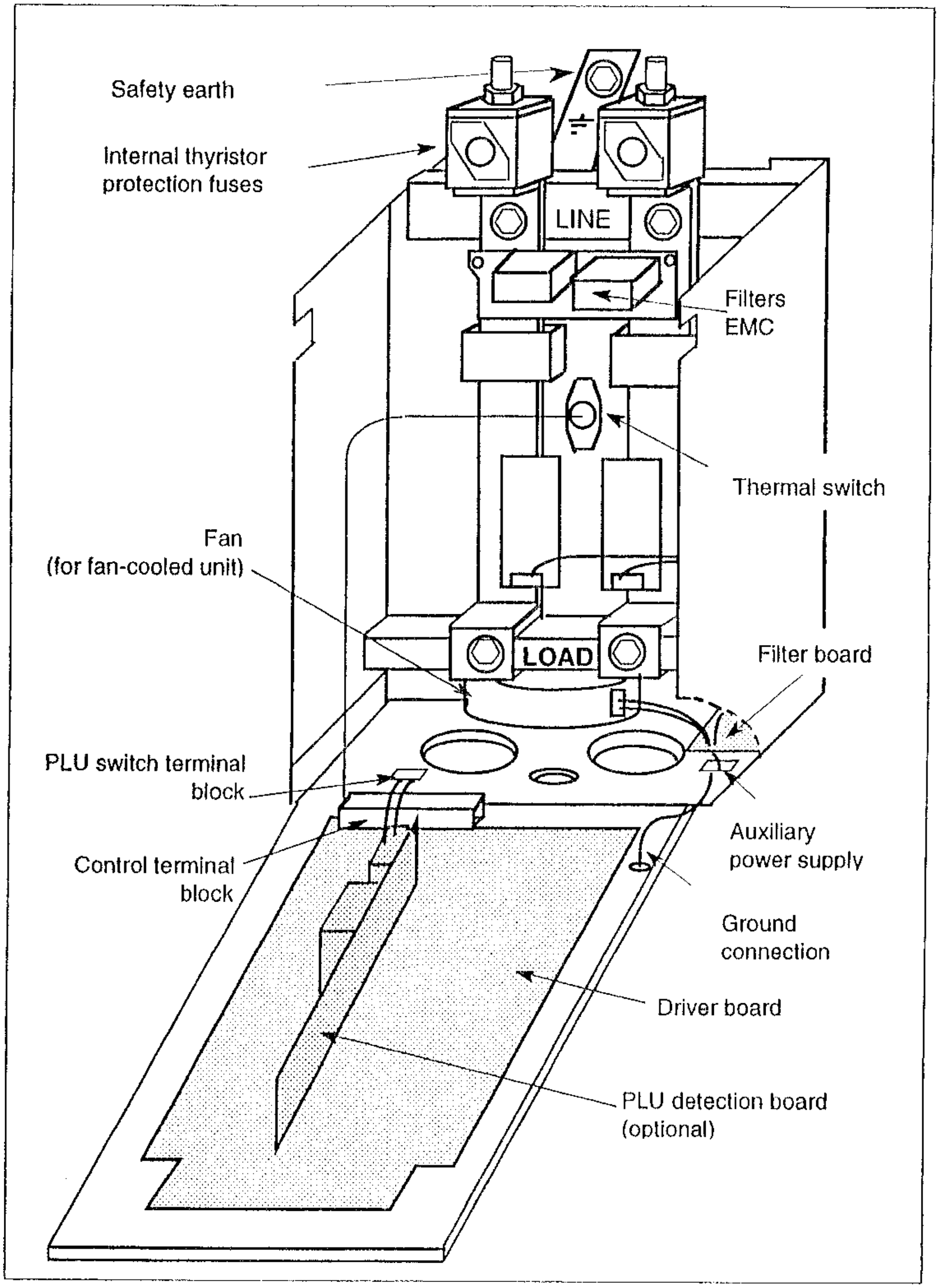


Figure 1-2 Overall view of the TC2000 unit with the access door open (PLU option installed)

The inputs of channels **A** and **B** are located on the user terminal block of the driver board.

In the **three-phase** configuration, only one control signal is applied to input **A.**
In the **single-phase** configuration, two signals are applied to inputs **A** and **B**.

Solid state contactors.

The input signals of the TC2000 series static contactors must be **logic.**

- dc signals
  - single-phase and three-phase configuration without PLU option:
    - 10 V
  - three-phase configuration with PLU option:
    - 5 V
    - 10 V
    - 20 mA
- ac signals (three-phase configuration only):
  - 100 to 240 Vac

  With the ac signal, the PLU/IPU option is not available.

Power thyristor units.

The input signals of the TC2000 series power thyristor units must be **analogue.**

- dc voltage signals (single-phase and three-phase configuration):
  - 0 - 5 V
  - 0 - 10 V
  - 1 - 5 V
  - 2 - 10 V
- dc current signals (single-phase and three-phase configuration):
  - 0 - 20 mA
  - 4 - 20 mA.

The TC2000 series **power thyristor units** possess a supply voltage variation **compensation** within the range **+ 10%** to **-15%** of the nominal voltage.

This instantaneous compensation is used to maintain the power transmitted to the load constant in spite of the supply voltage variations, thus preventing fluctuations of the controlled value.

TECHNICAL DATA

The TC2000 series is a series of solid state contactors and power thyristor units designed to control the electrical power of industrial three-phase and single-phase loads.

Attention !

It is the user's responsibility to ensure that the unit is compatible with the conditions of installation before commissioning the unit.

Power

Nominal current (per channel)	**60 A, 75 A, 100 A, 150 A, 250 A, 300 A** **400 A, 500 A**
Nominal voltage	**120** to **500 Vac** line to line (+10% -15%)
Frequency	**50** or **60 Hz**
Operation type	• **Solid state contactors** Tyristor firing in Logic (ON/OFF) mode Logic signals • **Power thyristor units** Thyristor firing in Burst firing mode Analogue signals
Configuration type	• Three-phase **Two phase** control (only one control signal). • Single-phase Control of **two** independent single-phase **loads** (2 control signals).
Three-phase phase rotation	Insensitive (except for the PLU option)
Thyristor firing	Burst firing mode: firing ON/OFF when zero voltage crossing is reached for each of the 2 phases.

Load

Load type	**Resistive** loads with low temperature coefficient
Configuration type	Three-phase configuration: **closed delta** or **star without Neutral** (3 wires) Single-phase configuration: two **independent** single-phase loads.

Protection

Thyristors	Internal high-speed **fuses**. **RC** snubbers and **Varistor** at thyristor terminals. Fuse blown trip indicator. As an option, fuse blown indication micro-switches.
Auxiliary power supply	**1 A** external fuse (not supplied)
Mechanical protection	Covers guaranteeing **IP20** protection (in front fascia).
Thermal protection	Thermal safety switch (stops thyristor firing if the maximum thyristor temperature is exceeded).

Insulation

Unit	Insulated irrespective of the configuration type. Must be connected to earth
Coolers	Insulated for models up to 250 A
Control signals	Insulated from the control circuit. In the single-phase configuration, the 2 dc signals are connected to the same common 0V.

Control

Solid state contactors	Logic signal which can be selected in the factory	
Firing type	ON/OFF (Logic)	
• dc signal in standard version	- Voltage **10 V**	V max = 25 V
	ON status	V > 5 V (4 mA min)
	OFF status	V < 1 V
• dc signal with PLU option	- Voltage **5 V**	V max = 12 V
	ON status	V > 1.5 V (4 mA min)
	OFF status	V < 0.5 V
	- Voltage **10 V**	V max = 25 V
	ON status	V > 5 V (4 mA min)
	OFF status	V < 1 V
	- Current **20 mA**	I max = 40 mA
	ON status	I > 4 mA
	OFF status	I < 0.2 mA
• ac signal (PLU not available)	Voltage **100 to 240 V**	V max = 264 V
	ON status	V > 85 V
	OFF status	V < 10 V
Power thyristor units	Analogue signal which can be selected by the user using jumpers	
Firing type	Burst firing, the typical modulation period at 50 % power is **0.6 s** (for another period contact as)	
• dc signal	- Voltage	**0-5 V; 0-10 V; 1-5 V; 2-10 V**
	- Current	**0-20 mA; 4-20 mA**
• Manual control	External **5 kΩ** potentiometer Input configured in **0-5 V** **+ 15 V** voltage available on the user terminal block	
Power supply	• Power thyristor units: **115 V** or **230 V** (+10 %-15 %). The exact definition of the power supply voltage is used to adjust the supply variation compensation accurately. • Solid state contactors with the PLU/IPU options: **115 V** or **230 V** (+10 %-15 %).	

Thermal characteristics

Operating temperature	**0 to 50°C** in vertical position (40°C for the 500 A current)
Storage temperature	**- 10°C to 70°C**
Heat dissipation	The thyristor units dissipate on average **1.3 W** per A and per phase
Cooling	
• 60 and 75 A	Convection cooling, power supply consumption **5 VA**
• 100 to 150 A	Built-in fan, power supply and fan consumption **35 VA**
• 250 to 500 A	Two built-in fans, power supply and fan consumption **70 VA**
Fan supply	**115 V** or **230 V** For power thyristor units and for static contactors with the PLU/IPU options, the power supply is used to power the fans.

Environment

Operating altitude	**2000 m** maximum
Operating amosphere	Non explosive, non corrosive and non conductive.
Pollution	Degree **2** (**IEC 664**)
Humidity	RH **5%** to **95%** non condensing.

Options

PLU / IPU options (three-phase operation only)

Partial load unbalance (PLU) detection system.	
An alarm for:	• a **10 %** unbalance of line currents • a thyristor short circuit • a fuse blow-out • the absence of a phase.
Alarm output	Relay **deactivated** in alarm status. Alarm stored in memory (requiring acknowledge) or not stored in memory according to user cabling. Relay switch **N/O** open in alarm status (PLU option) or relay switch **N/C** (closed in alarm status (IPU option))
Switch cut-off capacity	**0.25 A** at 250 Vac or 30 Vdc
Power supply required	**115 V** or **230 V**.

Fuse blown indication micro-switches

Internal high-speed fuses	Fuse blown indication micro-switches (thyristor protection).

Internal CEM filters

Conducted emissions	To reduce the conducted emissions that occur when using thyristor units, the EMC internal filters is added (standard for 60 A and 75 A; optional for 100 A and 150 A).

UNIT CODING

Series / Configuration / Nominal current / Nominal voltage / Auxiliary power supply / Input A / Input B / Options / 00

Series	Code
Solid state contactors and power thyristor units	TC2000

Configuration	Code
Three-phase. 2 controlled phases	[✓ 02]
Single-phase. 2 independent phases	21

Nominal current	Code
60 amperes	[✓ 60A]
75 amperes	75A
100 amperes	100A
150 amperes	150A
250 amperes	250A
300 amperes	300A
400 amperes	400A
500 amperes	500A

Nominal line to line voltage	Code
120 volts	120V
240 volts	240V
277 volts	277V
440 volts	440V
480 volts	480V
500 volts	[✓ 500V]

For other voltages , contact your Eurotherm office

Auxiliary power supply	Code
Without auxiliary power supply (60 A and 75 A solid state contactors without PLU option)	000
230 /115 V single-phase supply:	
100 volts	100V
110 volts	[✓ 110V]
115 volts	115V
120 volts	120V
200 volts	200V
220 volts	220V
230 volts	230V
240 volts	240V

Input A Three-phase configuration or single-phase config. channel A	**Code**
Power thyristor units:	
"Burst mode"	
thyristor firing	
Analogue signal	
0-5 volts	**0V5**
1-5 volts	**1V5**
0-10 volts	**0V10**
2-10 volts	**2V10**
0-20 milli-amperes	**0mA20**
4-20 milli-amperes	**4mA20**
Solid state contactors:	
"ON/OFF"	
thyristor firing	
dc logic signal	**LGC**
100 to 240 Vac logic signal (three-phase only)	**ACL**

Input B	**Code**
Three-phase configuration	**000**
Power thyristor units:	
"Burst mode"	
thyristor firing	
Single-phase config. channel B	
Analogue signal	
0-5 volts	**0V5**
1-5 volts	**1V5**
0-10 volts	**0V10**
2-10 volts	**2V10**
0-20 milli-amperes	**0mA20**
4-20 milli-amperes	**4mA20**
Solid state contactors:	
"ON/OFF"	
thyristor firing	
Single-phase config. channel B	
dc logic signal	**LGC**

Options	**Code**
PLU detection (only in three-phase configurations; analogue or dc logic signal)	
• relay switch open in alarm status	**PLU**
• relay switch closed in alarm status	**IPU**
Fuse blown indication micro-switches	**FUMS**
No internal fuses	**NOFUSE**
Internal EMC filters (100 A and 150 A nominal)	**FILT**

CODING EXAMPLE

Installation and TC2000 series unit parameters

A power thyristor unit for a three-phase load in a delta configuration.

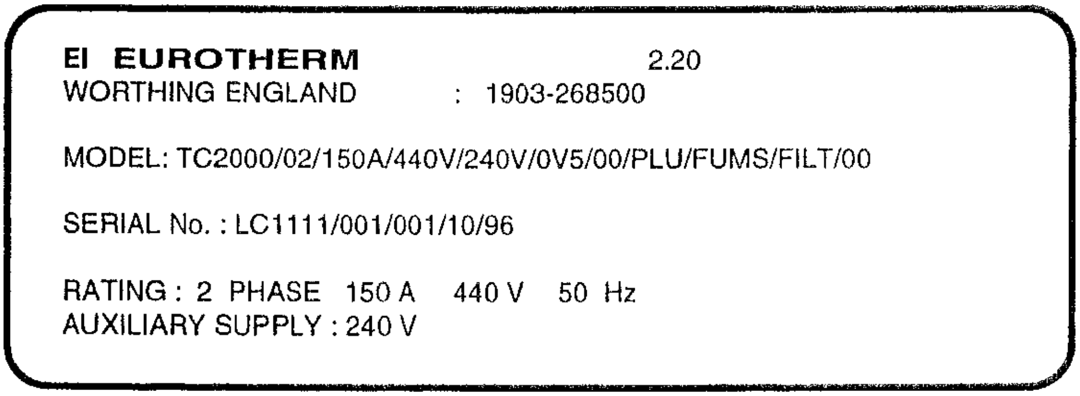
- Three-phase configuration on 440 V supply
- Nominal current of a phase of the 120 A load
- 240 V auxiliary power supply and 0-5 V analogue control
- Partial load unbalance detection system, relay switch open in alarm status
- Fuse blown indication micro-switches
- Internal EMC filters to reduce the conducted emissions.

Coding : **TC2000 / 02 / 150A / 440V / 240V / 0V5 / 00 / PLU / FUMS / FILT / 00**

SERIAL NUMBER LABELS

Two **identification** labels (specifying the **coding** of the unit) and a **configuration** label provide all the information relating to the factory settings of the unit.

An identification label is **externally** located on the right-hand side panel of the unit.



El EUROTHERM 2.20
WORTHING ENGLAND : 1903-268500

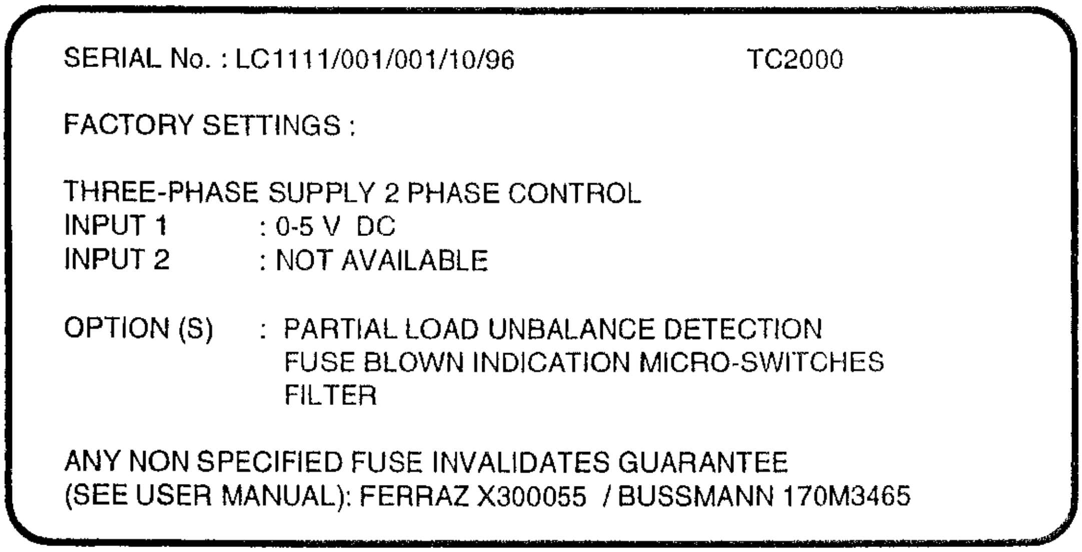
MODEL: TC2000/02/150A/440V/240V/0V5/00/PLU/FUMS/FILT/00

SERIAL No. : LC1111/001/001/10/96

RATING : 2 PHASE 150 A 440 V 50 Hz
AUXILIARY SUPPLY : 240 V

Figure 1-3 Example of identification label for a TC2000 model unit
The information corresponds to the coding example.

The second identification label and a configuration label are located **inside** the thyristor unit.



SERIAL No. : LC1111/001/001/10/96 TC2000

FACTORY SETTINGS :

THREE-PHASE SUPPLY 2 PHASE CONTROL
INPUT 1 : 0-5 V DC
INPUT 2 : NOT AVAILABLE

OPTION (S) : PARTIAL LOAD UNBALANCE DETECTION
FUSE BLOWN INDICATION MICRO-SWITCHES
FILTER

ANY NON SPECIFIED FUSE INVALIDATES GUARANTEE
(SEE USER MANUAL): FERRAZ X300055 / BUSSMANN 170M3465

Figure 1-4 Example of configuration label for a TC2000 unit

Attention!

Following any reconfiguration on the part of the user, there is no guarantee that the thyristor unit and this information corresponds to the information related to the unit coding.

Chapter 2

INSTALLATION

Contents page

Chapter 2 INSTALLATION

Read this chapter completely before installation.

SAFETY DURING INSTALLATION

Danger !

TC2000 units must be installed by a qualified person.

Units must be installed in fan-cooled electric cabinets, guaranteeing the absence of condensation and pollution.
The cabinet must be closed and connected to the safety ground in accordance with the standards IEC 364 or the current national standards.

For installations in fan-cooled cabinets, it is recommended to place a fan failure detection device or a thermal safety control in the cabinet.

Bulkhead mountings are possible with **TC2000** series units.

The units must be mounted with the heatsink positioned vertically and with no obstructions either above or below which could block the passage of the ventilation air.

If multiple units are installed in the same cabinet, they should be arranged in such a way that the air expelled by one unit cannot be admitted into the unit located above it.

Attention !

The units are designed to be used at an ambient temperature less than or equal to **50°C** (40°C for 500 A nominal units)

Leave a minimum space of **5 cm** between two units placed beside each other.

Excessive overheating of the unit may cause incorrect operation of the unit, which in turn may cause damage the components.

---

60 to **75 A** units are **convection**-cooled.

100 to **500 A** units have **permanent** fan cooling.

DIMENSIONS

The dimensions, values and weights of the **TC2000** series thyristor units are given in figure 2-1 and in table 2-1.

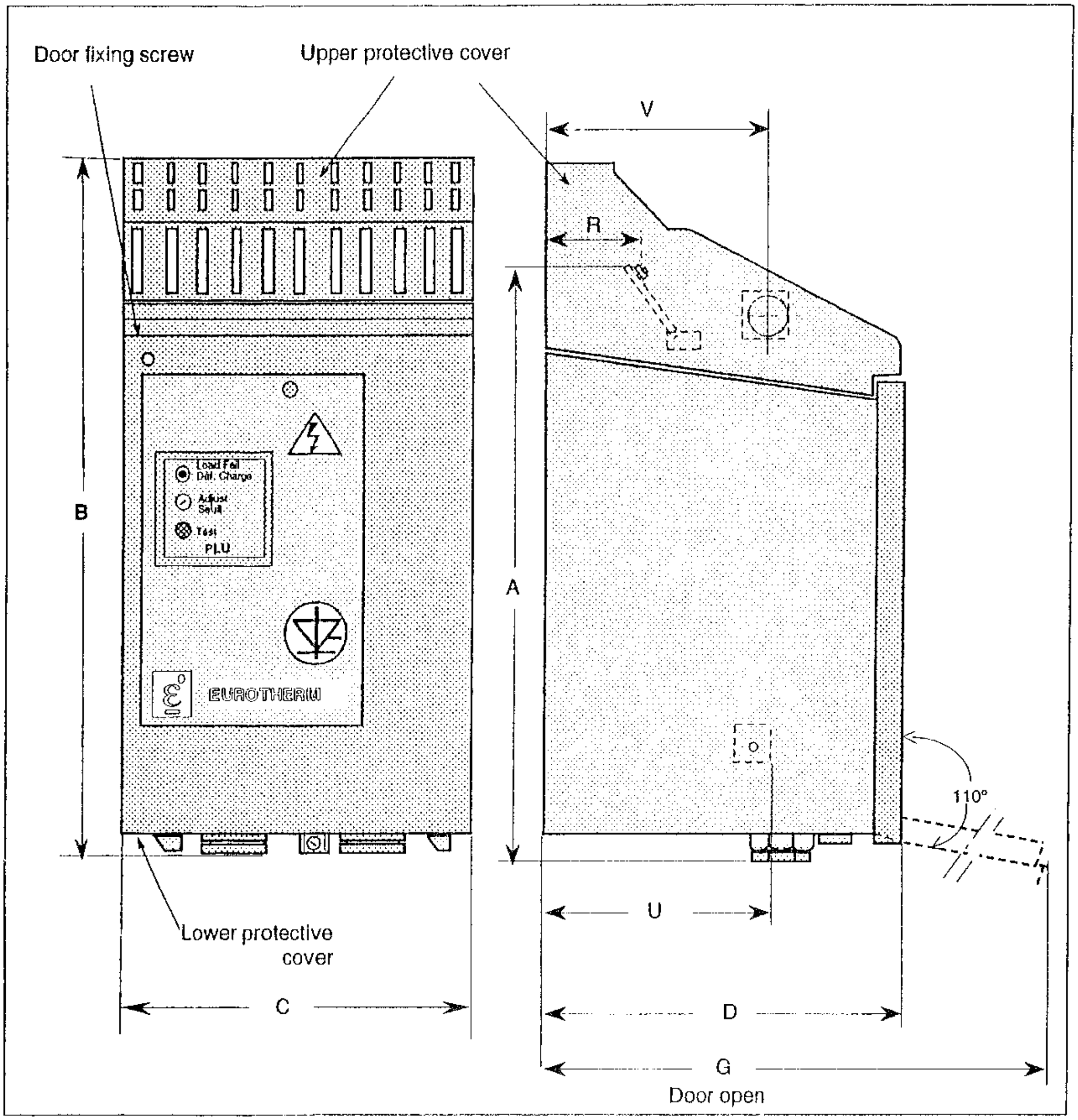


Figure 2-1 Overall dimensions with and without upper protective cover

Values	Nominal current			Description
	60 to 150 A	250 A	300 to 500 A	
A	415 mm	415 mm	425 mm	Height without protective cover
B	480 mm	480 mm	570 mm	Height with cover
C	133 mm	248 mm	248 mm	Width
D	268 mm	268 mm	268 mm	Depth
E	88 mm	203 mm	203 mm	Width between the fixing holes
F	328 mm	328 mm	328 mm	Height between the fixing holes
G	557 mm	557 mm	557 mm	Depth with the door open
K	350 mm	350 mm	350 mm	Height of lateral fascias
R	30 mm	50 mm	20 mm	Distance between "Earth" busbar and panel
U	138 mm	147 mm	150 mm	Depth between "LOAD" terminal and panel
V	125 mm	148 mm	170 mm	Depth between "LINE" terminal and panel
Poids	10 kg	16 kg	16.5 kg	-

Table 2-1 Dimensions, fixing values and weights of TC2000 series units

MECHANICAL MOUNTING

TC2000 units have two protective covers (upper and lower).

The units can be fixed with the protective covers in place.
However, for the connection, the upper protective cover must be removed.

After drilling the support panel at the dimensions and values given above, insert the fixing screws half-way in the partition holes or mounting plate.

Position the thyristor unit by first inserting the upper screw heads in the respective holes of the upper section.

Lower the unit making sure that the lower screws planned can be inserted correctly.

Then lower the unit completely until it is in position.

Fasten the 4 screws correctly.

INSTALLATION DETAILS

TC2000 series units are designed to be mounted directly on panels at the fixing points located on the rear of the unit.

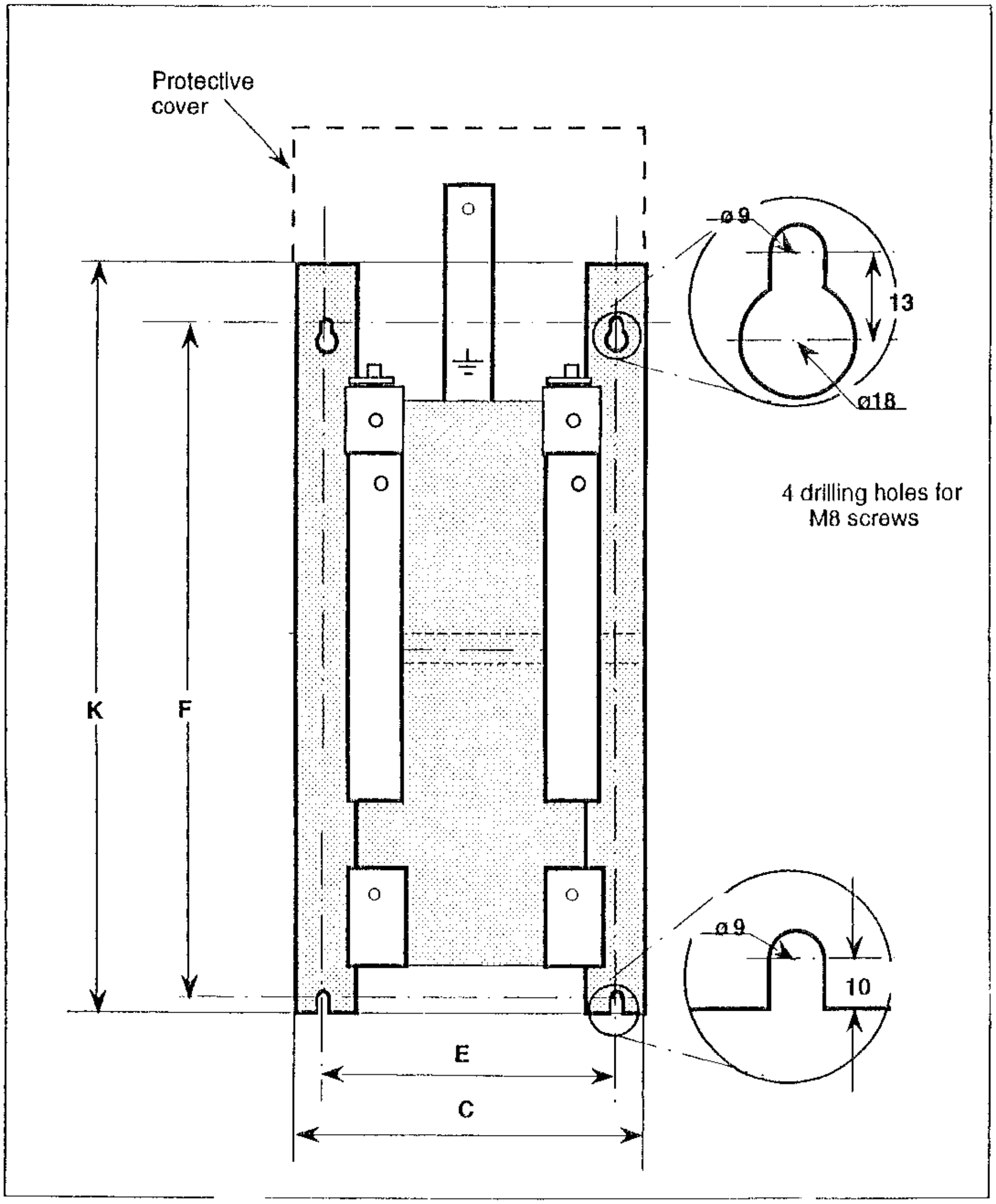


Figure 2-2 Fixing details

Chapter 3

CABLING

Contents page

Chapter 3 CABLING

SAFETY DURING CABLING

Danger !

⚠ Cabling must be performed by personnel who are qualified to work with low voltage electrical equipment.
It is the user's responsibility to cable and protect the installation in accordance with current professional standards.
A suitable device guaranteeing electrical separation of the equipment and the supply must be installed in order to perform the operation in complete safety.

TC2000 series units possess **two protective covers**: upper and lower.
The upper cover should be raised to facilitate cabling.
After connection and before power-up, put the upper protective cover back in place to ensure the specified **degree of protection**.

Danger !

⚠ Before any connection or disconnection, make sure that the power and control cables and wires are insulated from the voltage sources.

For safety reasons, the safety earth cable must be connected before any other connection during cabling and the last cable to be disconnected.

The **safety earth** is connected to the screw located on the strip provided for this purpose in the top part of the unit, behind the phase terminal and labelled as follows:

⏚

Attention !

⚠ To ensure that the TC2000 unit is grounded correctly, make sure that it is attached to the **reference ground plane** (panel or bulkhead). If this is not the case it is necessary to add a ground connection **no more than 10 cm long** between the ground connection and the reference ground plane.

Danger !

⚠ The purpose of this connection is to guarantee correct **ground continuity**. It is **not**, in any circumstances, a **substitute** for the **safety earth connection**.

FIXING POWER CABLES

The **supply side** power cables pass through the opening of the upper protective cover of the TC2000 unit. The upper covers of the units are raised in order to facilitate the connection of these cables.

For connection, this cover, which is fixed to the unit, must be raised. In order to do this:

- open the door by unfastening the front screw on the top left-hand corner of the door
- raise the door in order to release it from its notches
- open the door completely by pulling it towards you
- remove the upper cover by unfastening its two fixing nuts by sliding it one cm forwards to release the two catches located at the rear and raising it.

The supply side connection is performed on the terminals of each fuse at the upper part of the unit, labelled **LINE** (see figures 3-2 and 3-3).

The **load side** power cables are placed inside the unit through cable sheaths below the unit. The loads are cabled on screws located in the bottom part of the unit and labelled **LOAD** (see figures 3-2).

The capacities of the power terminals and cabling screws are given in table 3-1.

Tightening must not exceed the limit values according to the same table.

Nominal current	**60 to 150 A**	**250 A**	**300 to 500 A**
Supply and load Earth cable	4 to 70 mm² 16 to 35 mm²	120 mm² 70 mm²	185 to 2x150 mm² 95 to 185 mm²
Fuse terminals Tightening torque	M8 13.5 N.m	M8 13.5 N.m	M10 26 N.m
Load screw Tightening torque	M8 12.5 N.m	M10 16.4 N.m	M12 28.8 N.m
Earth screw Tightening torque	M10 16.4 N.m	M10 16.4 N.m	M12 28.8 N.m

Table 3-1 Details of power cabling for TC2000 thyristor units

The cross-section of the connection wires to be used must correspond to the Standard **IEC 943**

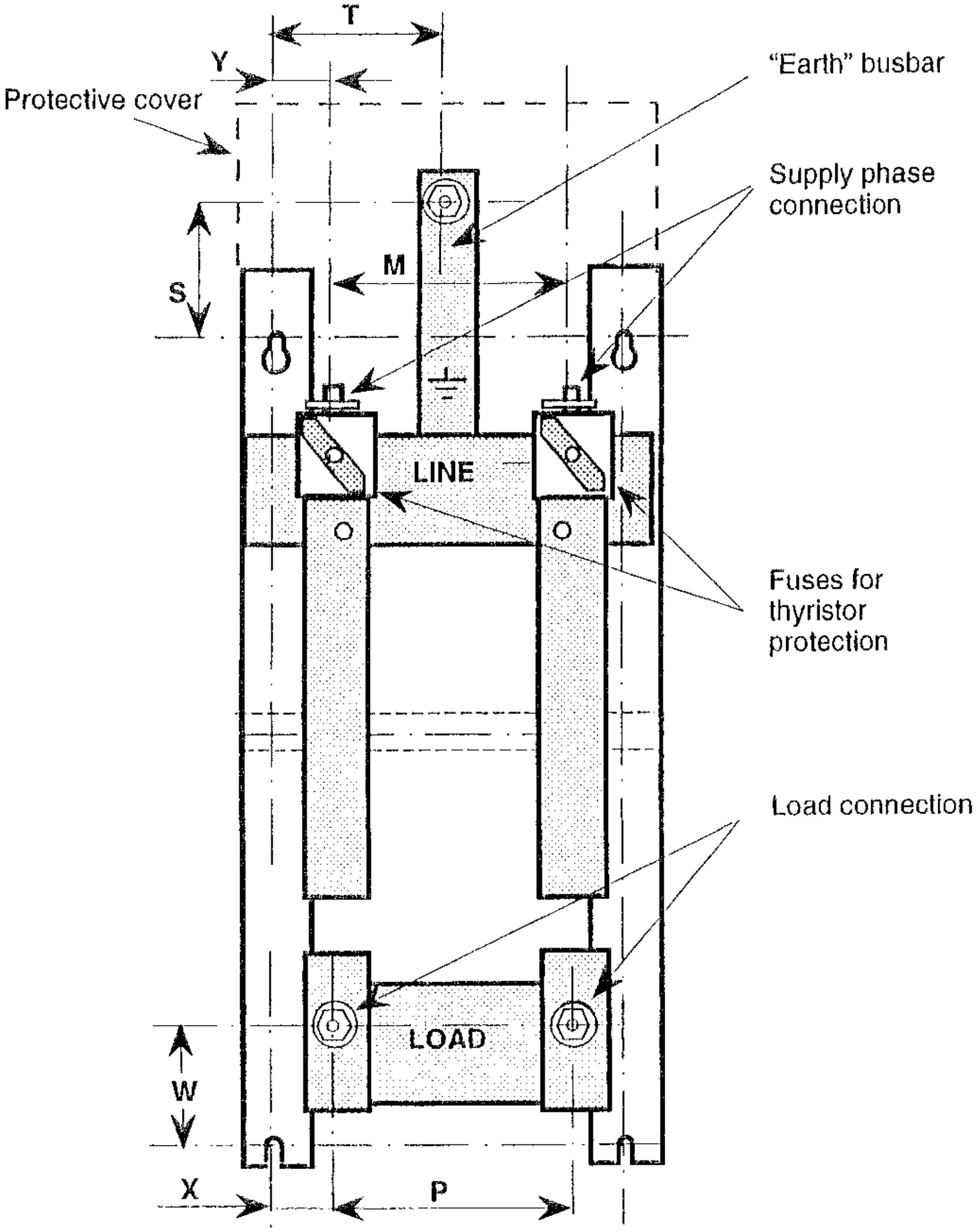


Figure 3-1   Power cable fixing points (60 to 250 A units)

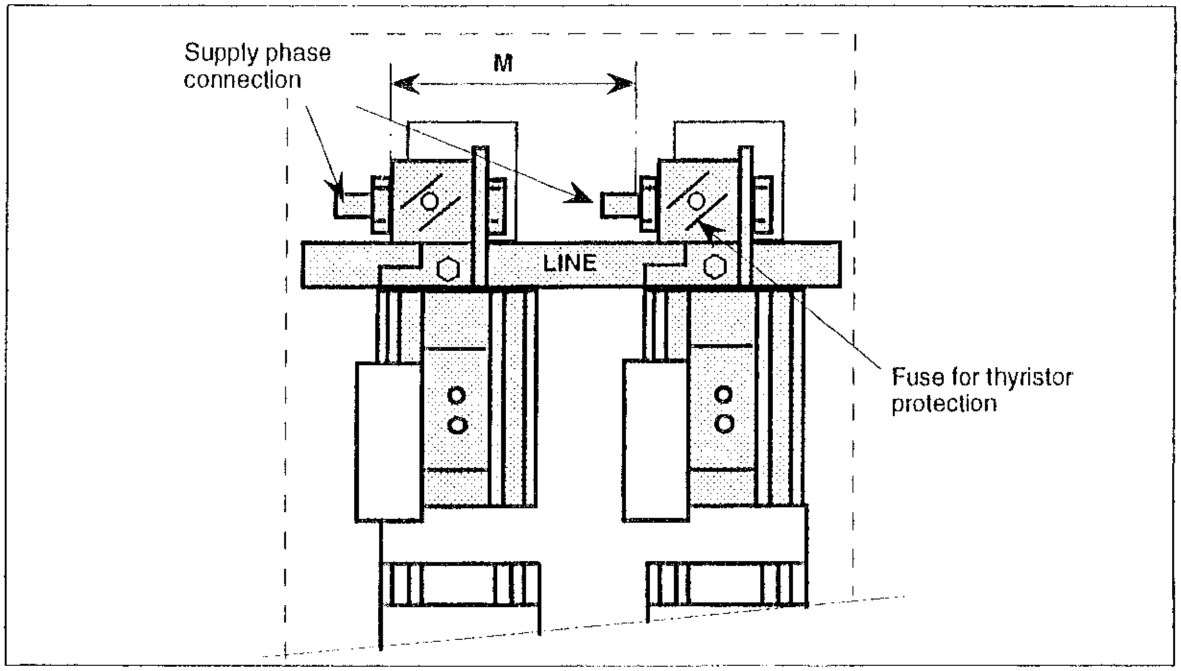


Figure 3-2 Specific power cable connection for 300 to 500 A units

Values	Nominal current			Description of distance
	60 to 150 A	250 A	300 to 500 A	
M	58 mm	135 mm	110 mm	"LINE" terminals 1 and 2
P	44 mm	150 mm	110 mm	"LOAD" terminals 1 and 2
S	50 mm	60 mm	30 mm	"Earth" busbar and upper fixing hole
T	45 mm	65 mm	96 mm	"Earth" busbar and left fixing hole
W	68 mm	70 mm	70 mm	"LOAD" terminal and lower fixing hole
X	20 mm	25 mm	20 mm	"LOAD" terminal and left fixing hole
Y	15 mm	32 mm	20 mm	"LINE" terminal and upper fixing hole

Table 3-2 Power cabling details

⚠ The power cables to a load pass through **cable sheaths** which must be tightened correctly after cabling.

POWER WIRING DIAGRAMS

If there are several TC2000 units on the same power supply, cable the units by producing a **circular permutation** of the supply phases.

The TC2000 thyristor units have **internal EMC filters** to reduce the conducted emissions to comply with the EN 50081-2.
These filters are the **standard** for the **60 A** and **75 A** units and **optional** for the **100 A** and **150 A** units. The one wire filter connection is made on the user terminal block under the unit.

Three-phase configuration (two-phase control)

The **order** of the phases must be observed if the unit includ the PLU option.

In two-phase control of a three-phase 3 wires load (star without neutral or a closed delta) the filter connection terminal (marked **L3/36**) must be connected to the non-controlled phase.

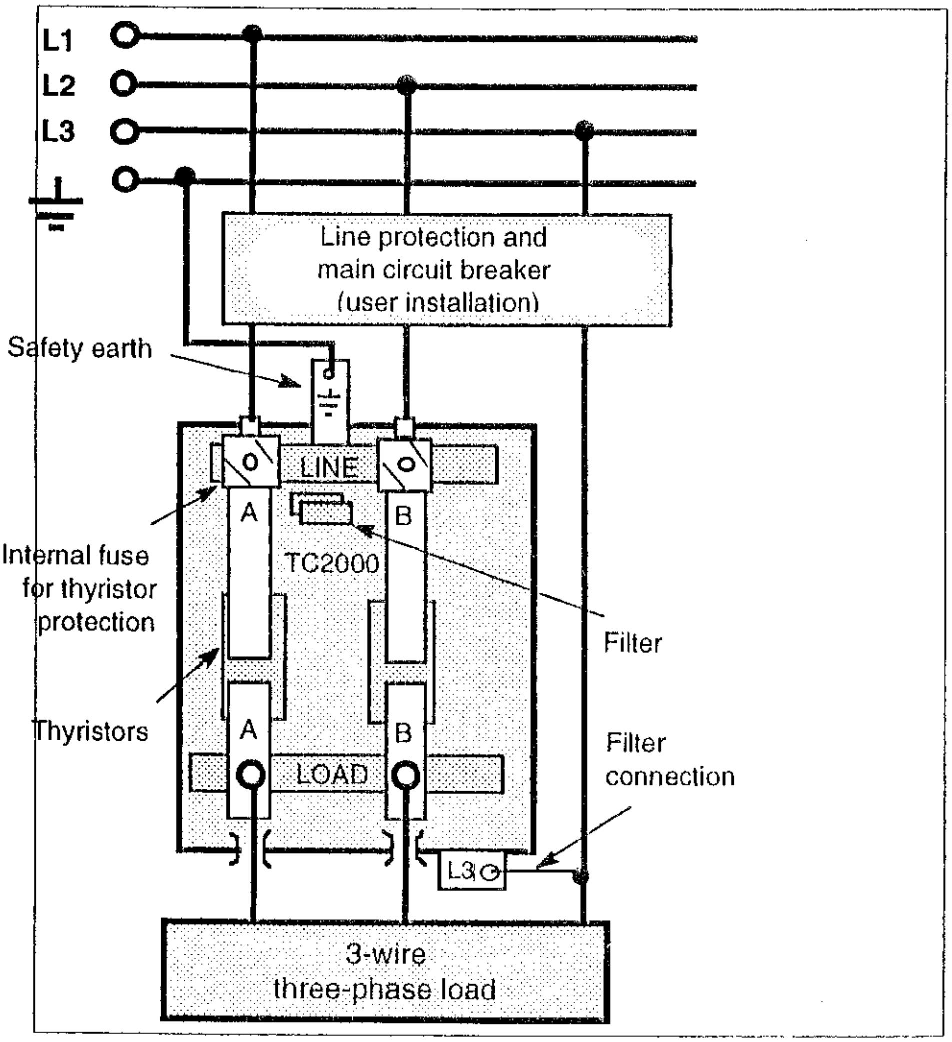


Figure 3-3 Example of TC2000 series unit three-phase wiring

Single-phase configuration (two independent single-phase loads)

The single-phase configuration of the TC2000 series unit can be performed:

- between one of the phases of the supply and neutral (in parallel)
- between two phases of the supply (in parallel)
- between two phases of the supply and neutral
- distributed between three supply phases.

Single-phase supply

In single-phase configuration the filter connection terminal (marked **L3/36**) must be connected to neutral. Filtering can only be used if loads supplied from a same single supply network.

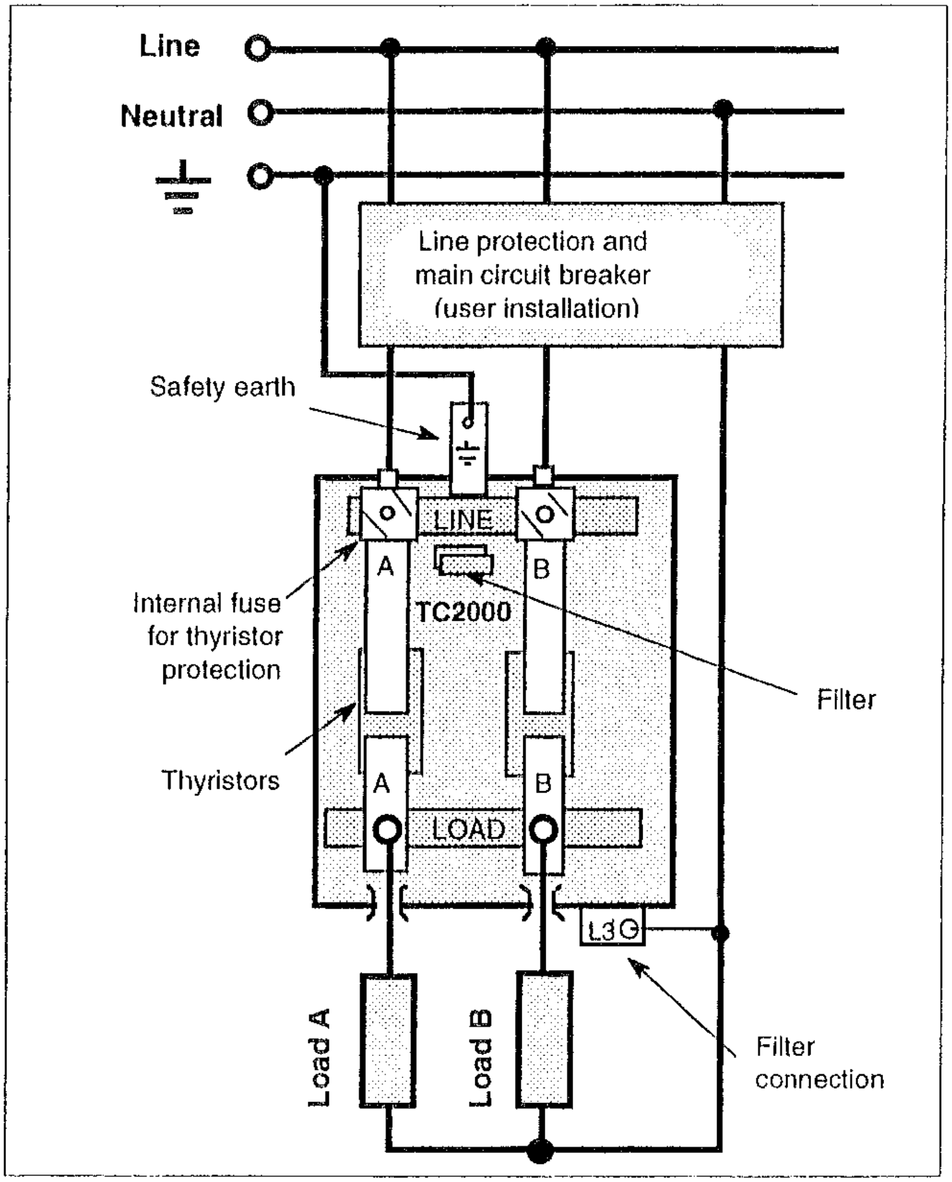


Figure 3-4 Example of power cabling of the TC2000 series unit
Single-phase configuration between one supply phase and the neutral

Three-phase supply

Filtering can only be used if one phase is common to two channels.

In single-phase configuration (three-phase supply) the filter connection terminal (marked **L3/36**) must be connected to commun phase

- for the 60 A and 75 A units (standard)
- for 100 A and 150 A units with FILT option,

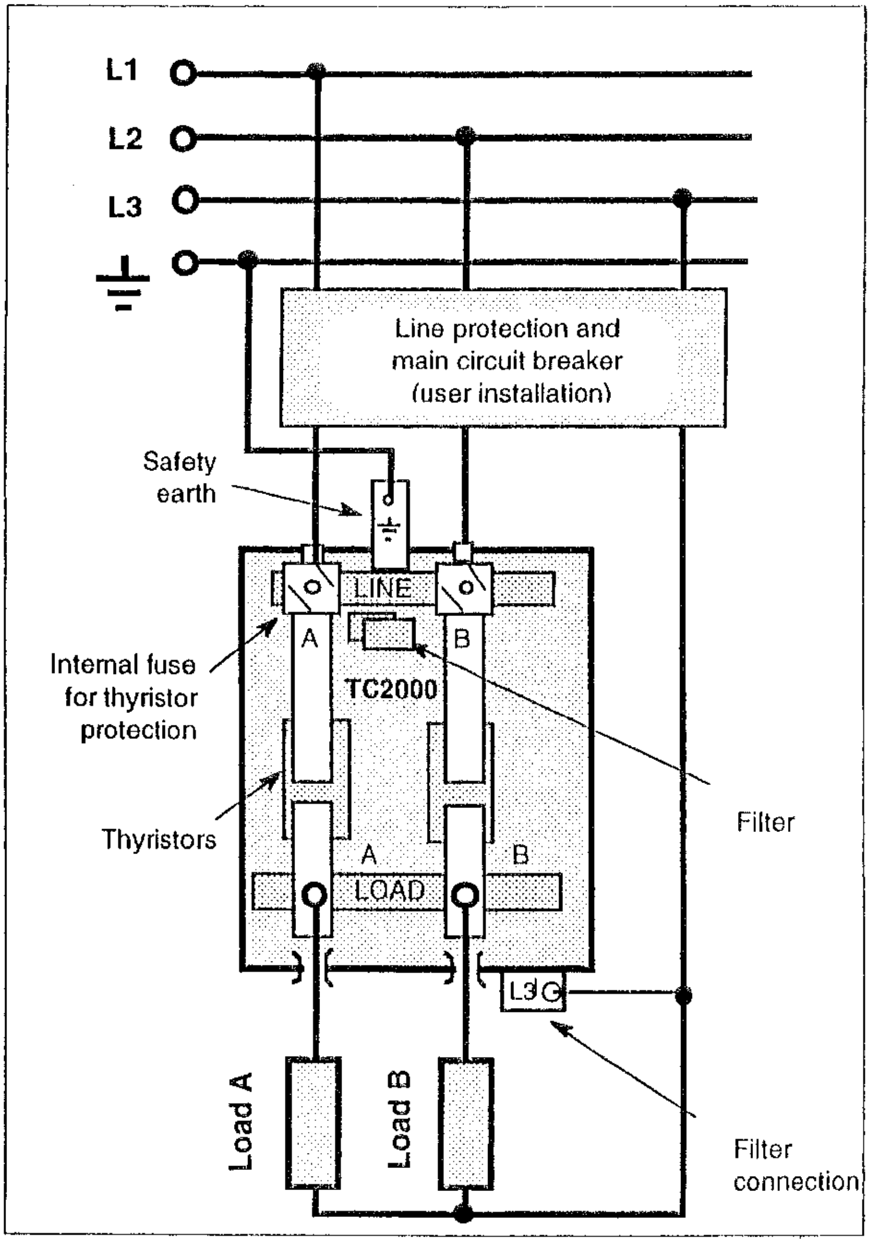


Figure 3-5 Example of power cabling of the TC2000 series unit
Single-phase configuration between 3 phases of the three-phase supply

AUXILIARY POWER SUPPLY

The auxiliary power supply is connected to a 2 terminal pluggable user terminal block, located to the right below the unit.

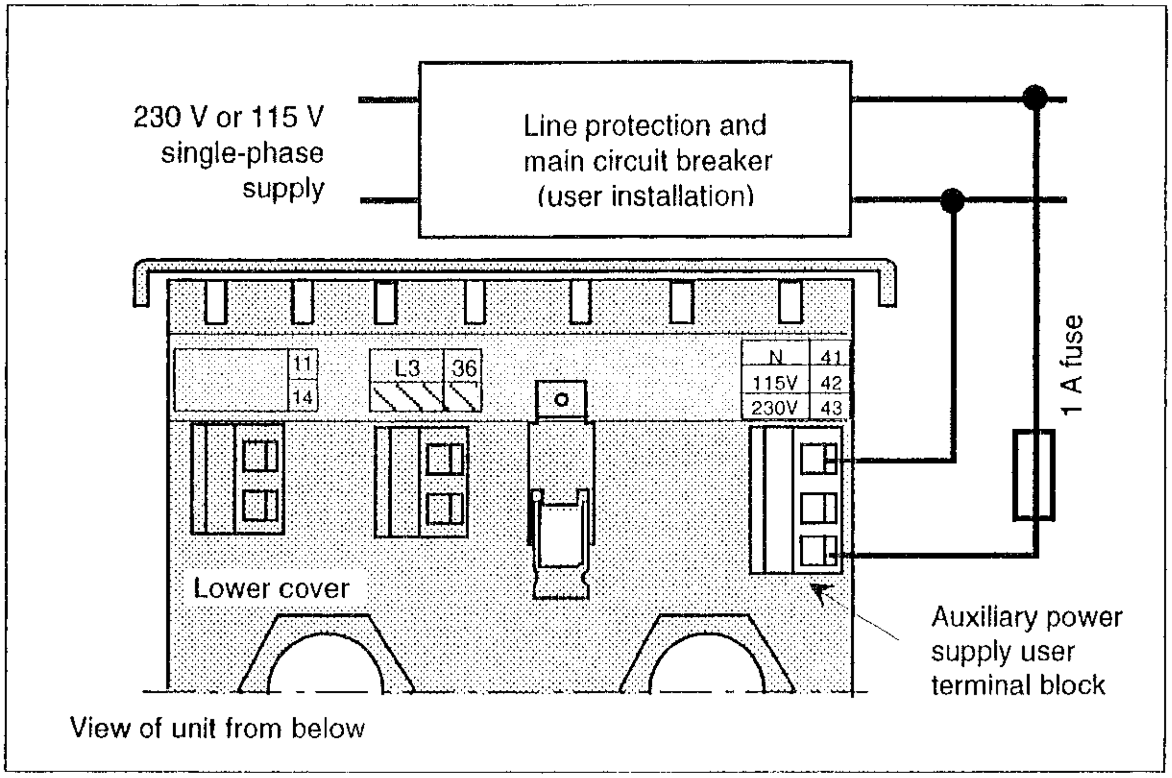


Figure 3-6 Auxiliary power supply configuration (230 V supply)

The auxiliary power supply is required in the following cases:

- permanent fan-cooling units (100 A to 500 A nominal current)
- power thyristor units (analogue control)
- static contactors with the PLU / IPU option
  (dc logic control in three-phase configuration).

Attention !

⚠ The auxiliary voltage is set at **100-110-115 -120 Vac** or **200-220-230-240 Vac** and must be connected to a **115 V** or **230 V single-phase** supply.

The auxiliary power supply voltage is configured in the factory according to the unit code. It is indicated on theuser terminal block label.

An external **1 A** fuse must be connected on the auxiliary power supply.

CONTROL CABLES

Attention!

The control connections must be made with **shielded cables connected to the earth (or ground) at both ends** in order to ensure maximum immunity against interference.

Insulate the control cables from the power cables in the cable tray.

Fixing

The control wires must be grouped together in a shielded cable passing through the **cable clamp** under the unit (**second** cable clamp supplied for the PLU option).

Important !

To facilitate the earthing of the cable shield and to ensure maximum immunity to electromagnetic interference, the **metal** cable clamp is **fixed directly to the ground** of the unit.

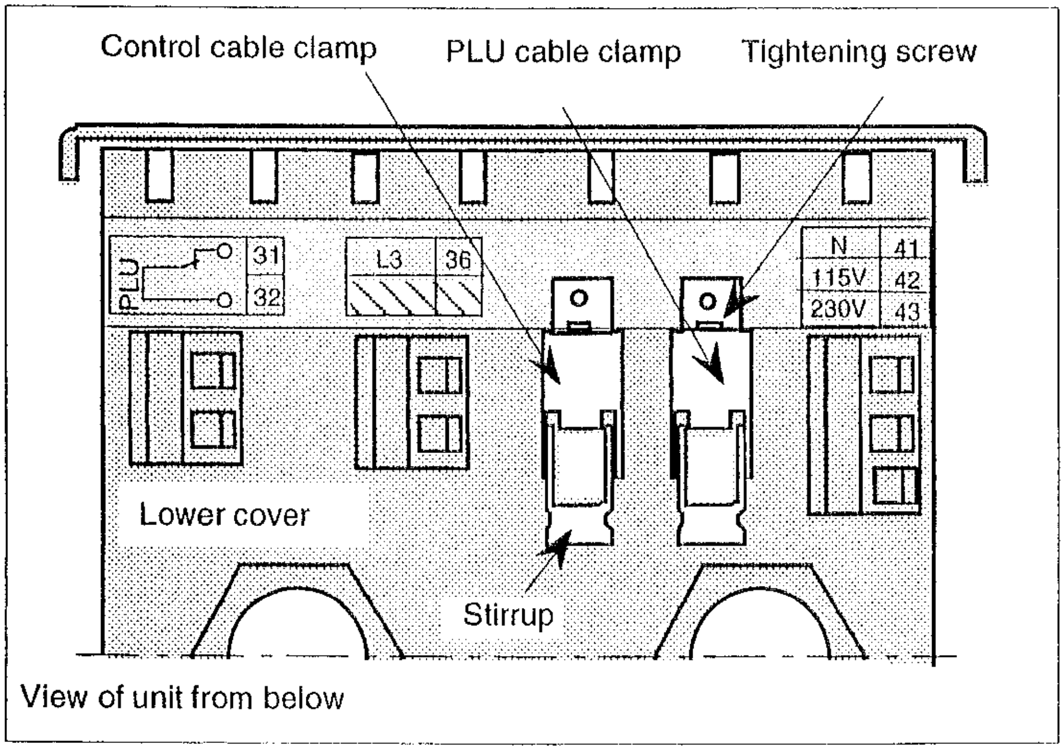


Figure 3-7 Control cable clamp layout

Shield connecting to the ground

To **insert** the control cable and **earth** its shield:

- **Strip** the shielded cable as shown in figure 3-8,a.
  The length of the wires (control, PLU relay acknowledge, measurement retransmission) must ensure the connection between the metal cable clamp and the board user terminal blocks, with the door open. The cabling inside the unit must be as short as possible.

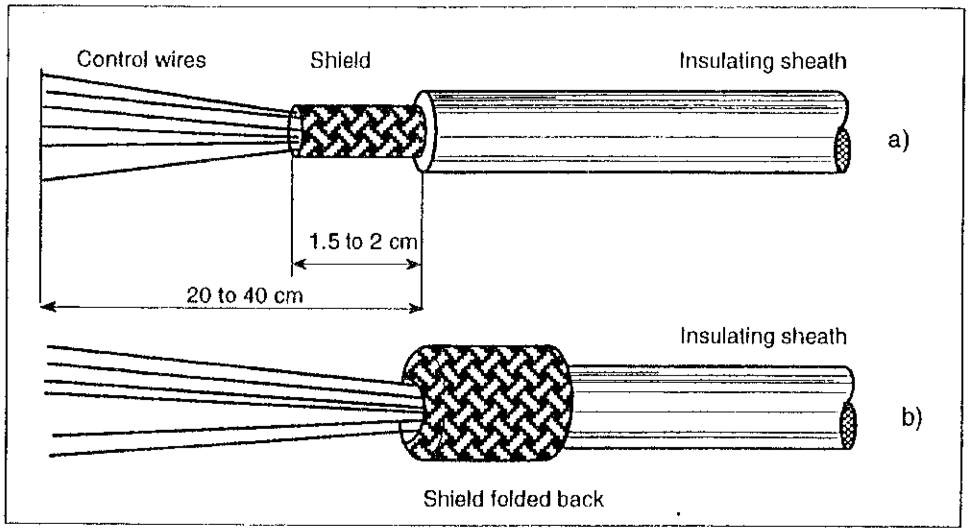


Figure 3-8 Control cable stripping

- **Fold back** the shield on the insulating sheath (figure 3-8,b)
- **Insert** the cable in the metal cable clamp so that the shield is located in the stirrup and does not enter the unit (it must not pass the lower cover).

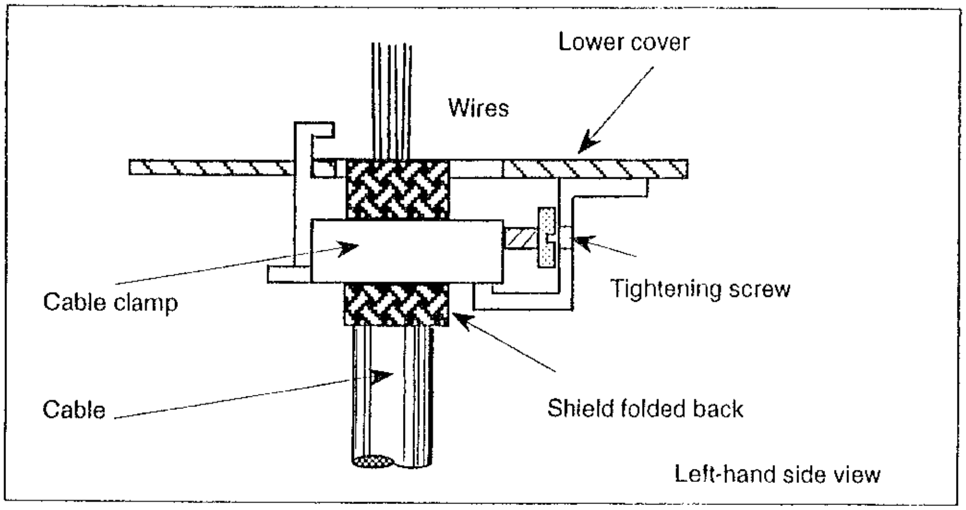


Figure 3-9 Cable tightening and shield grounding

- **Tighten** the stirrup (**4 x 1** flat screwdriver; tightening torque: **0.7 N.m.)**

The possible diameters of the cables with the shield folded back are **5 to 10 mm** per cable clamp.

DRIVER TERMINAL BLOCK

The following connections are made on the driver board user terminal block:

- the analogue or logic input signals
- the manual input potentiometers.

The terminal block can be accessed by opening the front door.

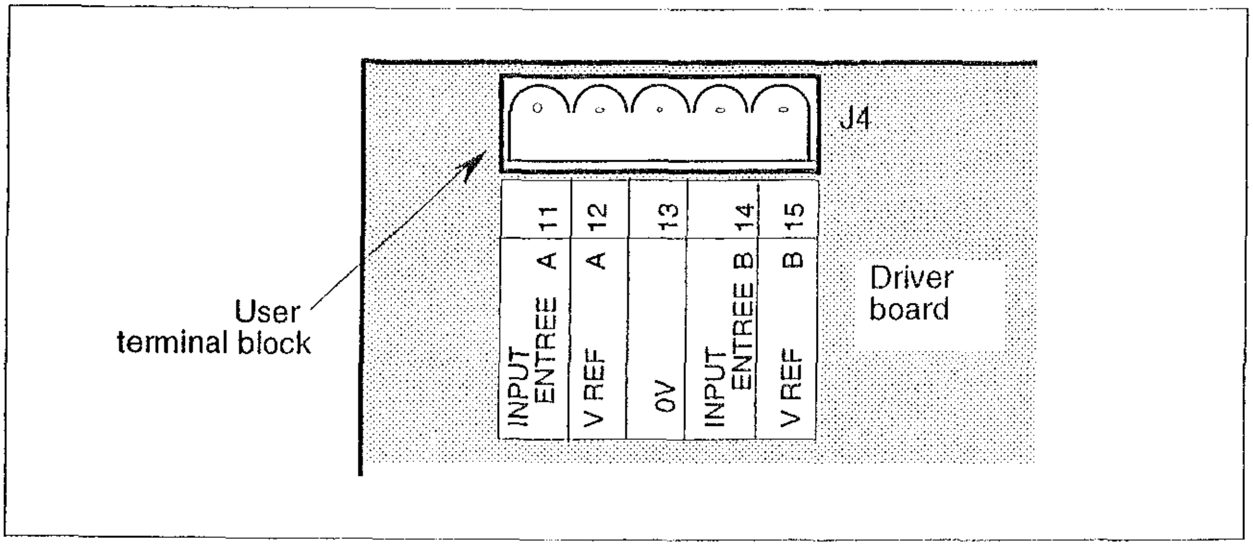


Figure 3-10 Driver terminal marking

Term.	Name on label	Destination
11	INPUT/ENTREE A	Input in three-phase configuration Input of channel A in single-phase configuration
12	V REF A	+15 V voltage output of channel A
13	0V	0 V common to the inputs of two channels
14	INPUT/ENTREE B	Input of channel B in single-phase configuration. Not used in three-phase configuration
15	V REF B	+ 15 V output of channel B

Table 3-3 Destination of the driver terminal block terminals

INPUT SIGNAL CONNECTION

The control wires are connected on the pluggable user terminal block, located on the **driver board**.

Driver terminal block terminal capacity: **0.22 mm^2 to 1.5 mm^2.**
Driver terminal tightening torque: **0.7 N.m.**

The inputs are **insulated** from the power supply and the load circuit.

In the single-phase configuration, inputs **A and B** are independent (0 V is common).
In the three-phase configuration, only one input **A** is used for the 2 controlled phases.

The driver terminal block is accessible with **the front door open.**
To open the door, unfasten the front **screw**, release the door from its notches by raising it and pull it towards you.

Danger !

Dangerous live parts may be accessible when the door is open
(if the TC2000 unit power is on)

Solid state contactors

Two types of signal are available:

- dc logic signals (three-phase or single-phase configuration)
- ac logic signals (three-phase configuration only).

Signal type		**ON state**	**OFF state**	**Maximum**	**Impedance**
dc Basic version	Voltage	> 5 V	< 1 V	25 V	390 Ω
dc PLU/IPU option	Voltage	> 1.5 V	< 0.5 V	12 V	100 kΩ
	Current	> 4 mA	< 0.2 mA	40 mA	250 Ω
ac (PLU/IPU not available)	Voltage	> 85 V	< 10 V	264 V	10 kΩ (50 Hz)

Table 3-4 Solid state contactor input parameters
Each dc input is in series with 2 opto-diodes; voltage drop 4 V.

Two independent dc logic signals in the single-phase configuration are applied to terminals **11** and **13** (input **A**) and terminals **14** and **13** (input **B**).

In the three-phase static contactor configuration, terminals **11** and **13** are used.

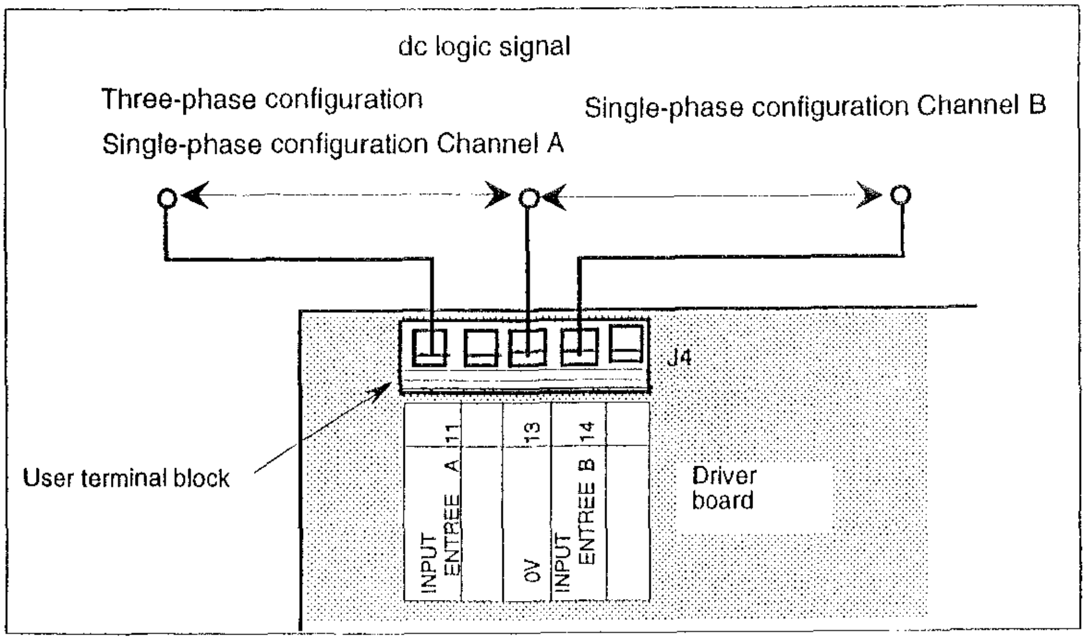


Figure 3-11 Configuration of the two solid state contactor dc inputs

An ac static contactor input (terminals **11** and **14** of the driver terminal block) is only available for the three-phase configuration without the PLU option.

The input is insulated from the power supply and from the load.

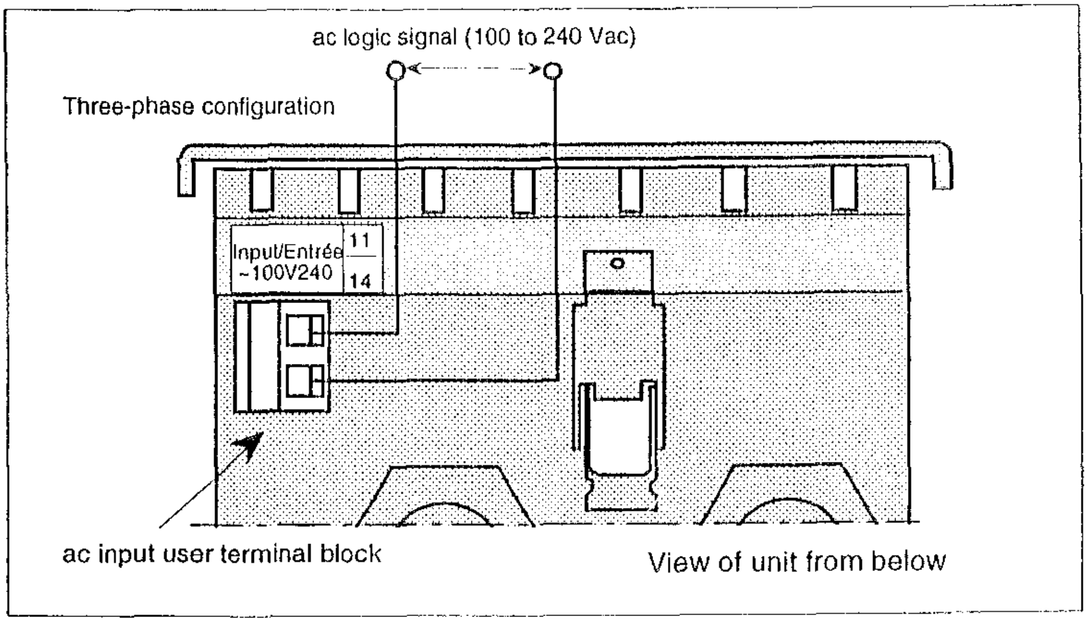


Figure 3-12 Configuration of the solid state contactor ac input

Power thyristor units

Analogue inputs

The TC2000 series power thyristor units are controlled by analogue signals.

In the single-phase configuration, two independent dc analogue signals are applied to terminals **11** and **13** (input **A**) and terminals **14** and **13** (input **B**).

In the three-phase configuration, an analogue signal is applied between terminals **11** and **13** of the power thyristor unit user terminal block.

The signal type and level can be configured using suitable jumpers.

Signal type	Signal level	Input impedance
Voltage	0 - 5 V 1 - 5 V 0 - 10 V 2 - 10 V	68 kΩ
Current	0 - 20 mA 4 - 20 mA	250 Ω

Table 3-5 Power thyristor unit analogue input parameters

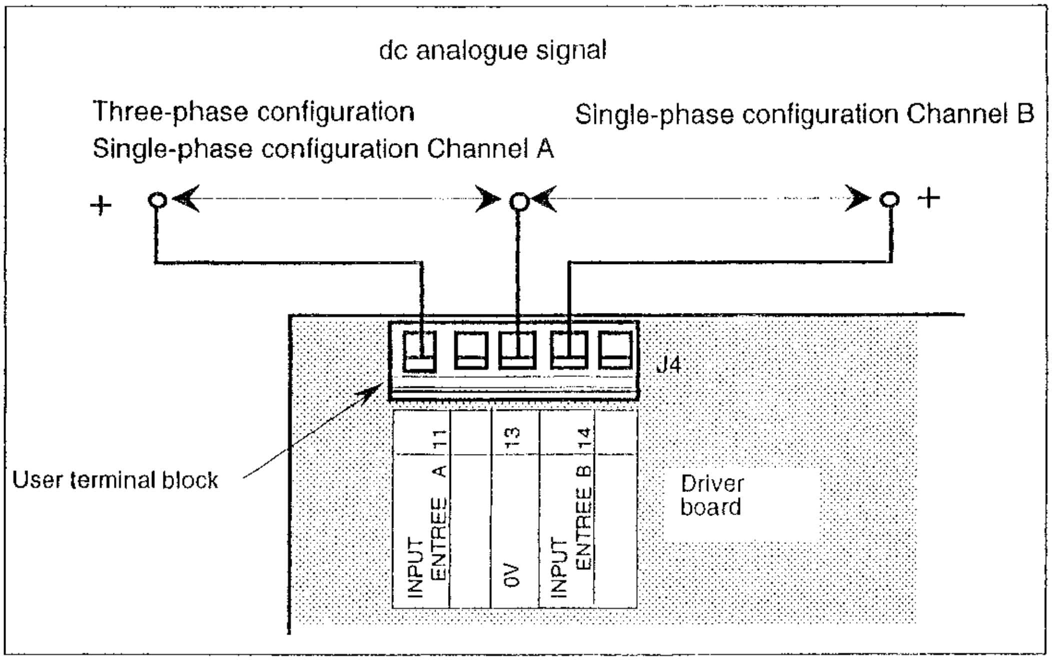


Figure 3-13 Power thyristor unit analogue input configuration

Manual inputs

The TC2000 series thyristor units (analogue operation) can be driven by **external potentiometers** when they are configured with a **0-5 V** or **0-10 V** input.

In the **three-phase** configuration, **only one** potentiometer connected to input **A** is used.

In the **single-phase** configuration, **two** potentiometers are independent.

For the connection of these potentiometers, two **+15 V** dc voltage outputs are provided on the driver terminal block (terminals **12** for channel **A** and **15** for channel **B**).
The +15 V internal voltage is available via a **10 kΩ** resistance of the driver board.

The potentiometers (**5 kΩ** for the **0-5 V** input or **20 kΩ** for the **0-10 V** input) are connected between terminals **12** and **13** for channel **A** and between terminals **15** and **13** for channel **B**.

The cursors are connected to terminal **11** (channel A) and to terminal **14** (channel **B**).

The auxiliary power supply must be connected.

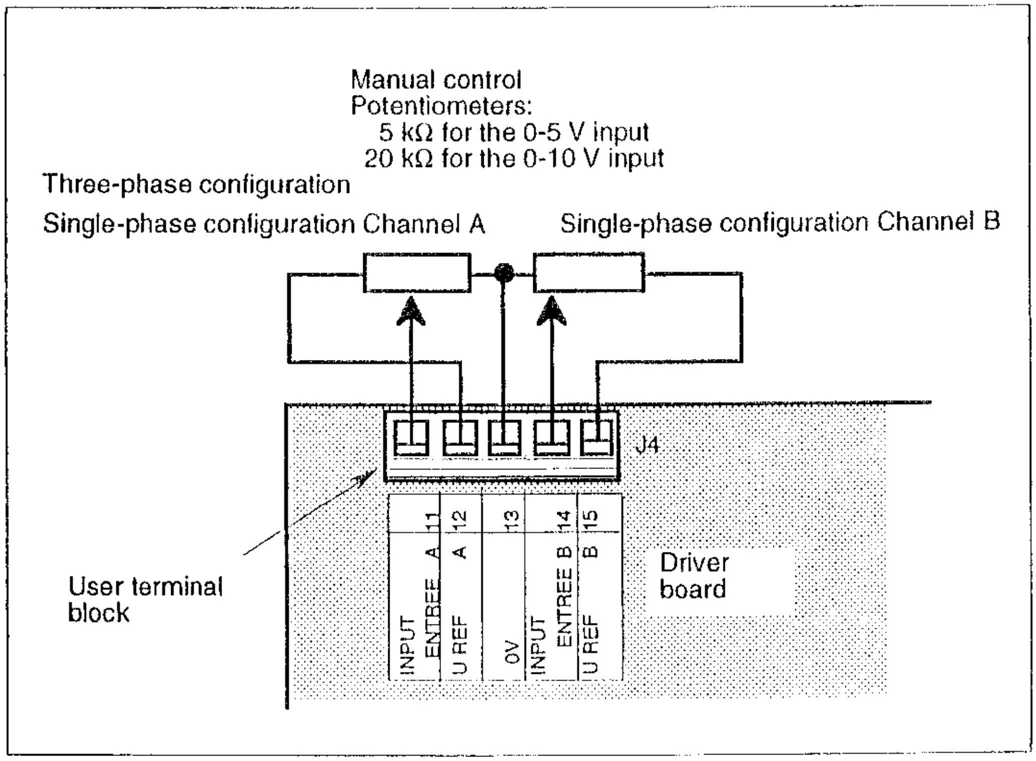


Figure 3-14 Power thyristor unit manual input configuration

PLU ALARM SIGNALLING (optional)

User terminal block

The connection of the PLU alarm relay switch, which signals the active status of the alarm, is made on the user terminal block under the unit, on the left.

The switch output terminals are marked **31** and **32** on the terminal block label.

The PLU alarm relay is **de-energised in alarm status**.
Its switch is **0.25 A** at **250 Vac** or **30 Vdc**

The type of alarm relay switch, configured in the factory (normally open N/O or normally closed N/C), is determined on the order by the PLU option code.

Code **PLU**	:	switch **N/O** (open in alarm status)
Code **IPU**	:	switch **N/C** (closed in alarm status).

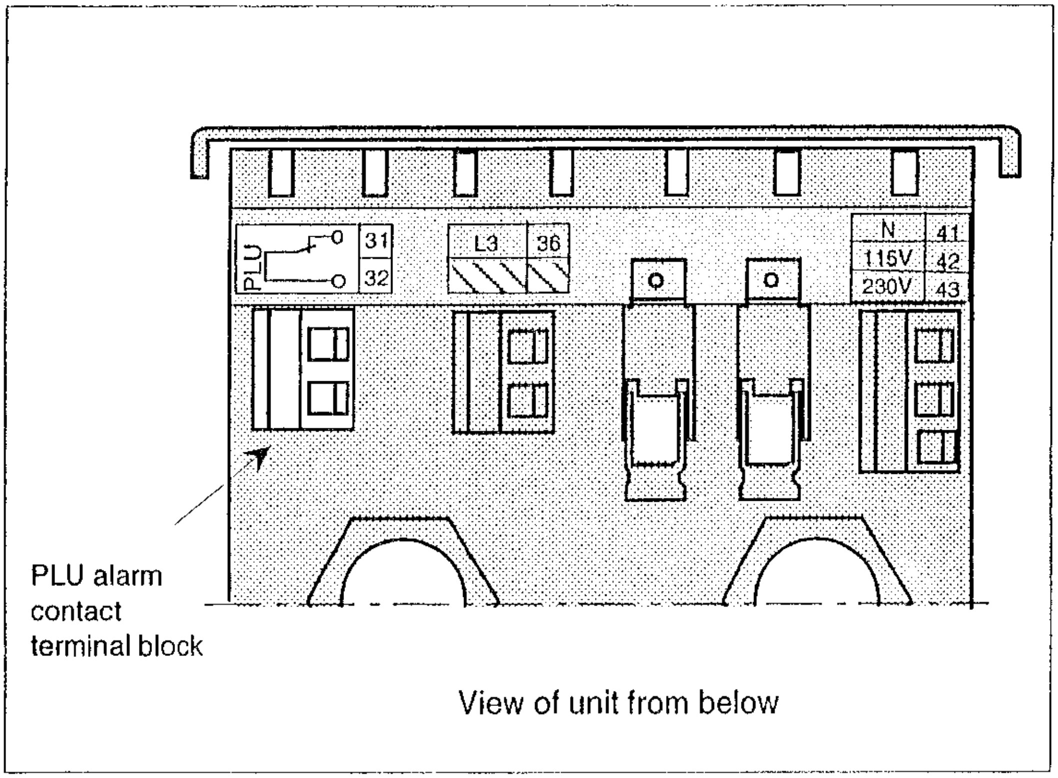


Figure 3-15 PLU relay switch user terminal block

PLU board

The PLU alarm status is acknowledged or memorised using an external switch connected on the PLU board (terminals **21** and **22**).

- Terminals **21** and **22** are short-circuited: the alarm is memorised;
  the opening of the shunt cancels the PLU relay alarm status if the fault disappears.
- Terminals **21** and **22** are not short-circuited: the PLU alarm is not memorised.

An external contact is connected on **one** plug-in terminal block located in the top right-hand corner of the PLU board. The external memorisation / acknowledge switch wires pass through a cable clamp, like that for control (see figures 3-7 to 3-9).

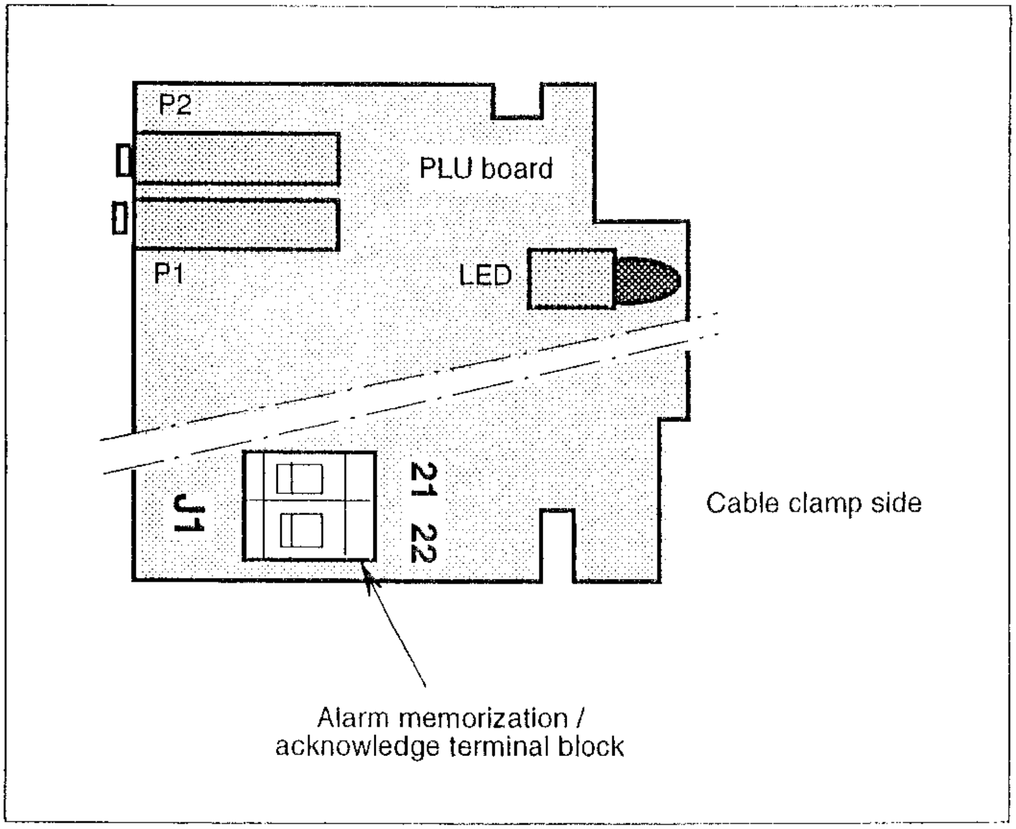


Figure 3-16 PLU alarm status memorisation / acknowledge terminal block

Chapter 4

CONFIGURATION

Contents page

Chapitre 4 CONFIGURATION

SAFETY DURING CONFIGURATION

The thyristor unit is configured using moveable **jumpers** on the driver board.

⚠ **Important**

The unit is supplied fully configured in accordance with the code on the identification label.

This chapter is included in order to

- **check** that the configuration is compatible with the application
- **modify,** if necessary, certain characteristics of the unit on-site.

Danger !

⚠ For safety reasons, the reconfiguration of the unit using jumpers must be performed with the unit **switched off** and by qualified personnel only.

Before starting the reconfiguration procedure, check that the thyristor unit is insulated and that an occasional power-up is impossible.

After the reconfiguration of the unit, correct the codes on the identification label.

DRIVER BOARD

Possible configurations

The type and configuration of the driver board of **TC2000** series units determines

- the operation type
    - solid state contactor (SSC) with ON/OFF firing mode
    - power thyristor unit with Burst firing mode
- the configuration type
    - three-phase
    - single-phase
- the input signal level.

The thyristor firing mode (ON/OFF or Burst mode) is determined by the coding.
The inputs can only be configured for power thyristor units and for SSC with the PLU option.

Operation	**Control signal**	**Configuration**	**PLU option**	**Input configuration jumpers**	**Thyristor firing mode**
Solid state contactor (SSC)	dc logic (code LGC)	Single-phase	Not applicable	Absent	ON/OFF
		Three-phase	No option		
		Three-phase	With option	Present	
	ac logic (code ALC)	Three-phase	Not available	Absent	
Power thyristor units	dc analogue or manual (codes from 0V5 to 4mA20)	Single-phase	Not applicable	Present	Burst mode
		Three-phase	With or without option		
Reconfigurated power thyristor units to SSC	dc logic or manual (order code not avail.)	Single-phase	Not applicable	Present	ON/OFF
		Three-phase	With or without option		

Table 4-1 Possible configurations of TC2000 series units

The manual control of the units requires the configuration of the inputs to **0-5 V** or **0-10 V**.

Operation type

The type of operation of the TC2000 unit (power thyristor unit and static contactor) is **configured in the factory** according to the unit order code.

- The codes **LGC** or **ACL** correspond to the operation of the unit as a **solid state contactor** with the "ON/OFF" thyristor firing mode.

- The codes **0V5** to **4mA20** correspond to the operation of the unit as a **power thyristor unit** with the "Burst mode" thyristor firing mode.

The type of operation can be reconfigured for the power thyristor units on the driver board using the following jumpers:

- **K16** and **K17** (for channel **A** in single-phase configuration and in **three-phase** configuration)
- **K26** and **K27** (for channel **B** in single-phase configuration).
  In the three-phase configuration, the positions of jumpers K26 and K27 are insensitive.

Operation	**Position of jumpers**					
	Three-phase configuration **Single-phase configuration Ch.A**			**Single-phase configuration** **Channel B**		
	K16	**K17**	**K18**	**K26**	**K27**	**K28**
ON/OFF firing mode (logic signal)	0	0	Indifferent position	0	0	Indifferent position
Burst firing mode (analogue signal)	1	1	0 (standard)	1	1	0 (standard)

Table 4-2 Operation type configuration

Notes:

- Units configured as solid state contactors in the factory (operation with logic signals) cannot be reconfigured for operation with analogue signals (except with the PLU option).
- The operation of power thyristor units configured in the factory according to the order code, can be reconfigured on-site with a logic signal in "ON/OFF" mode according to table 4-2.
- For power thyristor units the position of jumpers **K18** and **K28** is **0** (standard).
  The **1** position can be used for special applications (6 s Burst mode, C23 and C24 fitted).

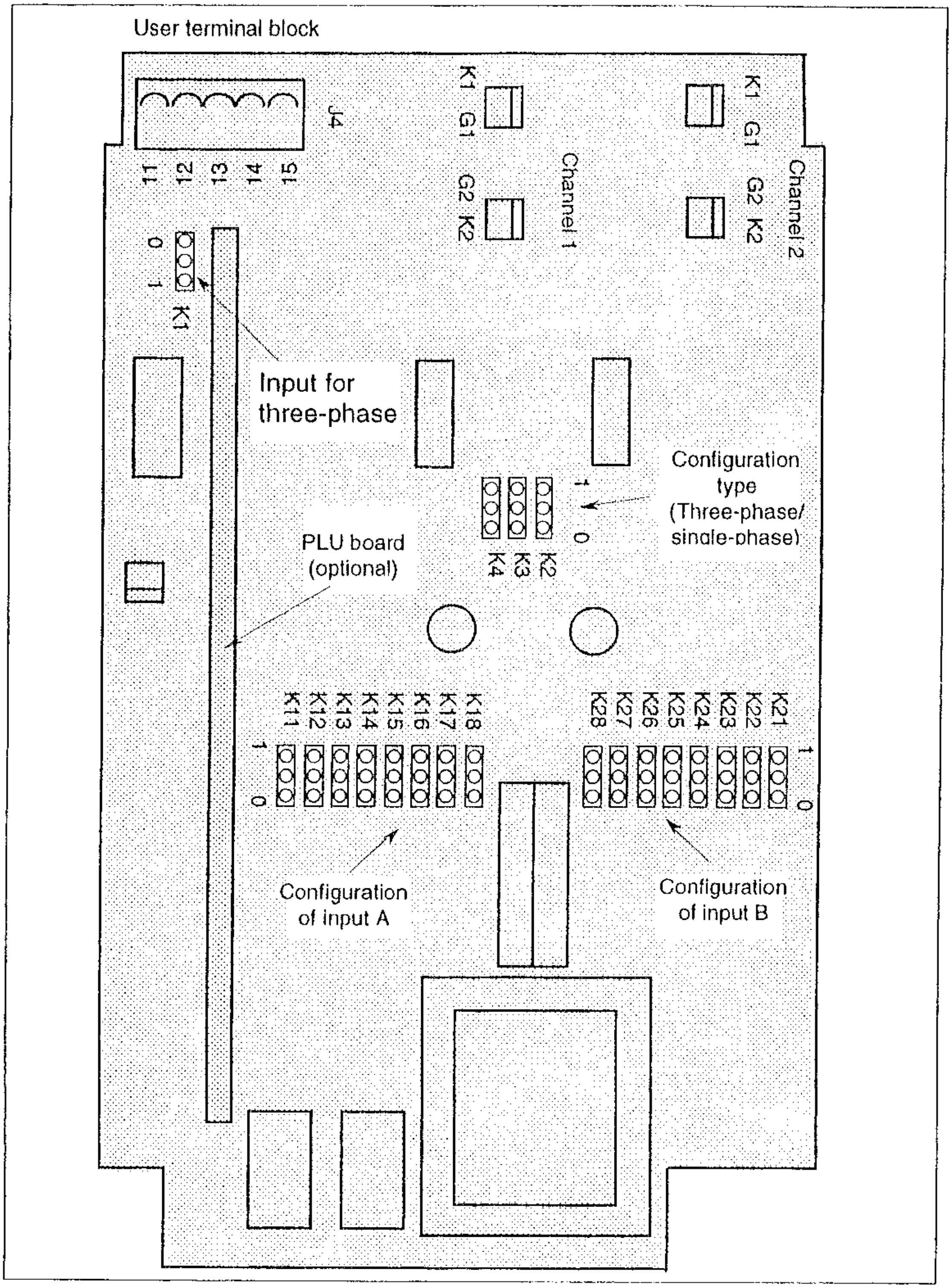


Figure 4-1 Location of the configuration jumpers on the driver board

Note: For static contactors with an ac input or a dc input without the PLU option, the driver board does not contain jumpers K11 to K28.

Configuration type

TC2000 series power thyristor units have been designed to operate in 2 types of configuration:

- **three-phase** in 2 phase control (3-wire load configuration)
- **single-phase** (the unit acts as 2 single-phase units built into the same unit with 2 different control signals);
  single-phase operation is impossible with the ac signal.

The configuration type is configured using jumpers **K1** to **K4** located on the driver board.

Configuration		**Position of jumpers**			
		K1	**K2**	**K3**	**K4**
Solid state contactor	Three-phase (only one control signal is used)	1	0	0	Absent
	Single-phase Two independent thyristor channels (two different control signals)	1	1	1	Absent
Power thyristor unit	Three-phase (only one control signal is used)	Absent	0	0	0
	Single-phase Two independent thyristor channels (two different control signals)	Absent	1	1	0

Table 4-3 Configuration type

Note :
- For **solid state contactors, K1 = 1** indicates that input **A** drives the unit in the three-phase configuration
- For **power thyristor units, K4 = 0** indicates that input **A** drives the unit in the three-phase configuration.

IInput type and level

Solid state contactors

The static contactors are driven by **logic** signals ("ON/OFF" firing).
The power is switched to zero voltage when the signal is present.

There are two possible types of input signal to control the static contactors:

- an **ac** signal (only in the three-phase configuration without the PLU / IPU option)
- a **dc** signal (three-phase configuration with or without the PLU/ IPU option or single-phase configuration).

The **ac** signal **(100 Vac** to **240 Vac)** corresponds the code **ACL**.
The input is configured in the factory with soldered bridges and specific components.
It is **impossible** to reconfigure it.

The **dc** signal corresponds to the code **LGC**. The possibility of reconfiguring the dc input depends on the type of configuration and whether the PLU / IPU option is present:

- In the three-phase configuration without the PLU/IPU option and in the single-phase configuration, it is impossible to reconfigure the logic dc inputs of the static contactor. The driver board **does not contain** configuration jumpers.

- In the three-phase configuration with the PLU / IPU option, the dc inputs can be (if necessary) reconfigured (to adapt the signal source) in terms of voltage and current. In this case, jumpers **K11** to **K15** are used for this configuration.
  In the standard version, the static contactor is supplied with the input configured to **0-5 V**.
  The position of jumpers **K16** and **K17** must be **0** (logic control).

Control	**Input rating**	**Position of jumpers**						
		K11	**K12**	**K13**	**K14**	**K15**	**K16**	**K17**
dc	10 V	0	1	0	1	0	0	0
logic	5 V	0	0	1	1	0	0	0
	20 mA	1	0	1	1	0	0	0

Table 4-4 Configuration of static contactor dc inputs in the three-phase configuration with the PLU/IPU option

Power thyristor units

The power thyristor units are driven by **analogue** input signals.
The power in the load is switched to zero voltage with a cyclic ratio **proportional** to the input signal.

In the three-phase configuration and in the single-phase configuration with or without the PLU / IPU option, the input signals can be configured with a choice of four voltage levels and two current levels.

Jumpers **K11 to K17** are used to configure

- the three-phase input
- input A in the unit three-phase configuration.

Jumpers **K21** to **K27** are used to configure input B only in the single-phase configuration.

For operation with an analogue signal or in manual mode, jumpers **K16** and **K17** for channel A and jumpers **K26 and K27** for channel **B** must be in position **1.**

Control	**Input**	**Position of jumpers**						
	level	**K11**	**K12**	**K13**	**K14**	**K15**	**K16**	**K17**
		K21	**K22**	**K23**	**K24**	**K25**	**K26**	**K27**
Analogue	0-5V	0	0	1	0	1	1	1
	1-5V	0	0	1	1	0	1	1
	0-10V	0	1	0	0	1	1	1
	2-10V	0	1	0	1	0	1	1
	0-20 mA	1	0	1	0	1	1	1
	4-20 mA	1	0	1	1	0	1	1
Manual	5 kΩ	0	0	1	0	1	1	1
(potentiometer)	20 kΩ	0	1	0	0	1	1	1

Table 4-5 Configuration of inputs for power thyristor units

PLU BOARD (OPTIONAL)

The PLU board is supplied fully configured in accordance with the ordering code. This paragraph is included in order to check that the configuration is compatible with the application or to modify, if necessary, certain characteristics of the unit on-site.

The jumpers of the partial load unbalance board (PLU board) are used to reconfigure:

- calibration or normal operation
- the supply frequency (**50** or **60 Hz**)
- the PLU detection test type.

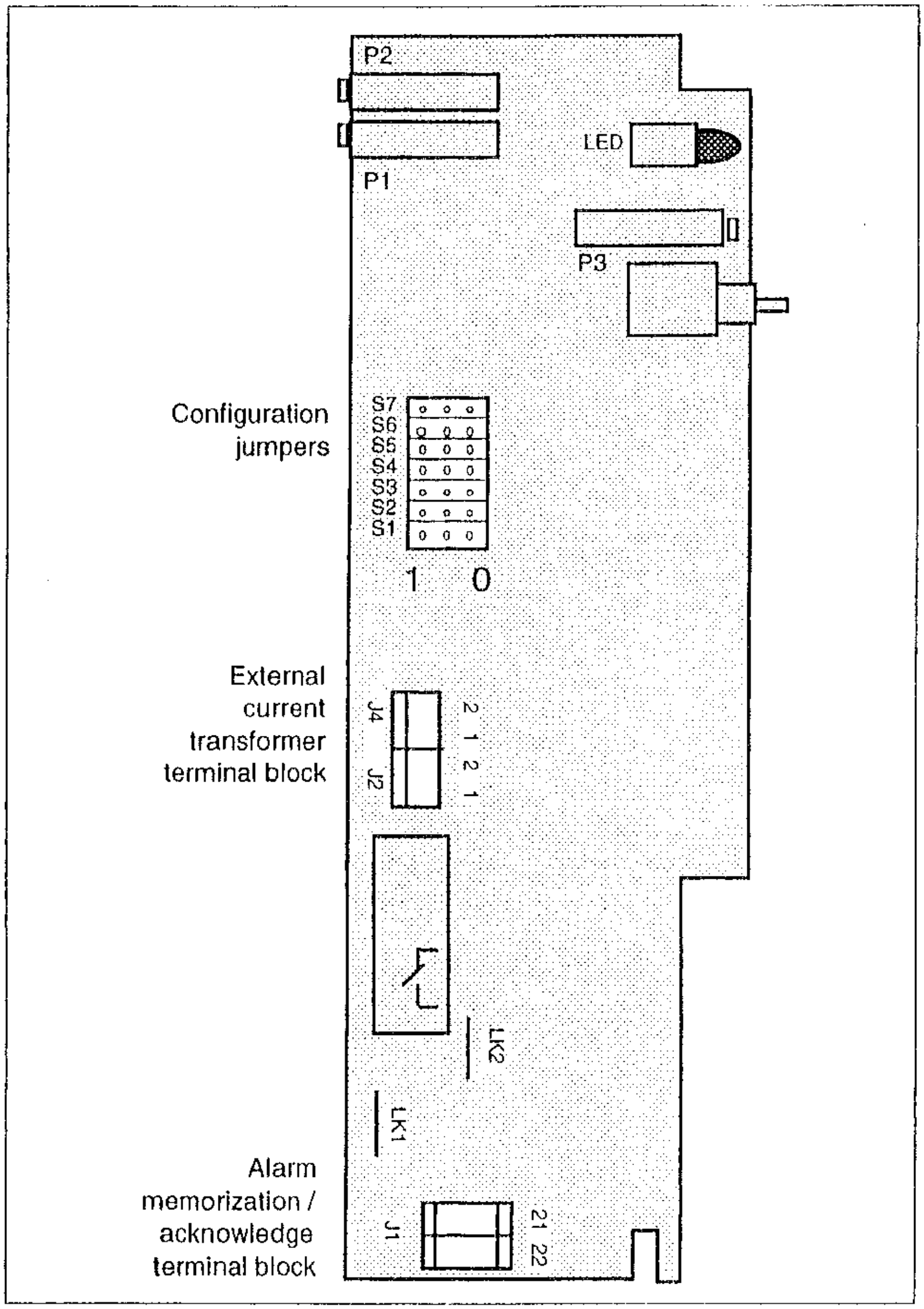


Figure 4-2 Position of configuration jumpers on the PLU board

For normal operation of the PLU circuitry jumper **S3** must be in position **0.**

The jumper **S7** must always be in position **1.**

For external measurements, two current transformers can be connected to the PLU board, in order to provide the information required for PLU detection (terminal blocks **J2** for phase **A** and **J4** for phase **B**, see figure 4-2). The jumper **S1** et **S2** must always be in position **1.**

Supply frequency

Frequency	**Position of jumper**
	S4
50 Hz (±2 Hz)	0
60 Hz (±2 Hz)	1

Table 4-6 Configuration of the frequency

Test

Operation	**Position of jumper**
	S5
Normal position for Test	0
Inversion of PLU for Test (PLU setting, if necessary)	1

Table 4-7 Configuration of the "Test" position

Alarm contact type

Contact type	**Link soldered**	
	LK1	**LK2**
Contact open in alarm state (PLU code)	Yes	No
Contact closed in alarm state (IPU code)	No	Yes

Table 4-8 Configuration of alarm contact type

Chapter 5

OPERATION

Chapter 5 OPERATION

THYRISTOR FIRING MODE

General

⚠ TC2000 series unit thyristors switch on and off at the **zero** supply voltage for each phase. This firing mode eliminates the steep fronts of the supply voltage applied to the load, **does not apply disturbances on the supply and, above all, prevents the generation of interference.**

The synchronisation of firing at zero voltage also means it is no longer necessary to detect the order of the phases beforehand when wiring the unit on a three-phase supply (except when the unit has the PLU/IPU option).

The thyristor firing mode of the TC2000 series units is determined by the type of operation of the unit (static contactor or power thyristor unit):

- the **solid state contactors** possess the **Logic** firing mode
- the **power thyristor units** possess the **Burst firing** mode.

For both these modes, the thyristor firing includes a whole number of alternations.

The modulation of the supply voltage applied to the load is performed:

- for the solid state contactors, by an external controller (e.g. temperature controller) with the use of a logic controller output;
- for the power thyristor units, by the internal modulator with an analogue input.

Supply variation compensation

TC2000 series **power thyristor units** with an **analogue control** are equipped with a compensation function for voltage variations within the range: **+ 10 %** to **- 15 %**.

This voltage is measured on the power supply.
To benefit from the supply voltage variation compensation functions, the power supply must be connected to the **same voltage** as the **power** (use of an external step-down transformer, if necessary).

Without a compensation of the supply voltage variations, a decrease (or increase) of 10% in the supply voltage would lead to a decrease (or increase) of 20% in the power sent to the load. By compensating for the supply voltage variation simultaneously, the thyristor unit does not transmit a power variation to the load, thus preventing fluctuations of the controlled value and the intervention of the controller.

"Logic" mode

The "**Logic**" mode of thyristor firing (also known as the "**ON/OFF**" mode) con,trols power in the load as a proportion of the firing time specified by the logic control signal.

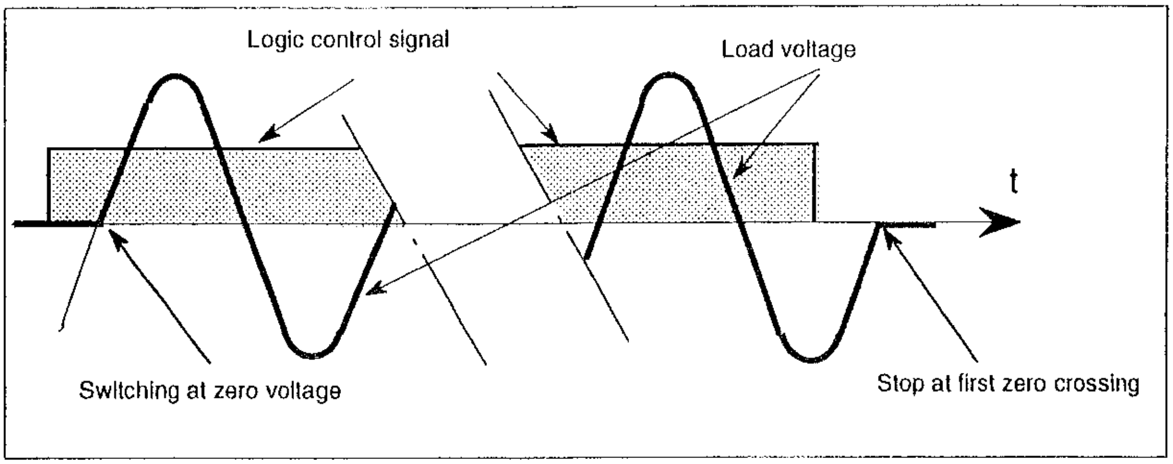


Figure 5-1 "Logic" firing mode

This firing mode is activated by a logic input signal greater than an "ON state" threshold (full thyristor firing), provided that the input signal is not less than an "OFF state" threshold.

Attention!

⚠ In logic firing mode (except specific application), use a control signal with an external modulation period less than **10 s** to reduce aging due to thermal fatigue of various elements of the installation (heating elements, thyristors, thyristor protection high-speed fuses) as much as possible and thus increase their service life.

"Burst firing" mode

In Burst firing mode, the power dissipated in the load is defined by the ratio of the thyristor firing period ($\mathbf{T_F}$) and the modulation period ($\mathbf{T_M}$).

The power delivered by a thyristor unit in Burst firing mode is therefore set by the firing period $\mathbf{T_F}$ varying within the modulation period $\mathbf{T_M}$.

The load power is proportional to the firing rate τ which depends on the firing period ($\mathbf{T_F}$) and the non-firing period ($\mathbf{T_{NF}}$):

$$\tau = \frac{\mathbf{T_F}}{\mathbf{T_F} + \mathbf{T_{NF}}}$$

or, using the modulation period ($\mathbf{T_M} = \mathbf{T_F} + \mathbf{T_{NF}}$), the firing rate (or cyclic ratio) can be expressed by:

$$\tau = \frac{\mathbf{T_F}}{\mathbf{T_M}} \quad \text{which is inversely proportional to } \mathbf{T_M}.$$

The load power can be expressed by:

$$\mathbf{P} = \tau \;.\, \mathbf{P_{MAX}} \;,$$

where $\mathbf{P_{MAX}}$ represents the load power during the thyristor firing.

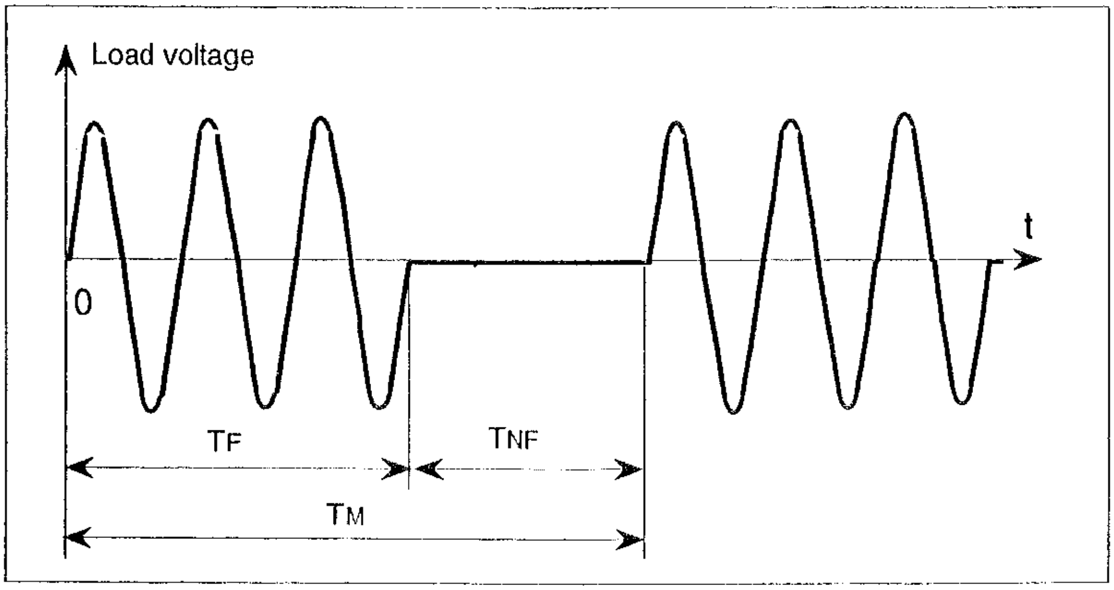


Figure 5-2 Burst firing periods

Using a variable modulation period according to the output power, the adjustment precision of the TC2000 unit is adapted to each specific setpoint zone.

At **50 %** power, the typical value of the modulation period is **0.6 s** ($T_F = T_{NF} = 0.3$ s).

- For a zone less than 50 % of the maximum setpoint, the firing period is decreased and the modulation period is increased.
- In the power zone greater than 50%, the non-firing period is reduced with the increase in the modulation period.

E.g.:

- for 50% power : $T_F = 300$ ms, $T_M = 600$ ms
- for 5 % power : $T_F = 250$ ms, $T_M = 5$ s
- for 90 % power : $T_F = 2.25$ s, $T_M = 2.5$ s

The unit output power is thus perfectly linear between **0** and **100 %** of maximum power for the analogue signal varying between **4** and **84%** of the maximum scale.
The control does not have an adjustment stage as in fixed modulation period units.

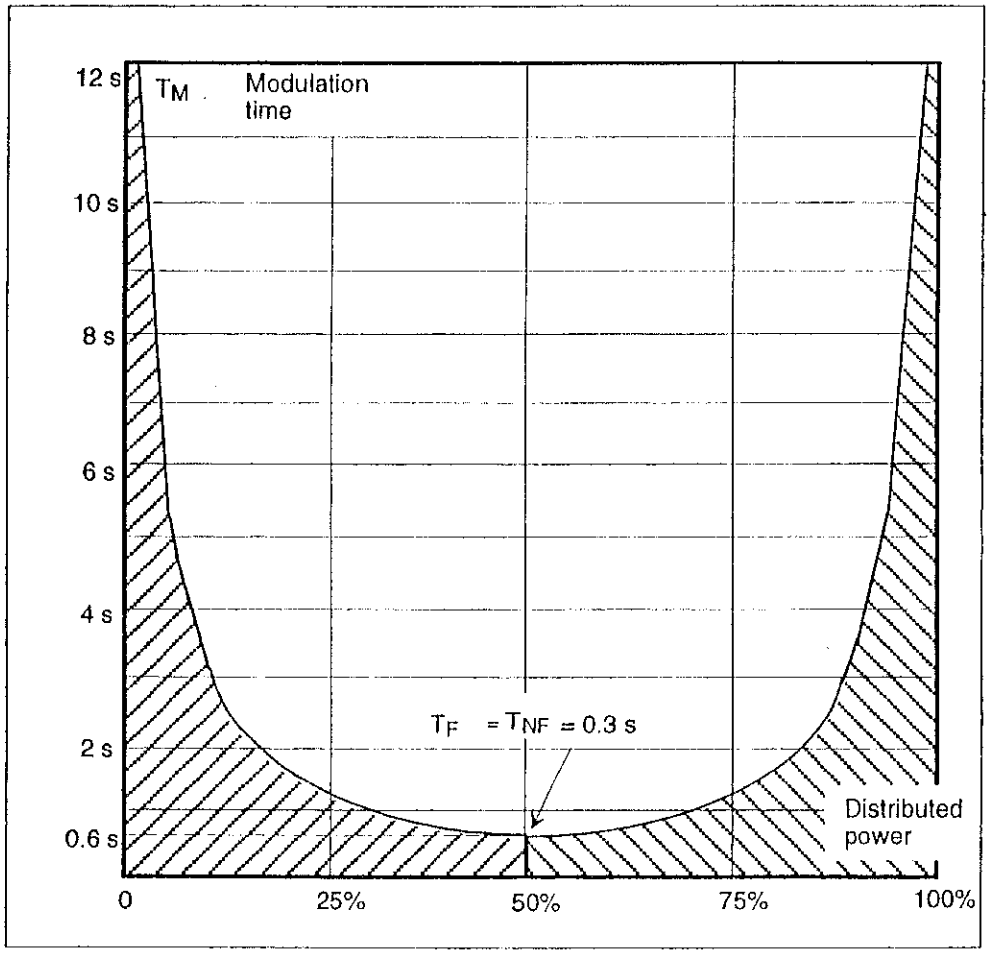


Figure 5-3 Modulation time as a function of power

PLU DETECTION

The partial load unbalance detection system (in three-phase operation only) provides an alarm for a current unbalance $\Delta\mathbf{I}$ of

$$\Delta \mathbf{I} = \pm 10\%. \mathbf{I}_{\text{Load}}$$

for a balanced three-phase load.

This partial load unbalance (PLU) detection is available **as an option** only for the **three-phase** configuration for:

- power thyristor units
- solid state contactors with the **dc logic** input.

The PLU option requires an auxiliary power supply irrespective of the type of unit cooling (fan-cooled or not fan-cooled) and the input type.

The PLU board is mounted perpendicularly on the driver board (see figure 4-1).

The **PLU alarm relay**, located on the PLU board, is **deactivated** in alarm status.

Depending on the code on the identification label, two types of alarm relay switch are available on the user terminal block (below the unit):

- switch N/O **open** in alarm status (code **PLU**)
- switch N/C **closed** in alarm status (code **IPU**).

The relay break-make contact cut-off capacity:

0.25 A at 250 Vac or 30 Vdc.

Chapter 6

COMMISSIONING PROCEDURE

Chapter 6 COMMISSIONING PROCEDURE

Read this chapter carefully before commissioning the thyristor unit

COMMISSIONING PROCEDURE SAFETY

Important !

Eurotherm cannot be held responsible for any damage to persons or property or for any financial loss or costs resulting from the incorrect use of the product or the failure to observe the instructions contained in this manual.

It is therefore the user's responsibility to ensure that all the nominal values of the power unit are compatible with the conditions of use and installation before commissioning the unit.

Danger !

Dangerous live parts may be accessible when the front door is open.

Only personnel qualified and authorised to work in industrial low voltage electrical environments can access inside the unit, after it has been insulated (wait for at least 5 s before accessing inside the unit).

Access to internal components of the unit is prohibited to users who are not authorised to work in industrial low voltage electrical environments.

The temperature of the heatsink may exceed 100°C.
Avoid all contact, even occasional, with the heatsink if unit it operational.

The heatsink remains hot for approximately 15 min after the unit has been switched off.

CHECKING THE CHARACTERISTICS

Attention !

Before connecting the unit to an electrical supply, make sure that the **identification code** of the thyristor power unit corresponds to the coding specified in the **order** and that the characteristics of the unit are **compatible with the installation**.

Load current

The maximum current in a load phase must be less than or equal to the value of the nominal current of the TC2000 series unit for operation at a specified temperature.

In three-phase operation, if the three identical loads are configured as **closed delta,** the line current of the thyristor unit is **$\sqrt{3}$ times as high** as the current of each arm of the delta.

If the three-phase load is presented by its power (**P**), the line current of the three-phase load for all configuration types can be calculated as follows:

$$I = \frac{P}{\sqrt{3} \times V_L}$$

(in this equation V_L represents the line to line voltage).

Supply voltage

For star configurations without neutral or closed delta, the nominal value of the TC2000 series unit voltage must be greater than or equal to the **line to line** voltage of the supply used.

Danger !

Never use a thyristor unit with a supply **voltage greater** than the nominal voltage specified on the serial number label code.

Auxiliary power supply voltage

The auxiliary power supply voltage is determined on the unit order.

It powers the actual electronics (for power thyristor units and for static contactors with the PLU / IPU option) and the fans of units with permanent fan-cooling (100 A to 500 A nominal current).

The auxiliary voltage is set to 100-110-115-120 Vac or 200-220-230-240 Vac according to the type of internal transformer. The auxiliary power supply transformers are selected in the factory, according to the coding.

The configured auxiliary voltage is marked on the label of the connection user terminal block of the auxiliary voltage (below the unit) and on the identification label.

Input signals

For power thyristor units and static contactors with the PLU / IPU option, the jumper configurations on the driver board must be compatible with the levels chosen for the signals used for control (see "Configuration").

PLU detection (optional)

- Check that the unit is configured for two phase control of the three-phase load (see page 4-6).
- Check that the auxiliary power supply is correctly connected.
- Check that the loads are correctly connected (closed delta or star without neutral configuration) and that the **phase rotation order** is **direct (1, 2, 3)** as in figure 3-3, for example.

PLU DETECTION ADJUSTMENT (optional)

Partial load unbalance (**PLU**) detection is possible as an option for power thyristor units and for static contactors with the dc signal.

The PLU detection circuit is adjusted in the factory for the nominal current and voltage in the three-phase configuration.

To retain the PLU detection performances with the real load which may be different to that defined in the order, the possibility of on-site adjustment is provided for.

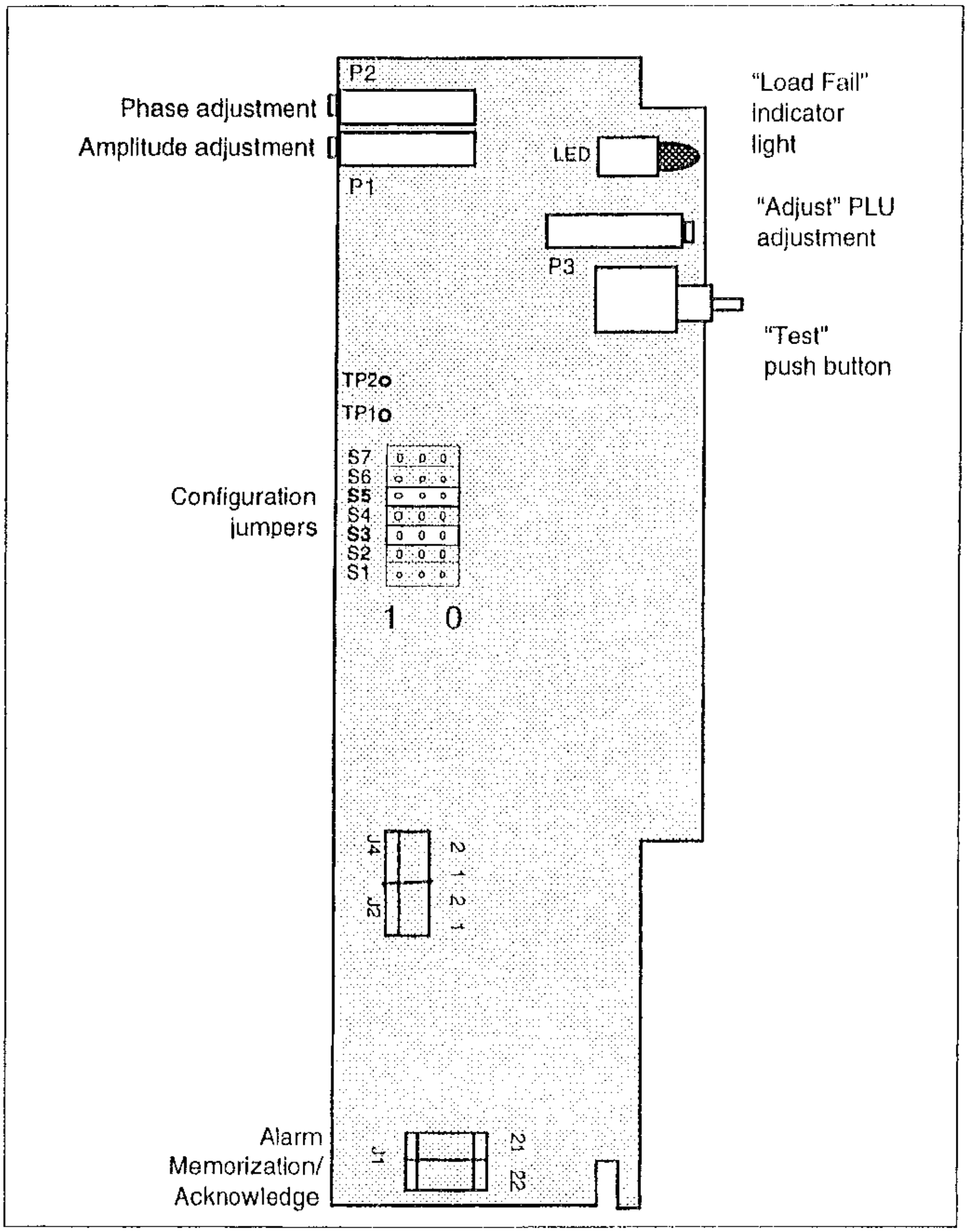


Figure 6-1 Location of adjustment equipment on the PLU board

Adjustment equipment

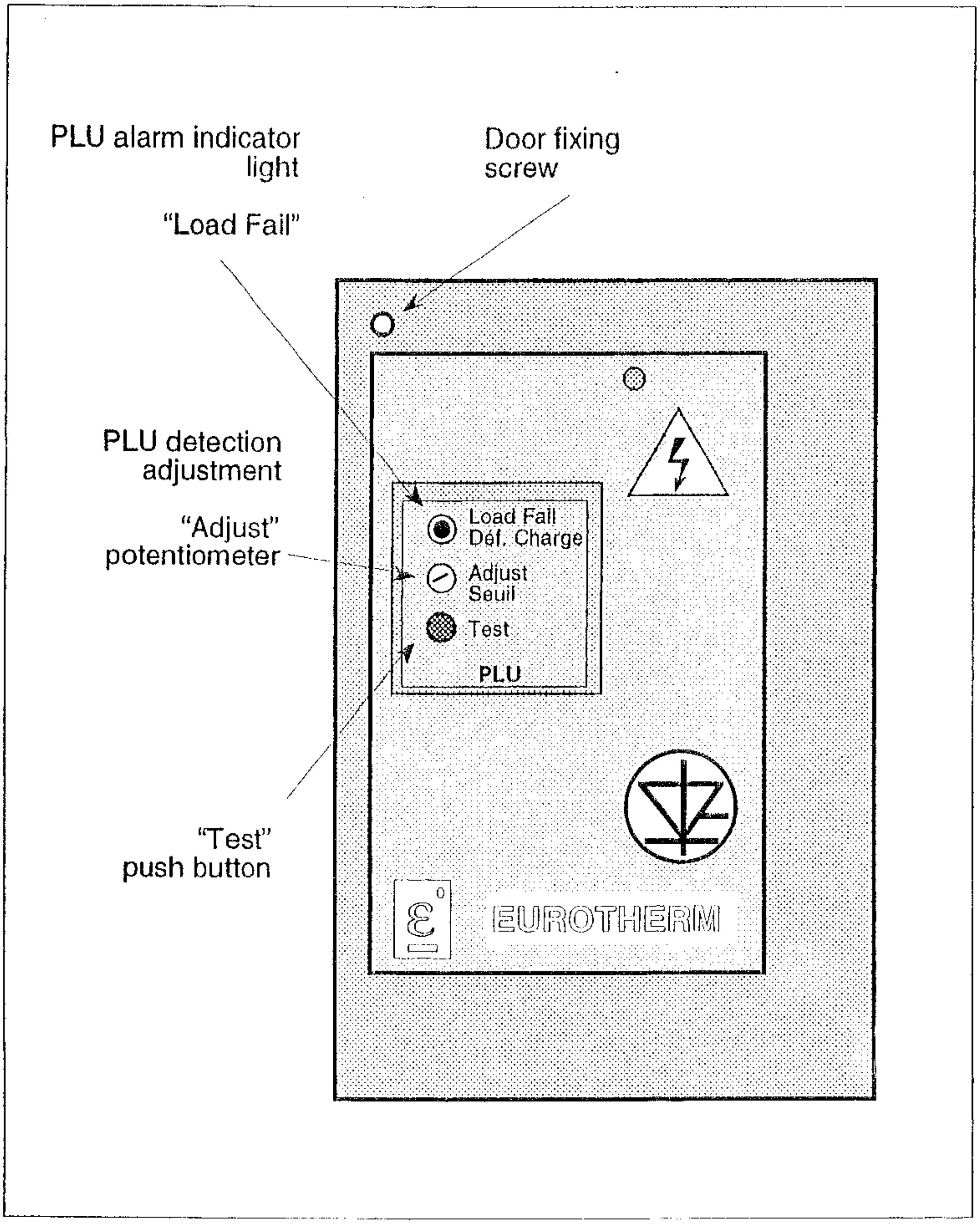


Figure 6-2 Location of adjustment equipment on the front fascia of the unit

Initially balanced load

- Set the thyristor unit to continuous firing (three-phase configuration)
- Turn the adjustment potentiometer (marked "**Adjust**" on the front fascia) to the limit anti-clockwise (minimum sensitivity).

  If the "**Load Fail**" indicator light is lit, wait for a few seconds until it goes off.
- Press the "**Test**" push button and keep it in this position.
  Turn the adjustment potentiometer slowly clockwise until the indicator light comes on.
- Release the "**Test**" button and check that the "**Load Fail**" indicator light goes off after a few moments. Otherwise, repeat the adjustment.
- Press the "**Test**" button again, the "**Load Fail**" indicator light should light up;
  the PLU alarm relay then changes status.
  Release the button.
- Decrease the control signal (to approximately 50%) and check that the alarm is not triggered.

  Press the button and check the triggering of the alarm (indicator light and relay).

Note : If abnormal operation is observed during the adjustment:

- **switch off** the thyristor unit and **insulate it**
- set jumper **S5** on the PLU board to position **1** (see figure 6-1)
- resume the adjustment.

The last adjustment must only be made **by personnel qualified and authorised** to work in an industrial electrical low voltage environment.

Initially unbalanced load

If the load is initially unbalanced, to obtain optimum PLU detection sensitivity, the PLU board must be recalibrated with power on.

Danger !

This adjustment must only be made **by personnel qualified and authorised** to work in an industrial low voltage electrical environment

---

- Set jumper **S3** on the PLU board to position **1** (see figure 6-1).
- Turn the "**Adjust**" potentiometer on the front fascia completely clockwise (see figure 6-2).
- Set the thyristor unit to full firing.
- Using the potentiometers **P1** (signal amplitude) and **P2** (signal phase) located on the PLU board, adjust in alternation to obtain the minimum of the error voltage.

  This voltage is available between the test points **TP1** and **TP2** on the PLU board.
- Reset jumper **S3** to position **0**.

Follow the adjustment procedure described for the initially balanced load.

Chapter 7

MAINTENANCE

Contents Page

Chapter 7 MAINTENANCE

Danger !

The unit must be maintained by qualified personnel only

THYRISTOR PROTECTION

The thyristors of the TC2000 series power units are protected as follows:

- internal high-speed fuses against over-currents;
- RC snubber and varistors - against too fast voltage variations and transient over-voltages when the thyristors are not conductors.
- thermal switch (for units with permanent fan cooling, nominal current greater than or equal to 100 A); in the event of accidental overheating of the cooler (for 100 to 500 A units), the thermal switch opens, which causes the thyristor firing to be stopped.

THYRISTOR PROTECTION FUSES

The standard version of TC2000 series units is supplied with high-speed fuses mounted on the line busbars.

Attention

High-speed fuses are only used for the internal protection **of thyristors** against wide amplitude over-loads.

These high-speed fuses may under no circumstances be used to **protect the installation.**

The user's installation **must be protected** (non-high-speed fuses, thermal or electromagnetic circuit breaker, suitable fuse-isolator) and comply with current standards.

The use of any fuses **other** than those recommended for thyristor protection **renders the thyristor unit guarantee null and void** (see table 7-1).

Table 7-1 contains all the references of the original internal fuses (when the thyristor unit leaves the factory) and the fuse which can be used for replacements during maintenance.

Maximum line-to-line voltage: **500 V.**

Nominal current		Reference		
Th. unit (A)	**Fuse (A)**	**EUROTHERM**	**FERRAZ**	**BUSSMANN**
60	80	LA172468U080	S300051	170M3461
75	100	LA172468U100	T300052	170M3462
100	125	LA172468U125	V300053	170M3463
150	200	LA172468U200	X300055	170M3465
250	315	LA172468U315	Q300003	170M4460
300	400	LA172468U400	H300065	170M5458
400	500	LA172468U500	K300067	170M5460
500	630	LA172468U630	M300069	170M5462

Table 7-1 Recommended high-speed fuses for thyristor protection

FUSE BLOWN INDICATION MICRO-SWITCH

As an option, high-speed fuses may be equipped with a fuse blown indication micro-switch (**FUMS** option) with the part No.:

for BUSSMANN fuses:
EUROTHERM DC172267 or FERRAZ P96015 or BUSSMANN 170H0069
for FERRAZ fuses:
EUROTHERM DC172997 or FERRAZ G310 000

To ensure improved insulation between the cabling of the micro-switches and the power and the cover, TC2000 models with a nominal current of 60 to 100 A are supplied with the "flags" type lugs and the insulating sleeves.

Each external terminal of the fuse blown indication micro-switch must be cabled with a "flag" lug and an insulating sleeve in compliance with figure 7-1.

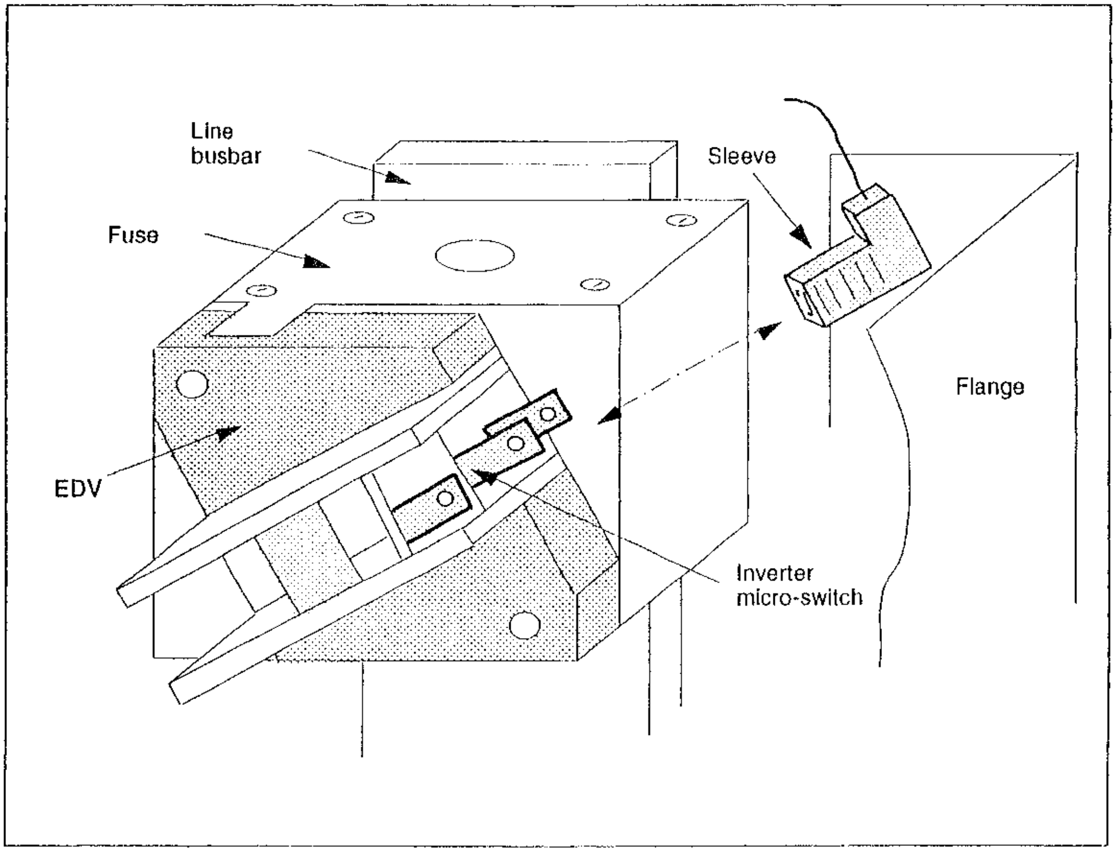


Figure 7-1 Use of "flag" lugs and insulating sleeves to observe insulating distances.

PROTECTION FUSES FOR AUXILIARY POWER SUPPLY CONNECTION

These fuses must be installed in each connection wire of the auxiliary power supply (see "Cabling") for the following units:

- power thyristor units
- static contactors with the PLU option
- all fan-cooled units (nominal current from 100 to 500 A).

Reference voltage (max)	**1 A fuse 6.3 x 32 mm**	**Fuse-isolator support**	**Overall "Fuse-isolator" dimensions (mm)**
500 V	CS174289U1A0	CP174293	63 x 15 x 52

Table 7-2 Recommended protection fuses for the auxiliary power supply connection

SERVICING

TC2000 thyristor units must be mounted with the heatsink positioned vertically and with no obstructions either above or below which could block the passage of the ventilation air.

Attention !

⚠ If multiple units are installed in the same cabinet, they should be arranged in such a way that the air expelled by one unit **cannot be admitted** into the unit located above it.

In order to ensure correct cooling of the unit, users are advised to **clean the heatsink and the protective grill** of the fans regularly according to the degree of environmental pollution.

Danger !

⚠ Every **six months**, check that the screws of the power cables and safety earth are **tightened correctly** (see "Cabling", page 3-3).

TOOLS

Operation	**Flat screw-driver (mm)**	**Wrench**	**Electrical equipment**
Fixing		Depending on M8 screw heads selected	
Opening (closing) of front door		CHc No. 4 for M5 screw	
Safety earth connection		HEX17 (M10) HEX19 (M12)	
Power connection (supply side) and fuse change		HEX13 (M8) (60 to 250 A) HEX17 (M10) (300 to 500 A)	
Load connection		HEX17 (M10) (25 to 250 A) HEX19 (M12) (250 to 500 A)	
Cable clamp tightening	0.5 x 3.5		
Control and auxiliary power supply connection	0.5 x 3.5		
Board fixing	0.8 x 5.5	For M4 nut	
Commissioning and calibration	0.4 x 2.5		Ammeter or RMS clip.

Table 7-3 Tools

PLU board (optional)

Unit series	Jumpers function
TC2000	Current transformer secondary connected on PLU board directly
	Normal operation
	50 Hz 60 Hz (not standard, no ordering code)
	PLU test button unbalance action : • direct • reverse
	Phase rotation sensitive: three-phase wiring according to documentation
	Phase rotation fixed
	PLU alarm contact in alarm state or unit not supplied : • open (code PLU) • closed (code IPU)

$\boxed{0}$: Factory set (selection possible but not codable)

FIGURATION RECAPIT

er board

it type	Wir
lid State ntactor On/Off)	Th

Power unit
(Burst mode)

Re
P

7-10

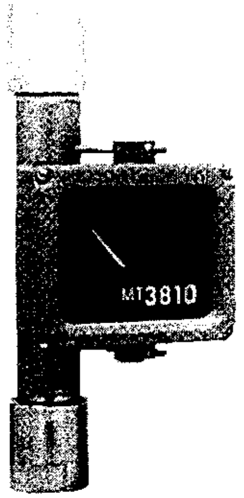
not a.

ent ation	Operation	Frequency	Test	Phase rotation		PLU alarm contact (soldered links)	
S2	S3	S4	S5	S6	S7	LK1	LK2
1							
	0						
		$\boxed{0}$ 1					
			$\boxed{0}$ 1				
				1			
					1		
						1 0	0 1

INDEX

Installation and Operation Manual
X-3810
July, 1997
Issue 2

Model MT 3810 Metal Tube Variable Area Flowmeter with Optional Electronics Based on Smart Meter Manager™ Technology



Model MT 3810

Brooks Instrument

FISHER-ROSEMOUNT™ Managing The Process Better.™

Essential Instructions

Read this page before proceeding!

Brooks Instrument designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using and maintaining Brooks Products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, telephone 1-215-362-3700 and the requested manual will be provided. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact your Brooks Instrument representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Brooks Instrument. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

⚠ CAUTION

This instrument contains electronic components that are susceptible to damage by static electricity. Proper handling procedures must be observed during the removal, installation or other handling of internal circuit boards or devices.

Handling Procedure:

1. Power to unit must be removed.
2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.
3. Printed circuit cards must be transported in a conductive bag or other conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.

Comments

This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs contain components that utilize metal oxide technology (NMOS, CMOS, etc.). Experience has proven that even small amounts of static electricity can damage or destroy these devices. Damaged components, even though they appear to function properly, exhibit early failure.

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Section 1 Introduction

Section 2 Installation

Section 3 Operation

Section 4 Maintenance

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Figures

Tables

Introduction

Section 1

1-1 Description

The Brooks® Model MT 3810 Variable Area Flowmeter is a rugged, all metal flowmeter offering 5% full scale accuracy. The Model MT 3810 is constructed with stainless steel components for measuring a variety of liquid and gas applications.

Flow rate indication is provided by means of magnetic coupling where a magnet, encapsulated in the float, is coupled to a rotatable magnet located in the rear of the indicator, thus turning the dial indicator mounted on the meter.

Optional accessories available include 4-20 mA output with HART® microprocessor transmitter with or without configurable alarms and pulse output for totalization. The microprocessor electronics are based on the proprietary Smart Meter Manager™ technology utilized as the basis for an array of Brooks products. Also available are front adjustable inductive alarms.

1-2 Design Features

- Broad range of flow capacities
- 5% Full scale accuracy
- Versatile construction for all gas and liquid applications
- No back pressure required for operation
- Flanged or female NPT connections
- Optional 4-20 mA and HART programmable microprocessor transmitter with or without alarms and pulse output for totalization
- Electronics designed with either intrinsically safe or explosion proof construction to meet UL, cUL, CENELEC and TIIS certifications and CE requirements

1-3 Specifications - Meter

⚠ WARNING

Do not operate this instrument in excess of the specifications listed below. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

Capacities, Pressure Drop and Viscosity Immunity Ceilings
Refer to Table 1-1

Accuracy
Standard Flow Accuracy: ± 5% Full Scale from 100% to 10% of scale reading

Repeatability
0.25% Full Scale

Pressure Ratings
Refer to Table 1-2 for maximum non-shock pressure

Scales
Standard: Detachable aluminum plate single or dual scales
Graduations: Choice of direct reading units, millimeter or percentage of maximum flow.

Operating Fluid Temperature Limits/Meter only
Minimum: -20°F (-29°C)
Maximum: 420°F (215°C)
Refer to Table 1-3 for temperature limitations for meters with electronics.

Materials of Construction:

Metering Tube
316L stainless steel

Flanges and End Fittings
Flanges: 316/316L dual certified stainless steel
NPT: 316L stainless steel

Connections
150 lbs or 300 lbs RF ANSI B 16.5 flanges or PN 40 DIN 2527/2635 or Female NPT
125/175 Ra flange finish
Vertical inlet and outlet

Floats
Standard: 316L stainless steel

O-rings (NPT only)
Standard: Viton®
Optional: Teflon®

Indicator Housing and Cover
Enclosure NEMA 4X construction
Die cast aluminum, polyurethane paint with glass window

Meter Dimensions
Refer to Figure 1-1, Sizes 7-13

1-4 Optional Accessories

Needle Valves and Sight Flow Indicators
For flowrate control, needle valves may be externally piped into the inlet or outlet side of the instrument. Needle valves can be supplied up to size 10 (1") maximum 6.6 gpm (1,500 l/hr) water equivalent. Sight flow indicators are available for all flanged meters and to size 13 (2") NPT meters.

1-5 Optional Electronic Equipment

Electronic equipment available with the Model MT 3810 includes the Microprocessor Transmitter, Microprocessor Transmitter/Alarm/Pulse Output for totalization, Inductive Alarms, and Transmitter with Inductive Alarms, refer to the following sections for additional information. All models are designed to be either Intrinsically Safe or Explosion Proof.

Table 1-1 Model MT 3810 Capacities, Pressure Drop and Viscosity Immunity Ceiling

		FLOAT MATERIAL STAINLESS STEEL 316L SS								
SIZE	CONNECTION SIZE	WATER		AIR (See Notes 1& 2)					Press. Drop Inches W.C.	Viscosity Immunity Ceiling (Centistokes)
		gpm	l/h	scfm	m^3/h	nm^3/h	ln/h	slpm		
7	1/2"	0.11	25	0.49	0.84	0.78	780	13.97	12.1	5
		0.29	65	1.30	2.20	2.05	2,050	36.71	12.1	1
		0.59	135	2.40	4.09	3.80	3,800	68.04	12.1	5
		0.88	200	3.73	6.34	5.90	5,900	105.64	14.1	1
8	1/2"	1.10	250	5.25	8.92	8.30	8,300	149	18.1	9
		1.76	400	7.71	13.12	12.20	12,200	218	22.1	6
		2.86	650	11.76	20.00	18.60	18,600	333	24.1	9
		4.40	1,000	21.37	36.34	33.80	33,800	605	52.3	6
10	1"	5.28	1,200	19.35	32.90	30.60	30,600	548	24.1	20
		6.60	1,500	25.61	43.55	40.50	40,500	725	28.1	6
		10.56	2,400	41.73	70.97	66.00	66,000	1,182	34.2	20
		15.40	3,500	65.44	111.29	103.50	103,500	1,853	62.3	6
12	1-1/2"	17.60	4,000	67.02	113.97	106	106,000	1,898	20.1	25
		26.40	6,000	95	161.28	150	150,000	2,686	24.1	25
		35.20	8,000	151	256.98	239	239,000	4,279	60.3	2
		46.20	10,500	212	360.20	335	335,000	5,998	120.6	2
13	2"	28.60	6,500	102	174.19	162	162,000	2,901	20.1	40
		41.80	9,500	161	274.18	255	255,000	4,566	24.1	40
		55.00	12,500	202	343.00	319	319,000	5,712	40.2	6
		88.00	20,000	392	666.64	620	620,000	11,101	120.6	6

Notes:
1) Air flows for scfm and slpm are given at 14.7 psia and 70°F
2) Air flows for nm^3/h are given at 14.7 psia and 0°C
3) All meters have a 10:1 turndown

Table 1-2 Model MT 3810 Pressure Ratings

	316/316L Stainless Steel (psig at indicated temperature)						
Flange Rating*	-20°F to 100°F	200°F	300°F	400°F	500°F	600°F	617°F
150 lb.	275	240	215	195	170	140	134
300 lb.	720	620	560	515	480	450	448

	316L Stainless Steel (psig at indicated temperature)						
Threaded NPT	-20°F to 100°F	200°F	300°F	400°F	500°F	600°F	617°F
7 & 8	1500	1500	1400	1400	1300	1200	1200
10	1500	1500	1400	1400	1300	1200	1200
12	1500	1500	1400	1400	1300	1200	1200
13	1300	1300	1200	1200	1100	1000	1000

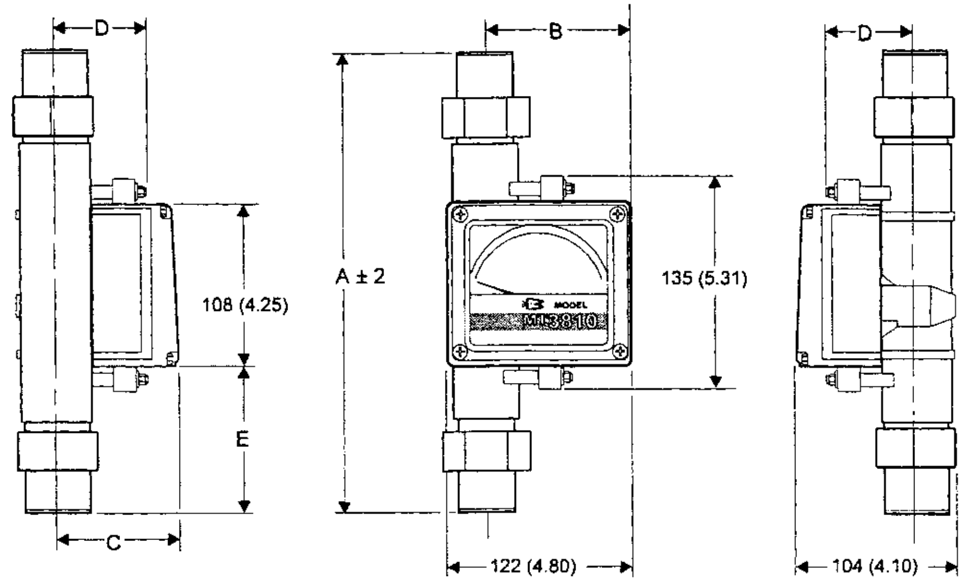
*Flanges are dual certified 316/316L Stainless Steel

Table 1-3 Maximum Fluid Temperature at 104°F (40°C) Ambient

Indicator Only	Microprocessor Transmitter with or without Alarms & Pulse Output	Inductive Limit Switch Alarms	Microprocessor Transmitter with Inductive Limit Switch Alarms
Standard	Standard	Standard	Standard
420°F (215°C)	195°F (90°C)	320°F (160°C)	195°F (90°C)

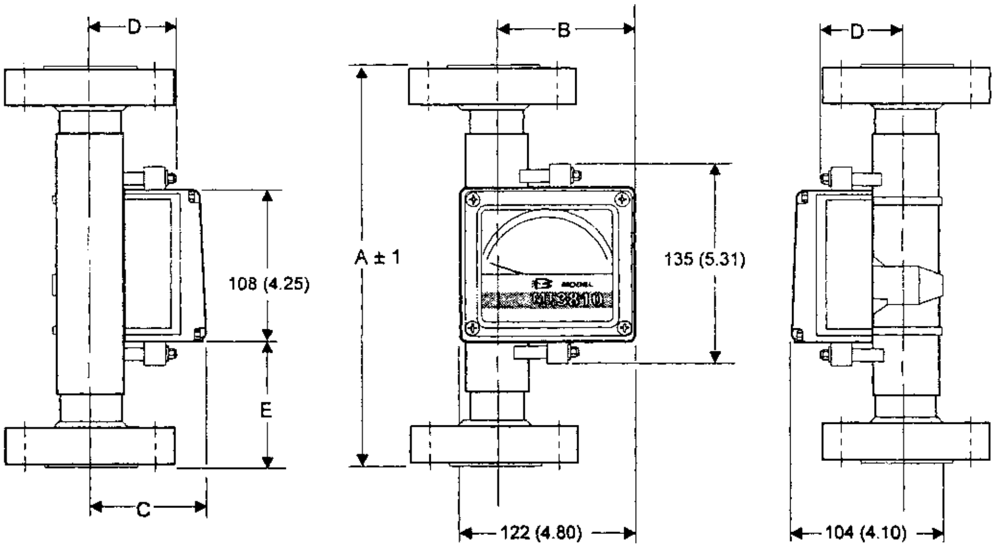
Figure 1-1. Model MT 3810 Meter Dimensions.

Model MT 3810 NPT-F Connection mm (inches)*



Meter Size	Connection	A	B	C	D	E	WEIGHT (Approx.)
7 & 8	1/2" NPT-F	225 (8.85)	88 (3.46)	72 (2.83)	53 (2.09)	59 (2.32)	1.3 kg (3 lbs.)
10	1" NPT-F	300 (11.81)	95 (3.78)	80 (3.15)	59 (2.32)	96 (3.78)	2.8 kg (7 lbs.)
12	1-1/2" NPT-F	300 (11.81)	105 (4.13)	89 (3.50)	65 (2.56)	96 (3.78)	5 kg. (12 lbs.)
13	2" NPT-F	300 (11.81)	111 (4.37)	95 (3.74)	77 (3.63)	96 (3.78)	6.3 kg (14 lbs.)

Model MT 3810 Flanged Connections mm (inches)*



Meter Size	Connection	A	B	C	D	E	WEIGHT (Approx.)
7 & 8	1/2" Flange	250 (9.84)	88 (3.46)	72 (2.83)	53 (2.09)	71 (2.78)	2.5 kg (6 lbs.)
10	1" Flange	250 (9.84)	96 (3.78)	80 (3.15)	59 (2.32)	71 (2.78)	4.2 kg (10 lbs.)
12	1-1/2" Flange	250 (9.84)	105 (4.13)	89 (3.50)	65 (2.56)	71 (2.78)	6.8 kg (15 lbs.)
13	2" Flange	250 (9.84)	111 (4.37)	95 (3.74)	77 (3.03)	71 (2.78)	8.7 kg (20 lbs.)

*Dimensions shown are for standard indicator units as well as units with the Smart Meter Manager transmitter or stand-alone inductive alarms.

Consult factory for dimensions of units with transmitters plus alarms or transmitters with inductive alarms.

1-5a Microprocessor Transmitter with or without Alarms and Pulse Output Based on Brooks Smart Meter Manager Technology

A. Design Features

- A 2-wire, loop-powered device for ease of wiring and installation
- 4-20 mA analog output for flowrate, with Bell-202 modulated HART communication channel
- User selectable 0% and 100% analog output ranges with optional smoothing
- Flexible (mix & match) units of measure for flowrates, totals, temperatures, densities, etc.
- Two flow totalizers: Resettable and inventory totalization
- User configurable, scalable pulse output for various engineering units
- Comprehensive alarms for both process flow and internal diagnostic checks
- Easily configured and compatible with other plant equipment
- Patented magnetic sensor which is resistant to external magnetic fields

B. Description

"Smart Inside" best defines the Brooks transmitter with optional alarms and pulse output for totalization. The transmitter (with or without the alarms and pulse output) is a compact microprocessor device designed to interface directly with the Model MT 3810 flowmeter. The microprocessor electronics are based on the Brooks Smart Meter Manager (SMM™) technology common to other Brooks flowmeters.

The transmitter is HART-programmable for numerous variables such as flow rate, totalization, calibration factors, and high-low alarm parameters. It is programmable with easy-to-use hand held configurators such as the Fisher- Rosemount™ HART 275 Communicator. Prior to shipment, commonly used default values are programmed by Brooks to ensure ease of operation and quick start-up. However, parameters may be reprogrammed by the user if needed. The 2-wire electronics system is easy to install and interface with other existing equipment such as process management systems or maintenance control packages.

In operation the microprocessor transmitter converts the measured process flow into a 4-20 mA output with HART protocol. The signal originates when the float magnet inside the metering tube passes a magnetic sensor mounted on the transmitter. Flow rate information may be viewed locally at the meter scale or displayed remotely (along with other flow data) as a function of external support systems through analog/pulse outputs or multiple digital communications.

In addition to transmitter features, this unit can also be ordered with optional alarms and pulse output provided by open collector switches. One or two alarms may be programmed prior to shipment of the unit or at the customer site with a hand held communicator.

C. Specifications - SMM Microprocessor Transmitter with or without Alarm and Pulse Output

⚠ WARNING

Do not operate this instrument in excess of the specifications listed below. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

Hazardous Location Classification (Approval pending)

UL/cUL listed - Intrinsically Safe
Division 1, Class I, II and III, Groups A, B, C, D, E, F, G for all enclosure options
Enclosure 4X

UL/cUL listed - Non-incendive for Division 2, Class I, II, III, Groups A, B, C, D, E, F, G for all enclosure options
Enclosure 4X

UL/cUL listed - Hazardous locations, Explosion Proof
Class I, Division 1, Groups C, D, Class II, Division 1, Groups E, F, G; Class III Enclosure 4X, for optional explosion proof housing

CENELEC approved - Intrinsically Safe
EEx ia IIC T4. Certified to EN50020 and EN50014, for all enclosure options. Ingress Protection IP 65 per IEC 529.

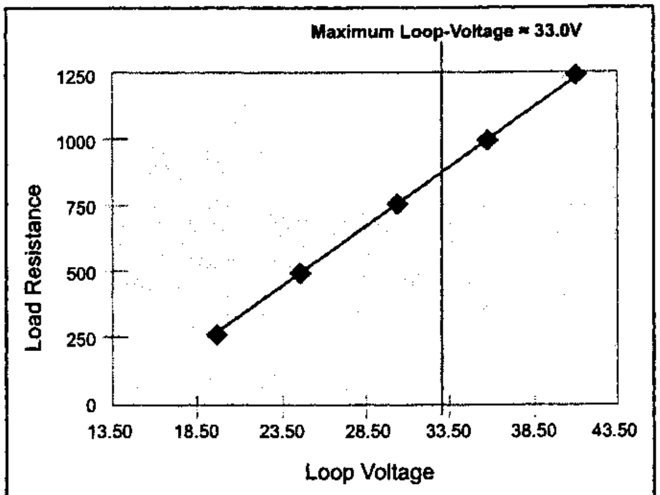
CENELEC approved - Flameproof
EEx d II B T4. Certified to EN50014 and EN50018, for explosion proof housing. Ingress Protection IP 65 per IEC 529.

Certified - CE Mark; EMC Directive 89/336/EEC

Power Supply and Maximum Load Resistance

21.0 to 33.0 Vdc Power Supply, refer to Figure 1-2.
Input Power: Derived from Analog Output (2-wire current loop transmitter).
For Intrinsically Safe applications, refer to entity parameters as shown in Figure 1-3.

Figure 1-2. Power Supply vs. Maximum Load Resistance.



Note: Load resistance should also include I.S. barrier resistance. When using Model 275 HART Communicator the minimum load resistance is 250 ohms.

Output Signals

Transmitter: 4-20 mA analog output with HART
Update Rate: 4 times per sec.
Range: 3.8 to 22.0 mA

Two Alarm Outputs (open collector)
Optically isolated outputs assignable to alarms, reverse flow indicator, or manual valve.
Maximum off-state voltage: 30 Vdc
Maximum off-state current: 0.05 mA
Maximum on-state voltage: 1.2 Vdc
Maximum on-state current: 20 mA

One Pulse Output (open collector)
Optically isolated. Scalable to a variety of engineering unit systems (pulses per liter, gallons, etc.)
Range: 1 Hz to 1 kHz
Maximum off-state voltage: 30 Vdc
Maximum off-state current: 0.05 mA
Maximum on-state voltage: 1.2 Vdc
Maximum on-state current: 20 mA

Ambient Temperature Limit
-20°F to 104°F (-29°C to 40°C)
For conditions outside of range consult factory.

Maximum Operating Temperature
Refer to Table 1-3

Linearity
Less than 1% at maximum current

Temperature Influence
Less than 0.04% per °C

Voltage Influence
Less than 0.002%/Vdc

Load Resistance Influence
± 0.1% full scale

Transmitter, Alarm and Pulse Output Wiring Diagrams
Refer to Figures 1-3, 1-4, 1-5 and 1-8.

For Division 1 explosion proof installations, the optional explosion proof enclosure must be used. This enclosure does not use the auxiliary terminal box, as shown on some of the installation diagrams. All connections are made directly within the housing.

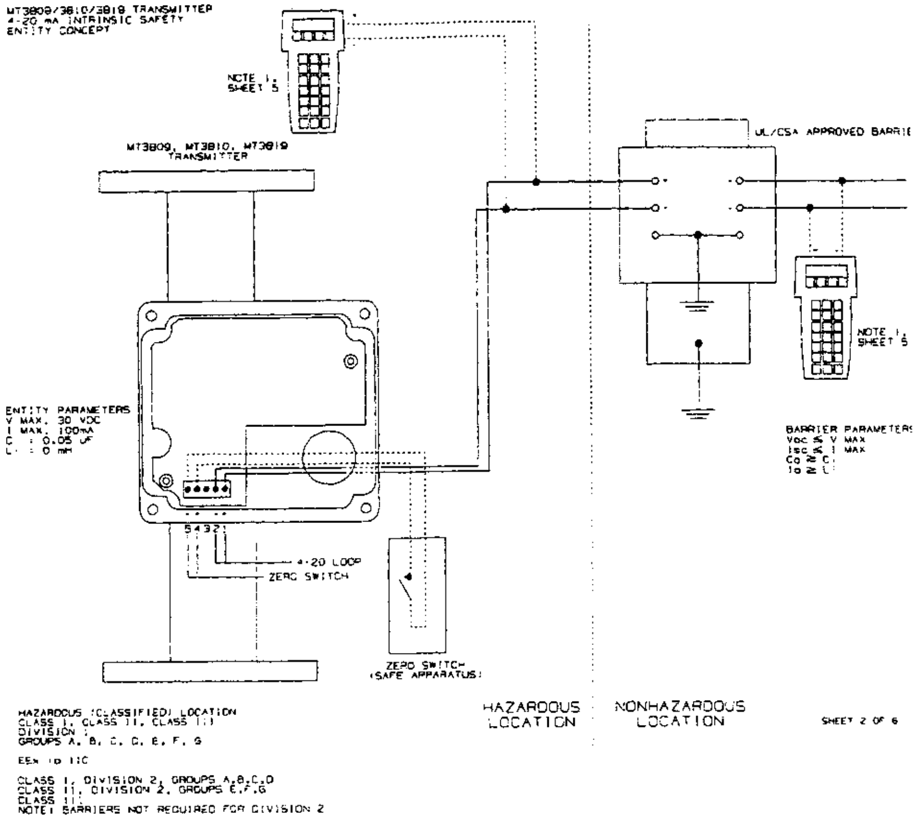
For Division 2 non-incendive installations, either the standard enclosure or the explosion proof enclosure may be used.

For both Division 1 explosion proof and Division 2 non-incendive installations, the barriers shown in the installation drawings are unnecessary.

Wiring must be done in accordance with the applicable electrical codes, i.e., NEC Chapter 5 and CEC Section 18 and any local codes.

D. Transmitter Accessories
General purpose and intrinsically safe HART compatible power supplies are available in 120V and 240V.

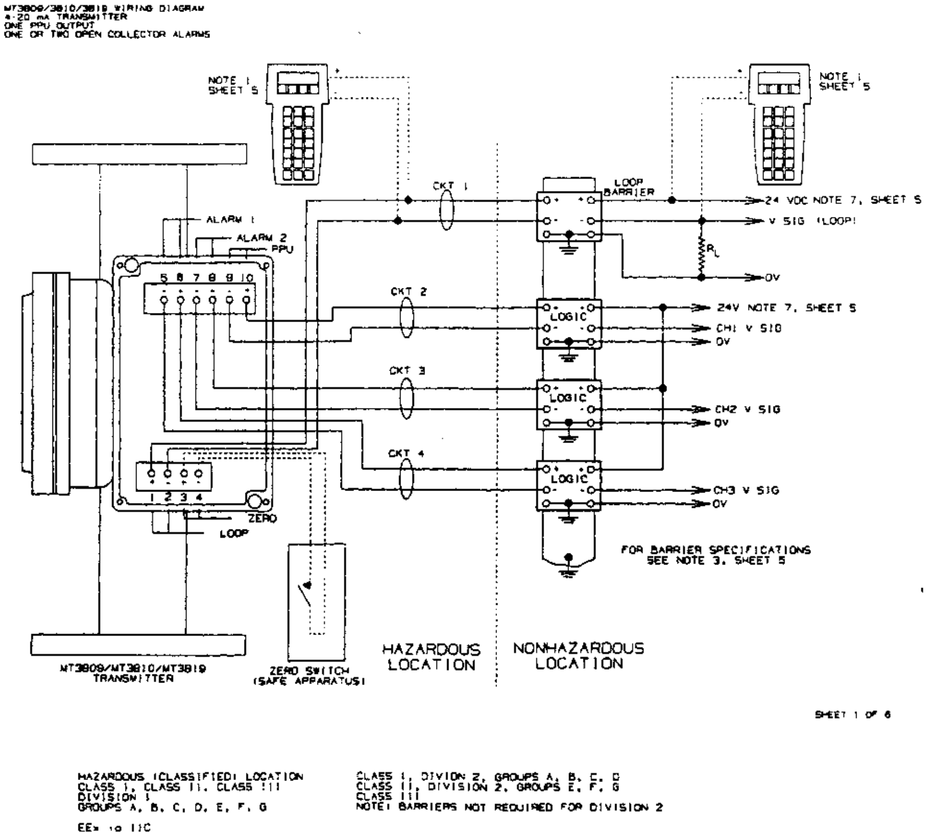
Figure 1-3. Transmitter Only Wiring Diagram.



Refer to Figure 1-8 for Wiring Diagram Notes

Ref. No. LR-981-Y-001 / 2

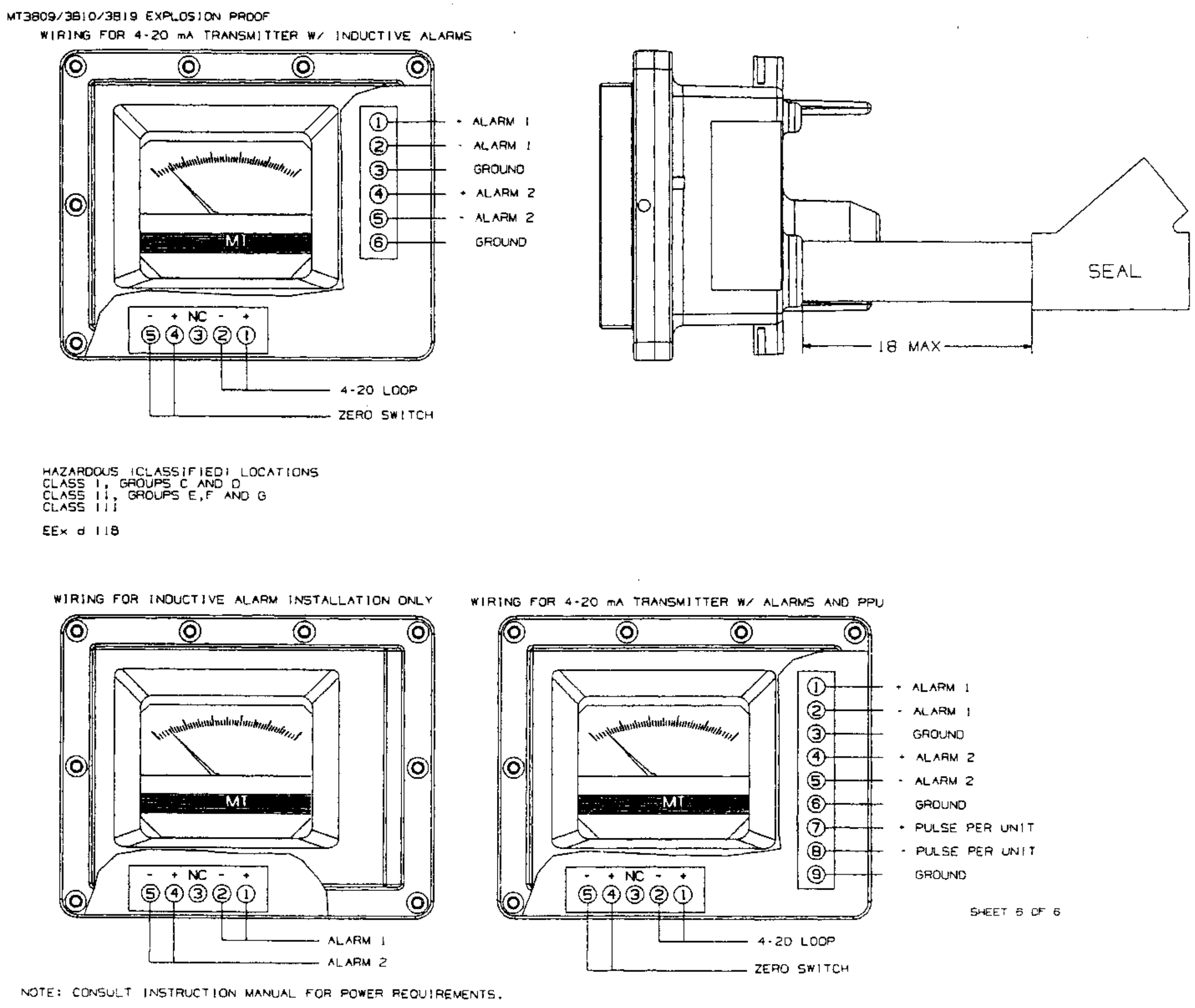
Figure 1-4. Transmitter with Alarm and Pulse Outputs Wiring Diagram.



Refer to Figure 1-8 for Wiring Diagram Notes

Ref. No. LR-981-Y-001 / 1

Figure 1-5. Model MT 3810 Explosion-proof Housing Wiring Diagram.



CONDUIT INSTALLATION: THE EXPLOSIONPROOF MT3809 INDICATOR HOUSING HAS ONE 3/4" NPT CONDUIT CONNECTION. THESE CONNECTIONS ARE MADE IN A CONVENTIONAL MANNER IN ACCORDANCE WITH LOCAL OR PLANT ELECTRIACAL CODES.

ALL CONDUIT THREADS MUST BE ASSEMBLED WITH A MINIMUM OF FIVE FULL THREADS ENGAGED. INSTALL PER NATIONAL ELECTRICAL CODE (NEC) AND CANADIAN ELECTRICAL CODE (CEC) FOR GROUPS C AND D. SEAL ALL CONDUITS WITHIN 18 INCHES OF THE ENCLOSURE.

NOTE: IN SOME APPLICATIONS IT MAY BE NECESSARY TO INSTALL CONDUIT SEALS AND ARRANGE FOR CONDUITS TO DRAIN TO PREVENT MOISTURE FROM ENTERING THE INDICATIOR HOUSING.

HAZARDOUS LOCATIONS INSTALLATIONS

WARNING: EXPLOSIONS CAN CAUSE DEATH OR SERIOUS INJURY. VERIFY THAT THE OPERATING ATMOSPHERE OF THE INSTRUMENT TYPE IS CONSISTENT WITH THE APPROPRIATE HAZARDOUS LOCATIONS CERTIFICATIONS.

WARNING: EXPLOSIONS MAY RESULT IN DEATH OR SERIOUS INJURY. THE INDICATOR COVER MUST BE FULLY SECURED TO THE INDICATOR HOUSING TO MEET EXPLOSIONPROOF REQUIRMENTS.

WARNING: EXPLOSION HAZARD-SUBSTITUTION OF COMPONENTS MAY INPAIR SUITABILITY FOR HAZARDOUS (CLASSIFIED) LOCATIONS. AVERTISSEMENT: RISQUE D'EXPLOSION-LA SUBSTITUTION DE COMPOSANTS PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS DE CLASSE I, CLASSE II.

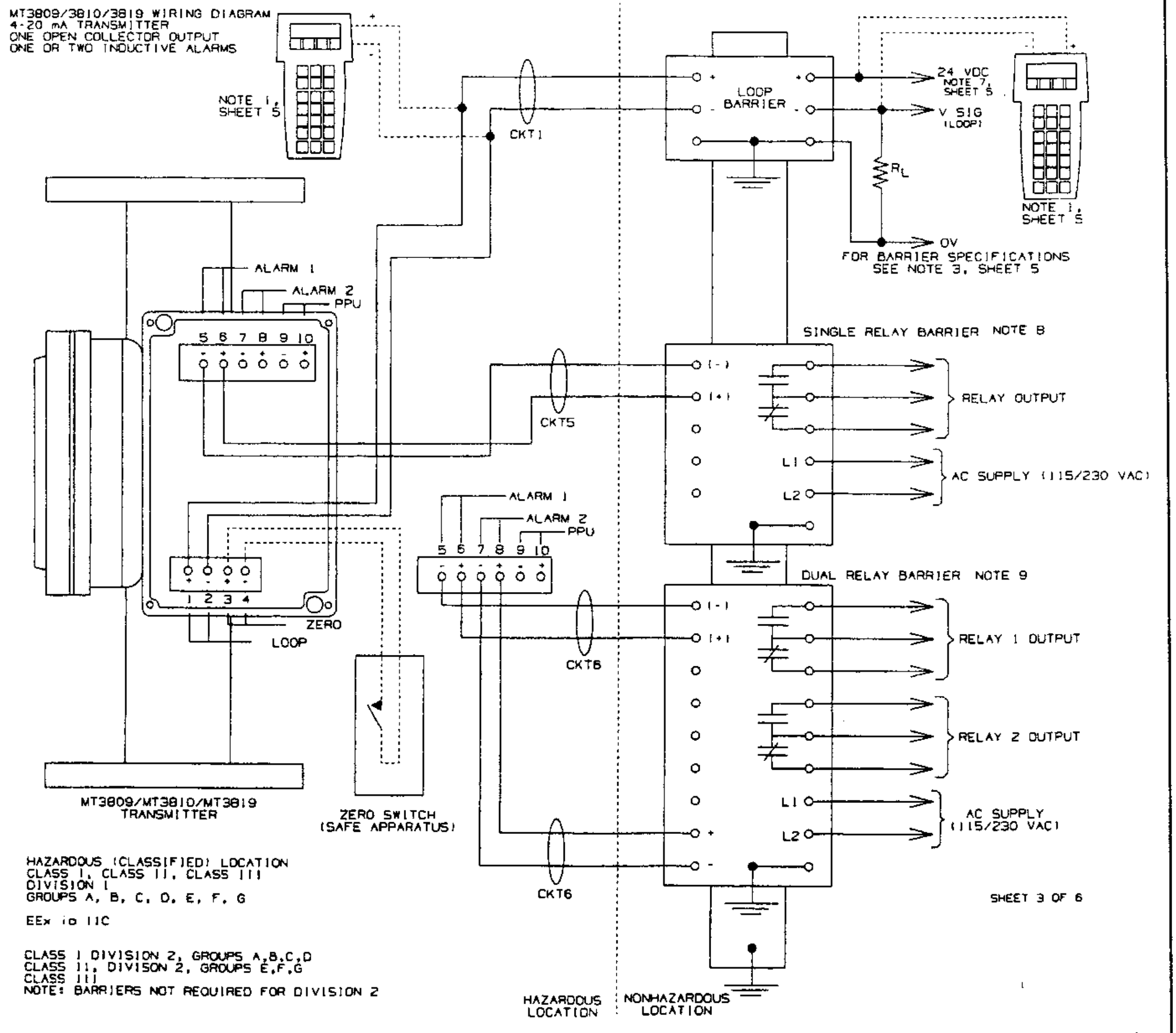
Ref. No. LR-981-Y-001 / 6

1-5b Microprocessor Transmitter with Inductive Alarms

This combined system provides both the sophistication of the microprocessor along with the simplicity of one or two switch inductive alarms. Specifications for the transmitter are as stated previously and specifications for the front adjustable inductive alarms are as follows.

Wiring Diagrams
Refer to Figures 1-6 and 1-8

Figure 1-6. Transmitter with Inductive Alarm Wiring Diagram.



Refer to Figure 1- 8 for Wiring Diagram Notes

Ref. No. LR-981-Y-001 / 3

1-5c Inductive Alarm Switches

A. Design Features

- 1 or 2 normally open inductive limit switches
- Optional intrinsically safe power supply/amplifier/relay unit
- For low or high limit signaling/switching
- Front adjustable

B. Description

One or 2 electronic limit switches can be installed in the indicator housing to allow initiation of signaling or switching functions on a preset flow value. The limit switch operates as a slot initiator that is inductively actuated by a disc mounted on the pointer shaft. Any flow value can be used for setting the limit value by sliding the initiator along the indicator scale. Minimum setting distance between two limit switches is approximately 40% full scale. The position of the initiator also serves to visually indicate the set value. Settings can be adjusted by removing the indicator cover, loosening, moving and retightening of the alarm indication needle, and replacement of the indicator cover.

C. Specifications - Inductive Alarm Switches

⚠WARNING

Do not operate this instrument in excess of the specifications listed below. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

Hazardous Location Classification (Approval pending)

UL/cUL listed - Intrinsically Safe
Division 1, Class I, II and III, Groups A, B, C, D, E, F, G for all enclosure options
Enclosure 4X

UL/cUL listed - Non-incendive for Division 2, Class I, II, III, Groups A, B, C, D, E, F, G for all enclosure options
Enclosure 4X

UL/cUL listed - Hazardous locations, Explosion Proof
Class I, Division 1, Groups C, D, Class II, Division 1, Groups E, F, G; Class III Enclosure 4X, for optional explosion proof housing

CENELEC approved - Intrinsically Safe
EEx ia IIC T4. Certified to EN50020 and EN50014, for all enclosure options. Ingress Protection IP 65 per IEC 529.

CENELEC approved - Flameproof
EEx d II B T4. Certified to EN50014 and EN50018, for explosion proof housing. Ingress Protection IP 65 per IEC 529.

Certified - CE Mark; EMC Directive 89/336/EEC

Power Supply

5-25 Vdc; For Intrinsically Safe applications, refer to Figure 1-6.

Impedance

Approximately 1 kohm with cam absent
Approximately 8 kohm with cam present

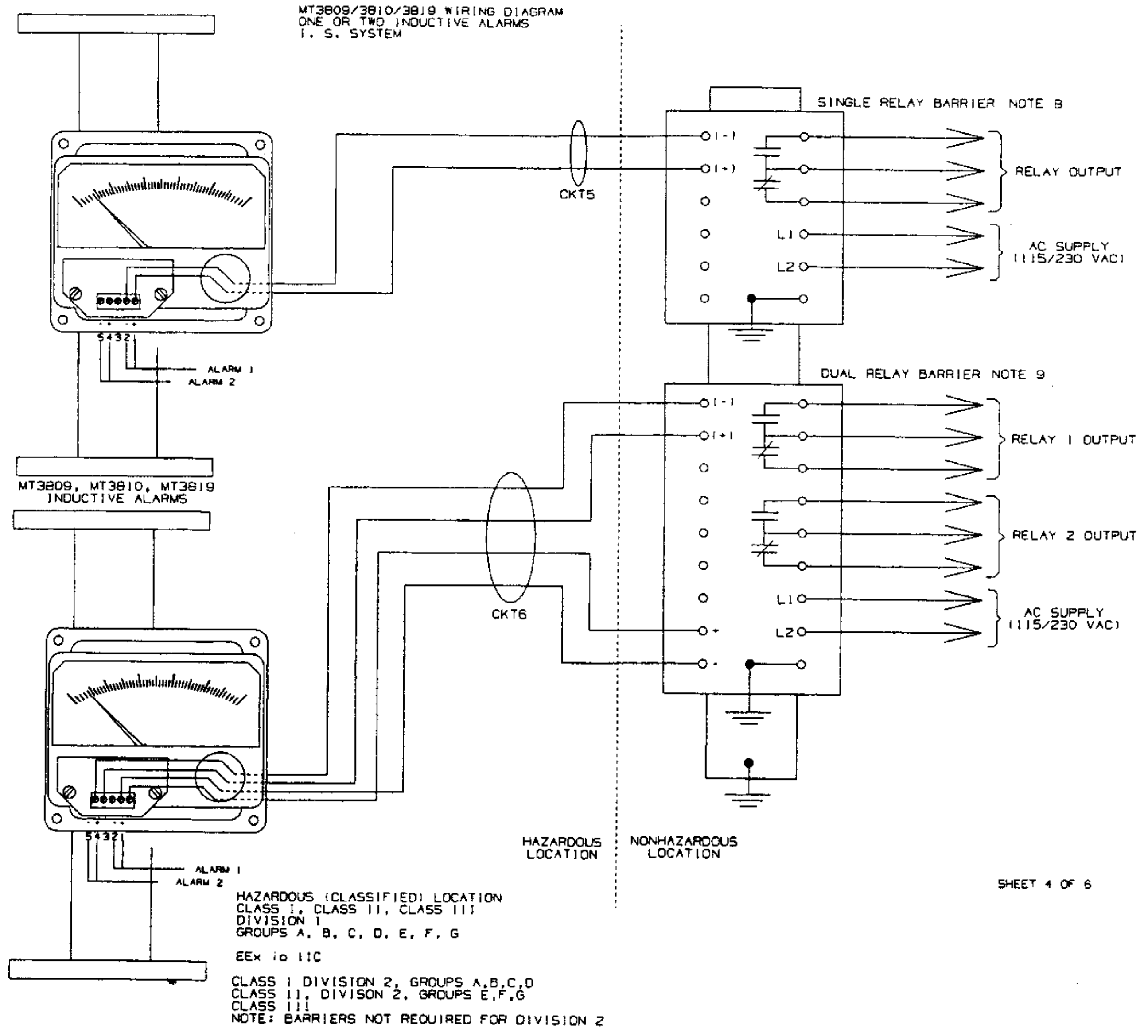
Ambient Operating Temperature
-20°F to 104°F (-29°C to 40°C)
For conditions outside range consult factory.

Maximum Operating Temperature
Refer to Table 1-3

Alarm Wiring Diagrams
Refer to Figures 1-7 and 1-8

Alarm Accessories
Amplifier Power Supply (approved isolated barrier) 1 or 2 channel approved for intrinsically safe application, remotely mounted, 115 or 230 Vac power. Single pole with double throw (SPDT) relay standard. For other configurations, consult factory.

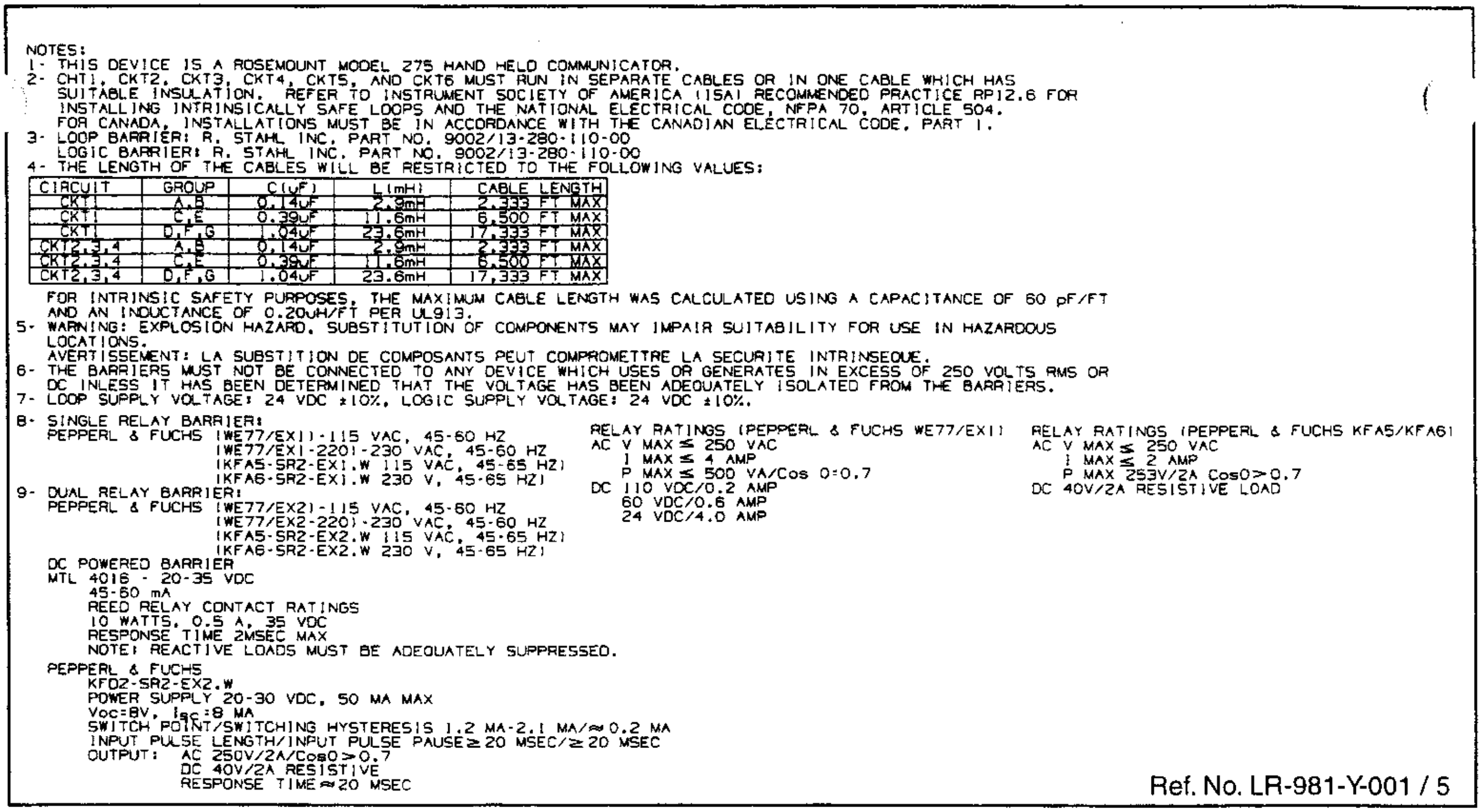
Figure 1-7. Inductive Alarms Only Wiring Diagram.



Refer to Figure 1-8 for Wiring Diagram Notes

Ref. No. LR-981-Y-001 / 4

Figure 1-8. Wiring Diagram Notes.



NOTES:

1- THIS DEVICE IS A ROSEMOUNT MODEL 275 HAND HELD COMMUNICATOR.

2- CHT1, CKT2, CKT3, CKT4, CKT5, AND CKT6 MUST RUN IN SEPARATE CABLES OR IN ONE CABLE WHICH HAS SUITABLE INSULATION. REFER TO INSTRUMENT SOCIETY OF AMERICA (ISA) RECOMMENDED PRACTICE RP12.6 FOR INSTALLING INTRINSICALLY SAFE LOOPS AND THE NATIONAL ELECTRICAL CODE, NFPA 70, ARTICLE 504. FOR CANADA, INSTALLATIONS MUST BE IN ACCORDANCE WITH THE CANADIAN ELECTRICAL CODE, PART I.

3- LOOP BARRIER: R. STAHL INC. PART NO. 9002/13-280-110-00
LOGIC BARRIER: R. STAHL INC. PART NO. 9002/13-280-110-00

4- THE LENGTH OF THE CABLES WILL BE RESTRICTED TO THE FOLLOWING VALUES:

CIRCUIT	GROUP	C(uF)	L(mH)	CABLE LENGTH
CKT1	A,B	0.14uF	2.9mH	2,333 FT MAX
CKT1	C,E	0.39uF	11.6mH	6,500 FT MAX
CKT1	D,F,G	1.04uF	23.6mH	17,333 FT MAX
CKT2,3,4	A,B	0.14uF	2.9mH	2,333 FT MAX
CKT2,3,4	C,E	0.39uF	11.6mH	6,500 FT MAX
CKT2,3,4	D,F,G	1.04uF	23.6mH	17,333 FT MAX

FOR INTRINSIC SAFETY PURPOSES, THE MAXIMUM CABLE LENGTH WAS CALCULATED USING A CAPACITANCE OF 60 pF/FT AND AN INDUCTANCE OF 0.20uH/FT PER UL913.

5- WARNING: EXPLOSION HAZARD. SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR USE IN HAZARDOUS LOCATIONS.
AVERTISSEMENT: LA SUBSTITION DE COMPOSANTS PEUT COMPROMETTRE LA SECURITE INTRINSEQUE.

6- THE BARRIERS MUST NOT BE CONNECTED TO ANY DEVICE WHICH USES OR GENERATES IN EXCESS OF 250 VOLTS RMS OR DC INLESS IT HAS BEEN DETERMINED THAT THE VOLTAGE HAS BEEN ADEQUATELY ISOLATED FROM THE BARRIERS.

7- LOOP SUPPLY VOLTAGE: 24 VDC ±10%, LOGIC SUPPLY VOLTAGE: 24 VDC ±10%.

8- SINGLE RELAY BARRIER:
PEPPERL & FUCHS (WE77/EX1)-115 VAC, 45-60 HZ
(WE77/EX1-220)-230 VAC, 45-60 HZ
(KFA5-SR2-EX1.W 115 VAC, 45-65 HZ)
(KFA6-SR2-EX1.W 230 V, 45-65 HZ)

9- DUAL RELAY BARRIER:
PEPPERL & FUCHS (WE77/EX2)-115 VAC, 45-60 HZ
(WE77/EX2-220)-230 VAC, 45-60 HZ
(KFA5-SR2-EX2.W 115 VAC, 45-65 HZ)
(KFA6-SR2-EX2.W 230 V, 45-65 HZ)

RELAY RATINGS (PEPPERL & FUCHS WE77/EX1)
AC V MAX ≤ 250 VAC
I MAX ≤ 4 AMP
P MAX ≤ 500 VA/Cos 0=0.7
DC 110 VDC/0.2 AMP
60 VDC/0.6 AMP
24 VDC/4.0 AMP

RELAY RATINGS (PEPPERL & FUCHS KFA5/KFA6)
AC V MAX ≤ 250 VAC
I MAX ≤ 2 AMP
P MAX 253V/2A Cos0>0.7
DC 40V/2A RESISTIVE LOAD

DC POWERED BARRIER
MTL 4016 - 20-35 VDC
45-60 mA
REED RELAY CONTACT RATINGS
10 WATTS, 0.5 A, 35 VDC
RESPONSE TIME 2MSEC MAX
NOTE: REACTIVE LOADS MUST BE ADEQUATELY SUPPRESSED.

PEPPERL & FUCHS
KFD2-SR2-EX2.W
POWER SUPPLY 20-30 VDC, 50 MA MAX
Voc=8V, I_{sc}:8 MA
SWITCH POINT/SWITCHING HYSTERESIS 1.2 MA-2.1 MA/≈0.2 MA
INPUT PULSE LENGTH/INPUT PULSE PAUSE≥20 MSEC/≥20 MSEC
OUTPUT: AC 250V/2A/Cos0>0.7
DC 40V/2A RESISTIVE
RESPONSE TIME≈20 MSEC

Ref. No. LR-981-Y-001 / 5

2-1 Receipt of Equipment

When the equipment is received, the outside of the packing case should be checked for any damage incurred during shipment. If the packing case is damaged, the local carrier should be notified at once concerning his liability.

2-2 Recommended Storage Practices

If intermediate or long-term storage is required for equipment, as supplied by Brooks Instrument, it is recommended that the equipment be stored in accordance with the following:

a. Within the original shipping container.
b. Stored in a sheltered area, preferably a warm, dry, heated warehouse.
c. Ambient temperature of 70°F (21°C) nominal, 110°F (43°C) maximum, 45°F (7°C) minimum.
d. Relative humidity 45% nominal, 60% maximum, 25% minimum.

Upon removal from storage, a visual inspection should be conducted to verify the condition of equipment is "as received".

2-3 Return Shipment

In the event that the flowmeter or electronics accessory is damaged during shipment, the Customer Service Dept., Brooks Instrument, 407 W. Vine St., Hatfield, PA 19440, should be contacted to obtain a return shipment form.

2-4 Installation of Flowmeter

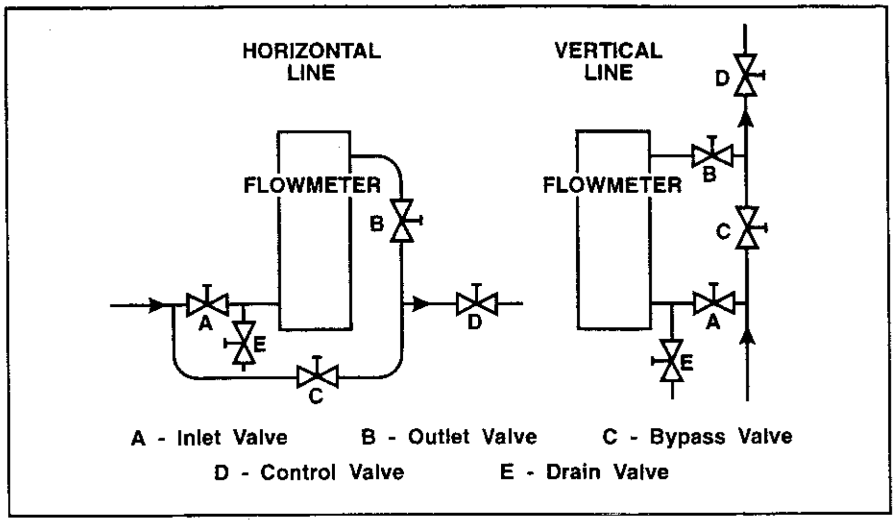
⚠ WARNING

If the inlet and outlet valves adjacent to the indicator are to be closed for any reason, the indicator must be completely drained. Failure to do so may result in thermal expansion of the liquid which can rupture the meter and cause possible personal injury.

Recommended installation for Model MT 3810 is as follows:

a. Carefully remove the covers from each end of the flowmeter.
b. Install the flowmeter with the inlet at the bottom and the outlet at the top.
c. When installing the flowmeter in the process line, follow accepted plumbing practices for flanged or NPT fittings.
d. Install the flowmeter within 5° of true vertical. Use of a level is recommended to determine the proper alignment.
e. Installation of a bypass piping arrangement is recommended, Figure 2-1. Bypass piping permits the meter to be isolated from the flow line for servicing and cleaning. (For more details refer to Brooks T-023 Technical Bulletin Guide for By-Pass Meter).

Figure 2-1. Typical Bypass Installation.

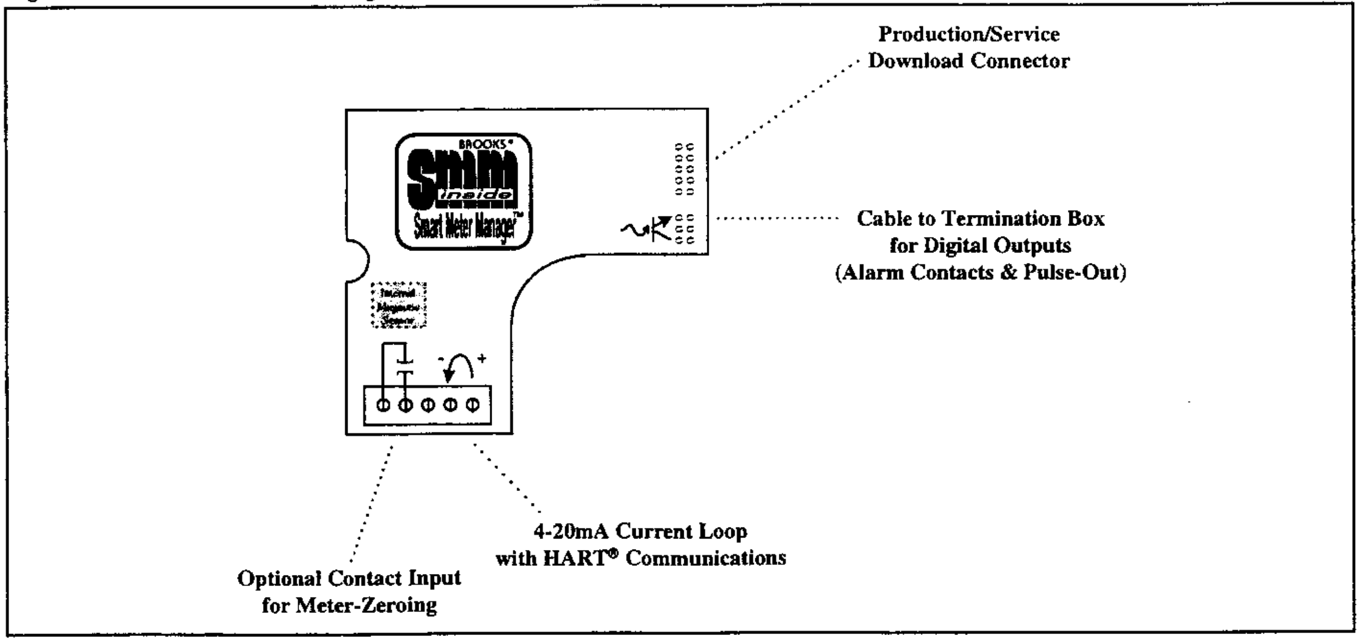


2-5 Installation of the Model MT 3810 Flowmeter with a Smart Meter Manager Transmitter with or without Optional Alarms and Pulse Output

a. Install the meter as described in Section 2-4.

b. Transmitter setup is done solely through proper system wiring and parameter configuration. Common transmitter parameters are set by Brooks prior to shipment. These parameters, such as flow rate, are set based on order information, meter configuration or defaults inherent to the transmitter. If requested when ordering the electronics, all parameters will be set prior to receiving the unit and no further configuration will be needed at installation. However, more detailed configurations as well as on-line monitoring can be done through standard HART communication protocol, or can be set using a Fisher-Rosemount™ Model 275 Hand-held communicator. See Operations Section 3 for manual programming details.

Figure 2-2. Smart Meter Manager Electrical Configuration.



With a HART protocol compatible transmitter, the digital communication signals are superimposed on top of the 4-20 mA signal. Communication of more than just the process variables is possible. Plants utilizing HART compatible transmitters can increase productivity by reducing trips to the field, gather data needed to reduce process downtime, proactively perform maintenance rather than reactively, and transport data to the field and back to the shop. Also, with the Fisher-Rosemount Asset Management Solutions™ software (AMS), information may be moved from the Model 275 communicator to your personal computer.

The 2-wire, 4-20 mA analog output provides real-time information on process flow rate. The 1200 baud, HART communication data is overlaid and transmitted on the 4-20 mA signal. Refer to Figure 2-2 for SMM electrical configuration. The float is constructed with an integral magnet that activates a magnetic sensor that is part of the transmitter. This same float magnet also drives the mechanical pointer.
The flow rate is scalable by setting independent high and low range parameters. The Analog Output (AO) transmitter parameters, AO Hi-Range and AO Lo-Range span the 4-20 mA signal. For example, if flow rate is normally between 100 and 500 gpm, the AO Hi-Range parameter is set at 500 and the AO Lo-Range is set at 100. Like other common parameters, the AO Hi-Range and AO Lo-Range can be set by Brooks prior to shipment.

c. Microprocessor Transmitter Wiring Connections
Refer to Figures 1-3, 1-4, 1-5 and 1-8 for detailed UL approved wiring hookup. Figures 2-3 through 2-6 are schematic drawings showing typical electronic hookups.

⚠ CAUTION

Since this is a magnetically activated device, strong magnetic fields and materials with magnetic properties may cause faulty operation when in close proximity to the flowmeter. This includes steel pipes, steel conduit, motors, and transformers.

Figure 2-3. Typical SMM Transmitter Analog Output and Power Wiring.

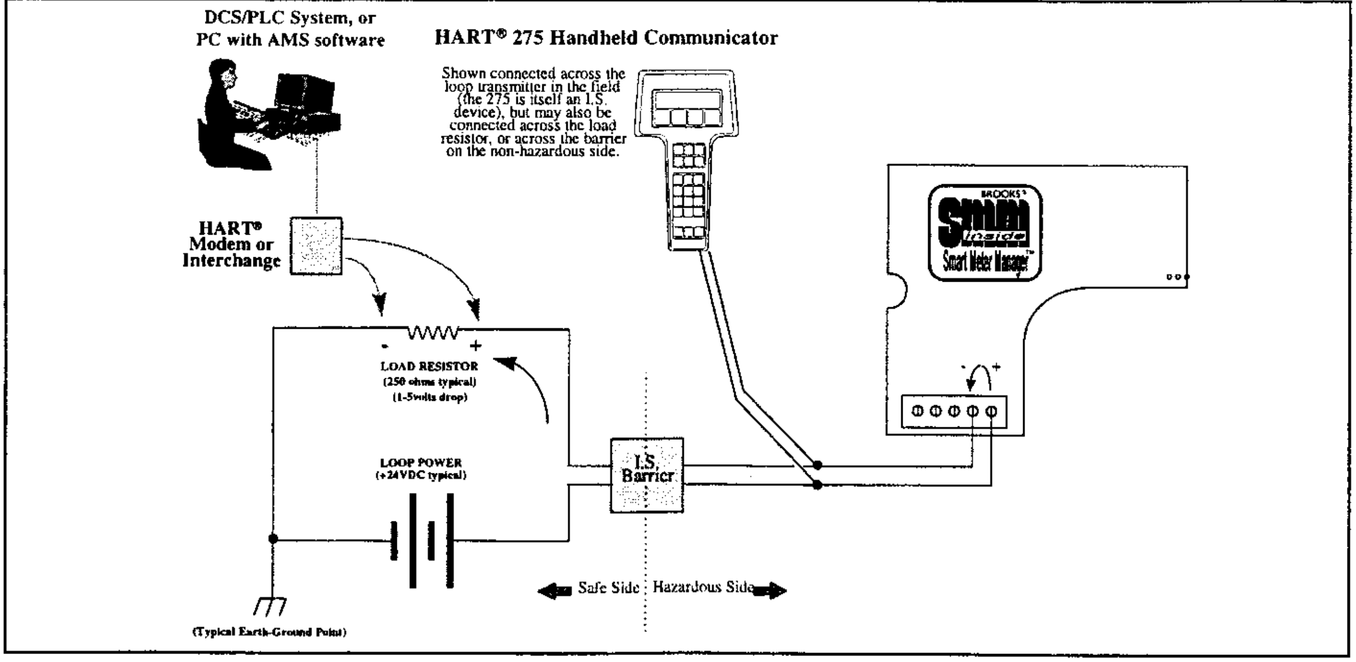


Figure 2-4. Alternate SMM Transmitter Analog Output and Power Wiring (Where 4-20 mA signal is not required).

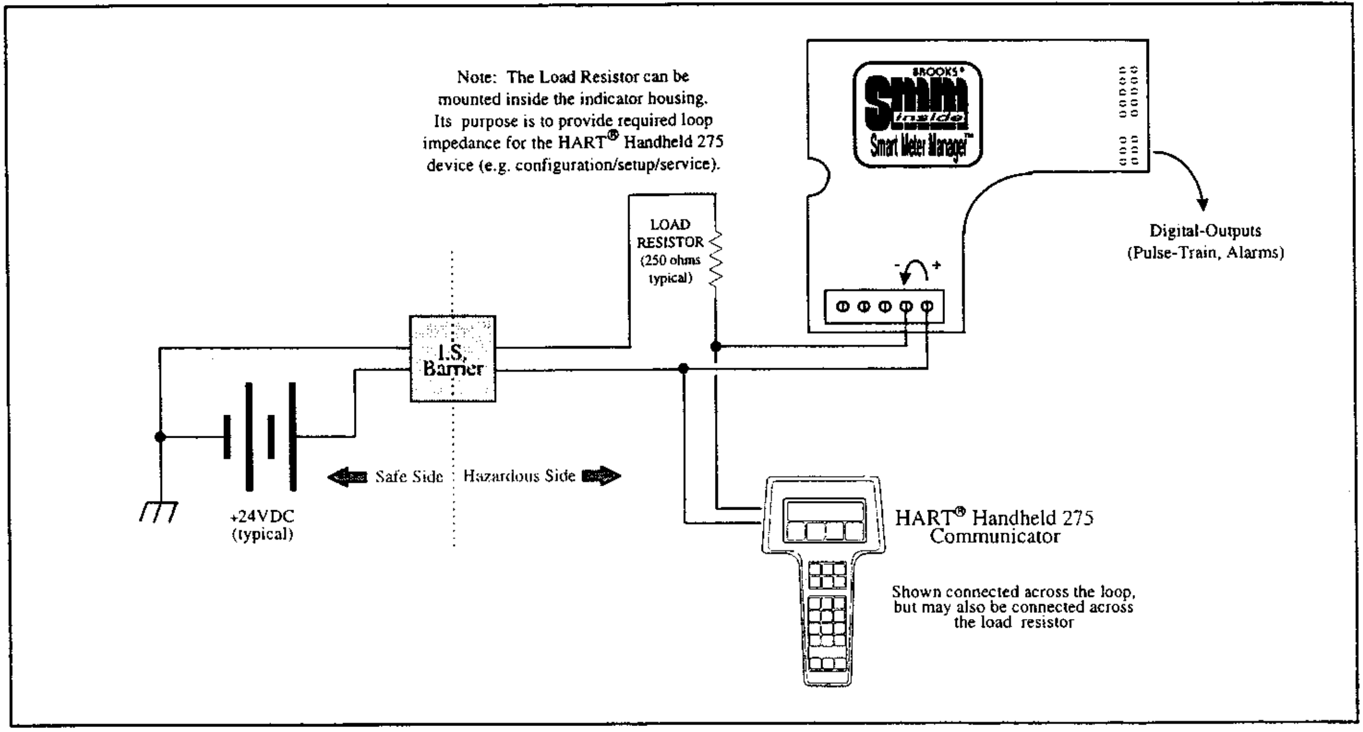
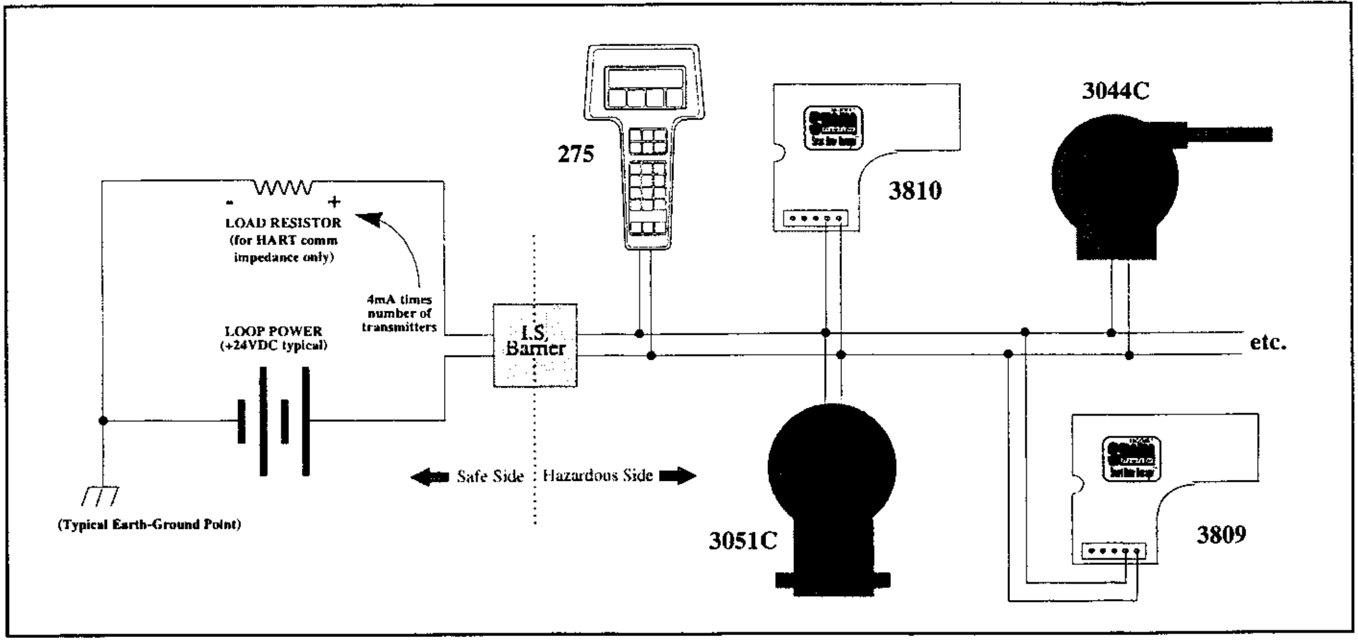


Figure 2-5. Multi-drop SMM Transmitter Analog Output and Power Wiring.



⚠ CAUTION

Flowmeters with a transmitter must be mounted at least 18 inches apart to prevent the interaction of adjacent float magnets and transmitter.

⚠ WARNING

To prevent ignition of hazardous atmospheres and serious personal injury, proper installation methods must be used as defined in Article 505 of the National Electrical Code, and the Canadian Electrical Code and ISA Standard 12.6.

Typically applications require only the use of the 2 wire loop analog signal. In some applications where transmitters and actuators are widely separated (e.g. tank farms), devices are wired in a multi-drop configuration to save wiring costs. Each unit is given an individual HART address in the range of 1-15 to distinguish each unit during communications over a common wire pair. In this configuration, the 4-20 mA output signal cannot be used.

To install the typical transmitter analog output configuration:

1. For intrinsically safe installation, intrinsic safety barrier selection, cable parameters, and power supply limits must be in accordance with the entity parameters shown in Figure 1-3. Alternatively, the optional intrinsically safe power supply available from Brooks may be used. Cable parameters for inductance and capacitance still apply.
2. If the area classification is Division 2, a barrier is not required and cable parameters are not applicable. The electrical code will require the use of conduit for wire protection. Refer to Figure 1-3.
3. If the installation is to be protected by Division 1 explosion proof methods, the optional explosion proof enclosure is required and explosion proof installation methods must be followed. Refer to Fig. 1-5.
4. It is highly recommended that shielded cable be used for hookup. The shield should be connected to chassis ground at the transmitter end and should be taped up and not connected at the receiver end. Insulation of the shield at the receiving end is especially important for intrinsically safe installations.
5. The maximum resistance of the loop resistor, the associated cable and the barrier is determined by the power supply voltage and is shown graphically in Figure 1-2.
6. After installation and powering of the loop, the transmitter must be zeroed, both electrically and mechanically. This operation will compensate for any stray magnetic effects in the vicinity of the transmitter. Flow must be verified to be zero when the zero function is momentarily activated.

   With the float at the zero flow position, set zero flow by either shorting the two pins together at the terminal block. If desired, a zero switch can be remotely mounted and wired to these terminals. The hazardous area classification will determine the wiring methods used for this switch.

   The pointer must also be adjusted to the reference line on the scale using the adjustment screw on the face of the pointer, next to the hub. The zero function may be activated as part of a periodical maintenance check.

7. Under actual flow conditions, verify that the transmitter output matches the mechanical pointer position. If a discrepancy is noted, the HART communications channel can be used to verify or adjust the transmitter settings. The Fisher-Rosemount Model 275 hand held communicator provides a simple means to accomplish this check anywhere in the loop. Refer to Figure 3-2 for connection instructions.

   Note: The Brooks SMM transmitter device description (DD) will not be programmed into the Fisher-Rosemount Model 275 hand-held communicators until after Summer 1997. Until the Brooks device description becomes standard to the Fisher-Rosemount Model 275 units, please contact Brooks Customer Service, Hatfield, PA, to provide programming for a nominal fee. After Summer 1997, we request that the customers update their Model 275 units through Fisher-Rosemount Service Centers located throughout the world.

d. Microprocessor Transmitter with Alarm and Pulse Output Wiring Connections

⚠ CAUTION

Since this is a magnetically activated device, strong magnetic fields and materials with magnetic properties may cause faulty operation when in close proximity to the flowmeter. This includes steel pipes, steel conduit, motors, and transformers.

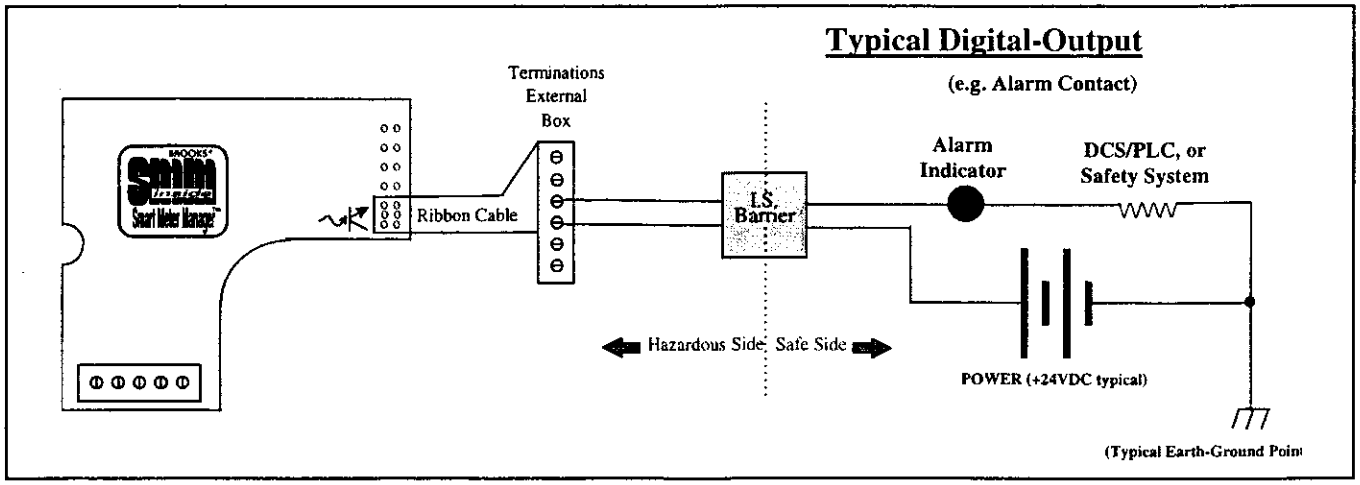
⚠ CAUTION

Flowmeters with a transmitter must be mounted at least 18 inches apart to prevent the interaction of adjacent float magnets and transmitter.

⚠ WARNING

To prevent ignition of hazardous atmospheres and serious personal injury, proper installation methods must be used as defined in Article 505 of the National Electrical Code, and the Canadian Electrical Code and ISA Standard 12.6.

Figure 2-6. Typical SMM Transmitter with Alarms and Pulse Digital Output and Power Wiring.



All internal parameters can be accessed over the HART communications channel, including the configuration of the output signals used for alarms and pulse output. An external termination box is attached for easy hookup of these signals. The alarms are configurable as normally open or normally closed.

The alarm contact and pulse output digital signals are electrically identical, independent, optically coupled transistor outputs. Wiring will be as required by the external driven system— Prover, DCS/PLC, terminal-automation system, batch controller etc. These can be wired as an open collector or open emitter signal on the high or low side of voltage-rail within the receiving equipment, depending upon the signal needs. When interfacing to external electronics, be careful to work within the voltage/current polarity and limits as specified in Section 1.

To install the typical transmitter alarms and/or pulse digital outputs configuration:

1. Intrinsically safe installations require the use of barriers, power supply limits and cable parameters as shown in the installation diagram. All connections are made in the terminal box attached to the back of the transmitter housing. Refer to Figures 1-4 and 1-8.
2. If the area classification is Division 2, a barriers are not required and cable parameters are not applicable. However, the electrical code will require the use of conduit for wire protection. Refer to Figures 1-4 and 1-8.
3. If the installation is to be protected by Division 1 explosion proof methods, the optional explosion proof enclosure is required and explosion proof installation methods must be followed. Refer to Figures 1-5 and 1-8.
4. It is highly recommended that shielded cable be used for hook up. The shield should be connected to chassis ground at the transmitter end and should be taped up and not connected at the receiver end. Insulation of the shield at the receiving end is especially important for intrinsically safe installations.
5. The maximum resistance of the loop resistor, the associated cable and the barrier is determined by the power supply voltage and is shown graphically in Figure 1-2.
6. The pulse and alarm outputs function as isolated switch closures (optically isolated open collector-emitter) and must be supplied with a power source, as shown in wiring diagram, Figure 1-4. Observe polarity and do not exceed 30 volts for the supply and limit load current to 20 mA for each output.
7. The zero function is activated by momentarily shorting the zero terminals on the wiring block. This may be accomplished with any conductive jumper or a switch which can be remotely mounted. The hazardous area classification will determine the wiring methods used for this switch.
8. After installation and powering of the loop, the transmitter must be zeroed, both electrically and mechanically. This operation will compensate for any stray magnetic effects in the vicinity of the transmitter. Flow must be zero and when the zero function is momentarily activated. The pointer must also be adjusted to the reference line on the scale using the adjustment screw on the face of the pointer, next to the hub. The zero function may be activated as part of a periodical maintenance check.

9. Under actual flow conditions, verify that the transmitter output matches the mechanical pointer position and that the alarms and pulse outputs are working properly. If a discrepancy is noted, the HART communications channel can be used to verify or adjust the transmitter settings. The Fisher-Rosemount Model 275 hand held communicator provides a simple means to accomplish this check anywhere in the loop. Refer to Figure 3-2 for connection instructions.

2-6 Installation of the MT 3810 Flowmeter with a Smart Meter Manager Transmitter with Inductive Alarms (1 or 2 switches)

a. Install the meter as described in Section 2-4.
b. Install the transmitter as described in Section 2-5.
c. Install the inductive alarms as indicated below Section 2-7.

2-7 Installation of the MT 3810 Flowmeter with Inductive Alarms (1 or 2 switches)

⚠ CAUTION

Since this is a magnetically activated device, strong magnetic fields and materials with magnetic properties may cause faulty operation when in close proximity to the flowmeter. This includes steel pipes, steel conduit, motors, and transformers.

⚠ CAUTION

Flowmeters with a transmitter must be mounted at least 18 inches apart to prevent the interaction of adjacent float magnets and transmitter.

⚠ WARNING

To prevent ignition of hazardous atmospheres and serious personal injury, proper installation methods must be used as defined in Article 505 of the National Electrical Code, and the Canadian Electrical Code and ISA Standard 12.6.

Install the meter as described in Section 2-4.

To install the inductive alarms (1 or 2 switches):

1. The inductive alarms can be supplied as a stand alone option or combined with the transmitter. When stand alone, connections to the alarms are made inside the indicator housing. When supplied in combination with the transmitter, connections are made inside the auxiliary terminal box attached to the indicator housing. Refer to Fig. 1-7 for stand alone inductive alarm installation and to Figures 1-6 and 1-8 for installation with the transmitter combined with the inductive alarms.
2. Intrinsically safe installations require the use of relay isolators for the alarms and a barrier for the transmitter, if equipped. Power supply limits and cable parameters must be as shown in the installation diagram.

3. If the area classification is Division 2, the transmitter barrier and cable parameters are not applicable. However for proper operation of the inductive alarms, the relay isolators must be used. The electrical code will require the use of conduit for wire protection.
4. If the installation is according to Division 1 explosion proof methods, the optional explosion proof enclosure is required and explosion proof installation methods must be followed. For proper operation of the inductive switches, the relay isolators must be used.
5. It is highly recommended that shielded cable be used for hook up. The shields should be connected to chassis ground at the transmitter/alarm end and should be taped up and not connected at the receiver end. The taping and insulation of the shields at the receiving end is especially important for intrinsically safe installations.
6. For the transmitter output, if supplied, the maximum resistance of the loop resistor, the associated cable and the barrier is determined by the power supply voltage and is shown graphically in Figure 1-2.
7. The relay isolator has built in power handling contacts. Refer to the specifications for these ratings.
8. If desired, the transmitter zero function can be remotely mounted using a momentary contact switch. Follow the same wiring practices as used for the other outputs.
9. After installation and powering of the loop, the transmitter must be zeroed, both electrically and mechanically. This operation will compensate for any stray magnetic effects in the vicinity of the transmitter. Flow must be zero when the zero function is activated, using the remote switch or shorting the zero terminals. The pointer must also be adjusted to the reference line on the scale using the adjustment screw on the face of the pointer, next to the hub. The zero function may be activated as part of a periodical maintenance check.
10. Under actual flow conditions, verify that the transmitter output matches the mechanical pointer position. If a discrepancy is noted with the transmitter, the HART communications channel can be used to verify or adjust the transmitter settings. The Fisher-Rosemount Model 275 hand held communicator provides a simple means to accomplish this check anywhere in the loop. Refer to Figure 3-2 for connection instructions.
11. Proper operation of the inductive alarms can be determined by manually rotating the mechanical pointer and observing the status lights on the relay isolator. The small alarm pointers indicate the alarm trip points. Changes to the set points can be made by loosening the pointer screws and repositioning the pointers.

Operation

Section 3

⚠ WARNING

Do not operate this instrument in excess of the specifications listed in Section 1-3. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

3-1 Pre-Start Check

At no flow condition the indicator pointer should align with the "0" mark on the scale. If necessary, adjust the pointer as per directions in the Maintenance Section 4-3.

3-2 Start-up and Operation of Flowmeter

a. Slowly initiate flow into the system. Open process valves slowly to avoid flow surges.

b. Check for leaks around the meter inlet and outlet connections. If no leaks are present, bring the system up to operating pressure.

3-3 Operation of the Model MT 3810 Flowmeter with a Smart Meter Manager Transmitter with or without Optional Alarms and Pulse Output for Totalization

a. Start-up the meter as described in Section 3-2.

b. Programming performed prior to shipment (parameters)
The SMM™ transmitter with or without alarms and pulse output is preprogrammed prior to shipment for the following parameters based on the order information, meter configuration and application. If parameters are not specified in the customer purchase order, the defaults inherent to the electronics will be as shown in (parenthesis).

Transmitter Only (uP)
Pre-Programmed Parameters

Model Number
Serial Number
Tag Name (blank)
Flow Rate units of measure (gpm)
Low Flow cutoff (10% FS flow)
Calibration factor (% scales only)
Analog Output LoRange
  (4 mA @ 0% flow)
Analog Output HiRange
  (20 mA @ 100% flow)

Transmitter (uP) Plus...
Alarms and Pulse Output
Preprogrammed Parameters

Alarm LoLimit (0% FS flow)
Alarm HiLimit (100% FS flow)
Pulse output units (1 ppg)
Resettable totalizer units of measure (gal.)
Inventory totalizer units of measurement (gal.)

c. Manual Programming or Reprogramming of the SMM electronics
If electronic parameters were not preprogramming prior to shipment or new settings are required, programming of the SMM transmitter with or without alarms and pulse output may also be done locally via a Fisher-Rosemount Model 275 hand held Communicator. Refer to Figures 3-1 and 3-2 for Device Description Basic Setup and Detailed Device Description Setup Trees.

Figure 3-1. Model MT 3810 SMM Electronics Device Description Tree (Basic Setup).

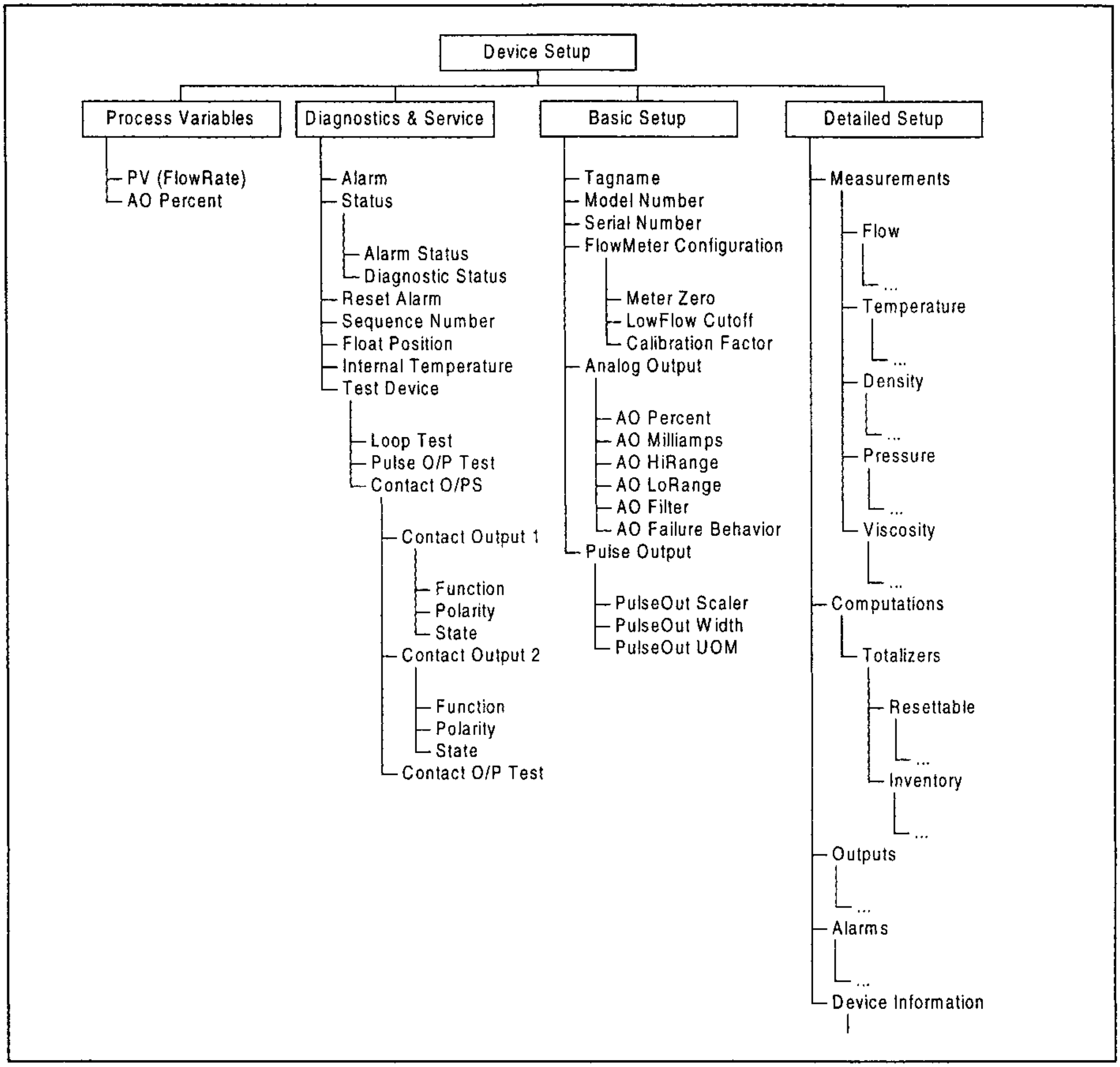
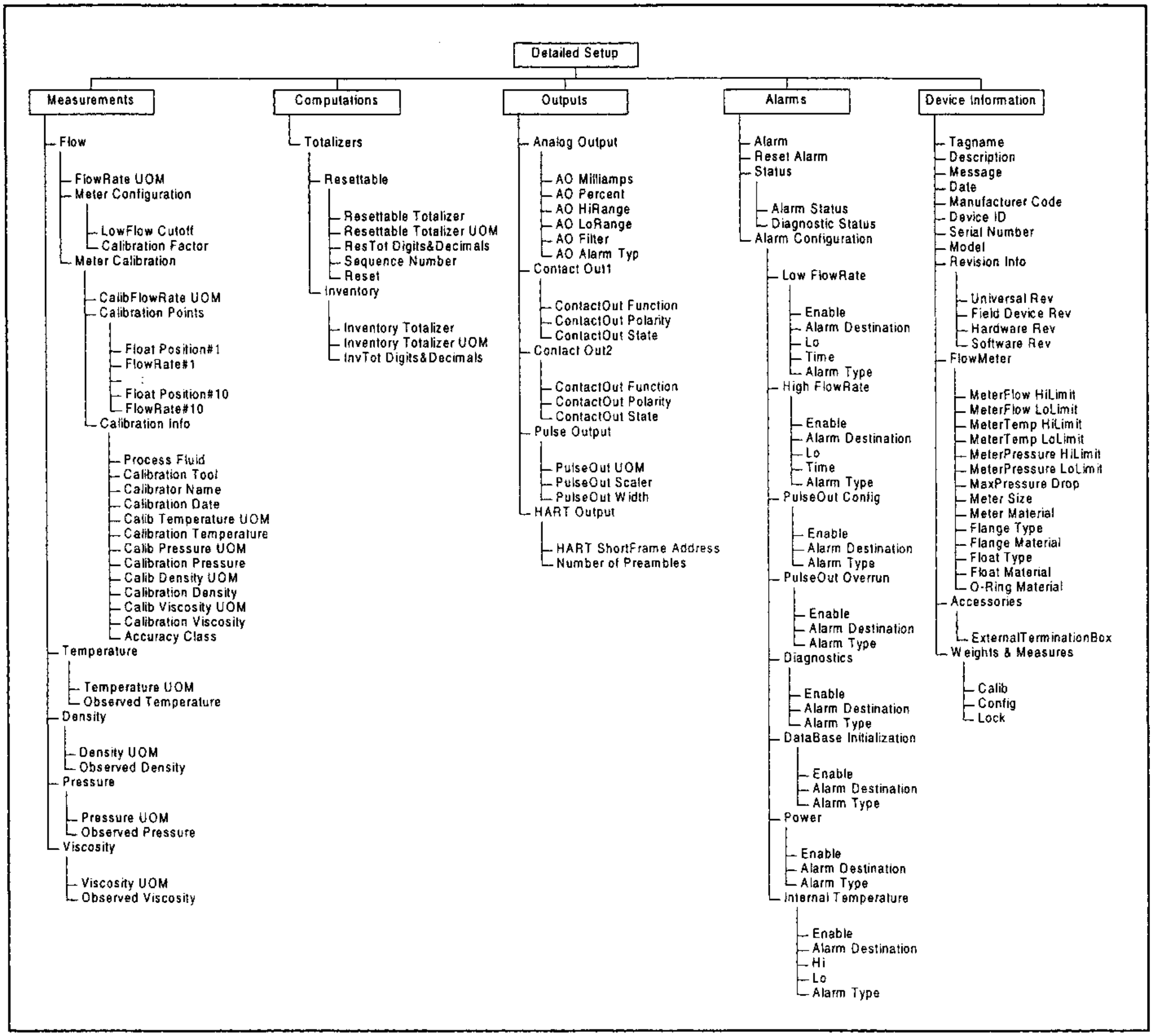
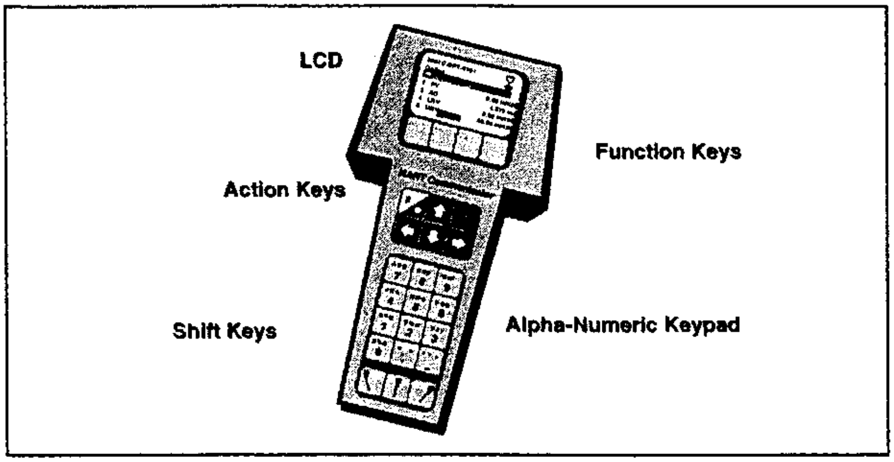


Figure 3-2. Model MT 3810 SMM Electronics Device Description Tree (Detailed Setup).



The HART Communicator is the hand-held interface that provides a common communication link to all HART compatible, microprocessor-based devices. A keypad, liquid crystal display (LCD) and software menu structure make up the HART communicator user interface. The Fisher-Rosemount Model 275 is easy to use. Just press a few buttons to become familiar with the Action Keys and menu structure.

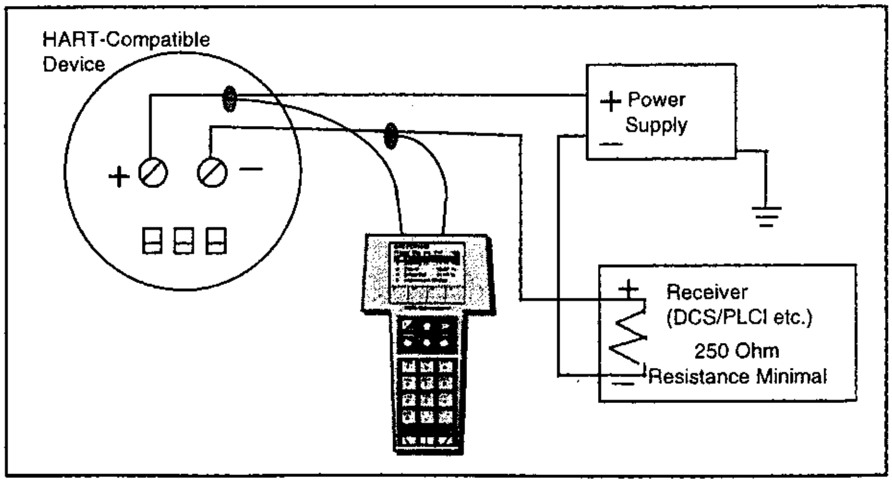
Figure 3-3. HART Communicator.



Typical Connection Fisher-Rosemount Model 275 Communicator Interface

The HART Communicator interfaces with any HART instrument from any wiring termination point in a 4-20 mA loop, provided a minimum load resistance of 250 ohms is present between the HART Communicator and power supply. A minimum load resistance of 250 ohms must be present between the HART Communicator and power supply in order for the HART Communicator to communicate with any HART compatible instrument. (An optional rugged 250 ohm resistor that attaches to the lead set is available from Fisher-Rosemount. The resistor must be installed in series, **not** in parallel.)

Figure 3-4. Typical HART Communicator Interface.

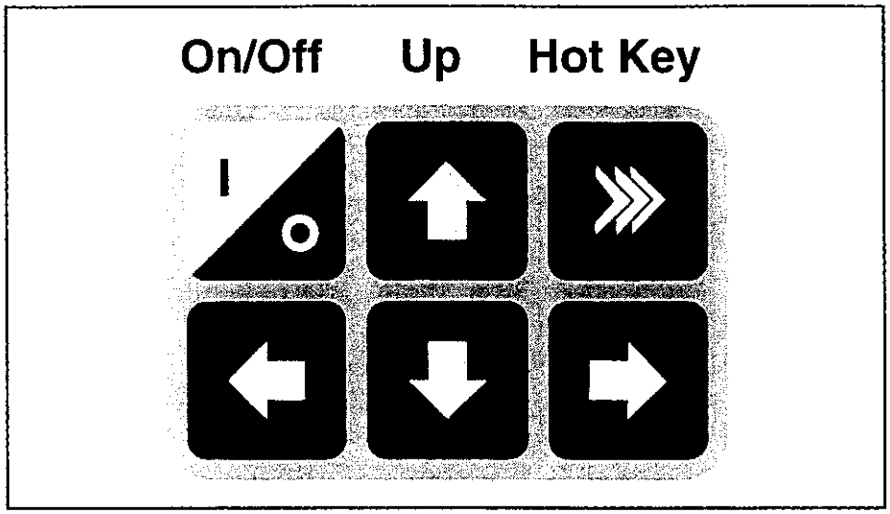


Fisher-Rosemount Model 275 Communicator Functions

Action Keys and Hot Key

Six Action Keys promote easy navigation through the menu structure. You may customize the Hot Key to quickly access a menu of your most frequently performed on-line tasks. The Hot Key Menu is a user-definable menu containing one permanent option, Range Values. Range Values provides quick access to rearrange capability. Up to 19 frequently performed tasks can also be added to this menu. These tasks are stored even when the communicator is off, and are always readily available by simply pressing the Hot Key.

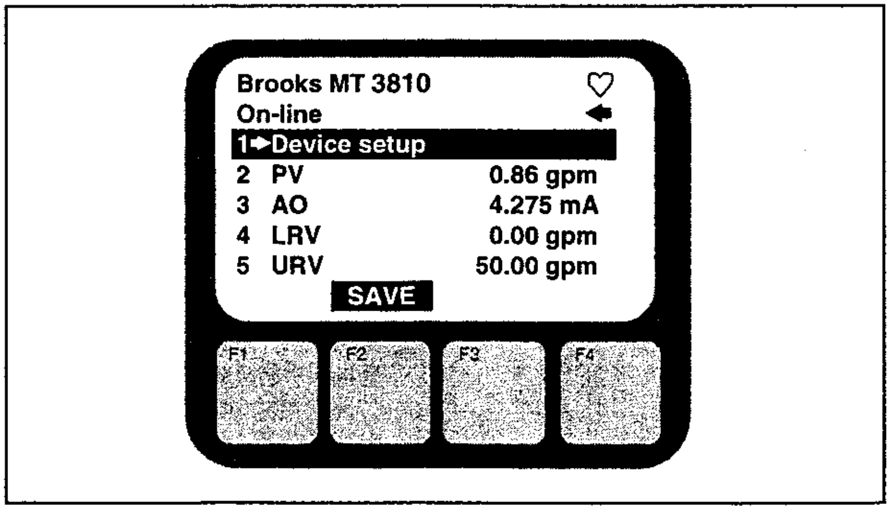
Figure 3-5. HART Communicator Action/Hot Keys.



LCD

The LCD is an eight-line by twenty-one character display that provides a window to all the functions of a HART compatible device. When connected to a HART compatible device, the top line of each menu displays the model name of the device and its tag. The bottom line of each menu is reserved for a dynamic label for each function key, F1 through F4.

Figure 3-6. HART LCD.



```
Brooks MT 3810
On-line
1→Device setup
2  PV              0.86 gpm
3  AO             4.275 mA
4  LRV             0.00 gpm
5  URV            50.00 gpm
         SAVE
```

Function Keys

Use the four function keys, marked F1 through F4 located below the LCD to perform software functions as indicated by the dynamic labels. Different labels appear over the four function keys as you move among the various menus.

On-line Menu

When connected to a HART compatible device, simply press the ON Key to display the On-line Menu. This menu contains the most critical information about the connected device and your measurement including:

- Model Number
- User-defined Tag Number
- Flow Rate Units of Measure
- Analog Output LoRange
- Analog Output HiRange

a. Simulation Mode

The HART communicator provides a mode that allows you to simulate an on-line connection to a specific HART compatible device. The simulation mode is a training tool that enables you to become familiar with a device before configuring it in a critical environment. Access to the simulation mode is through the utility menu.

For more details and instructions on use of the Fisher-Rosemount Model 275 Communicator please contact Brooks Service Department Representative or your local Fisher-Rosemount office.

b. Recalibration of Analog Transmitter Output (spanning high and low)

At any time after factory calibration, shipment, installation, or service, the SMM transmitter can be recalibrated by overwriting any of the previous calibration point-pairs, assuming that the user can provide a series of accurate rates of flow through the meter. If preferred, the meter with transmitter may be returned for Recalibration at the Brooks Service Department for a fee.

c. Basic Transmitter Setup Parameters

Refer to Figures 3-1 and 3-2. These are meter identification parameters set prior to shipment of the meter.

Flowmeter Identification: Model Number, Serial Number, Tag Name

Flowmeter Configuration: Low Flow Cutoff, Calibration Factor, Flow Rate Units of Measure

Transmitter Analog Output: Analog Output HiRange, Analog Output LoRange

d. Optional Programmable Alarm and Pulse Output Parameters and Features

Alarm Contact Output: HiLimit, LoLimit

One or two digital outputs are available for a alarm signals. Contact output polarity is configurable as normally open (N.O.) or normally closed (N.C.). The alarms may be set at the minimum and maximum flow rate or at any other preferred high and low limits. The units of measure of the alarm limits is the same units of measure as the process variable itself.

Computations: Totalization

Totalizers are available in both Resettable and Inventory options. Resettable totalization is used for batching while inventory totalization measures the total volume over time. Units of measure are set independently for each of these options.

Pulse Output: Pulse Out Scaler, Pulse Out Width

The SMM has a pulse output channel that indicates flow rate as a variable frequency and therefore can pass information to many types of external equipment such as batch controllers, automation systems or provers. The output pulse width default is 1 millisec but may be user-configured since certain external receiving equipment cannot keep up with high incoming frequency.

Low Flow Cutoff Warning for Pulse Output and Totalization

The low flow cutoff parameter can be programmed to signal when the flow level is below which the process is intended. Below this level, the totalizer will assume that the flow rate is actually zero and that no data should be accumulated by the totalizers.

Pulse Output Overrun Alarm

If a larger than acceptable output pulse width is configured, totalizer pulses may be delayed or queued. No loss of pulses will occur. The totalizer output pulses will to be sent until the queue is empty. Under these circumstances, an alarm message will be sent to the control station. However, the alarm can be disabled if not required.

Optional Alarm Configurations— Enable, Destination, Alarm Type (Latching)

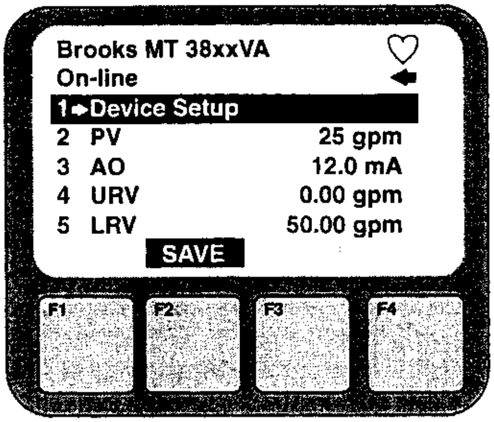
Three additional parameters may be programmed for process and diagnostic alarms to control functionality— enable, destination, and alarm type (latching). 'Enable' allows alarms to be enabled and disabled depending on use of the alarm. For example, if output pulses are being used it may be normal practice to delay (e.g. queue up) output pulses because of a slow receiving end-device that requires a wide pulse-width. The 'enable' parameter allows the user to *disable* the pulse output overrun alarm and not send an alarm when in fact pulse outputs are delayed by choice. Some critical diagnostic alarms, such as database initialization, can not be disabled or turned off.

When an alarm occurs, it can be posted through the defined 'destination' digital contact closure outputs #1, #2 both or neither. Therefore the alarms may be managed according to local operating practices and the need to notify upstream control/safety systems.

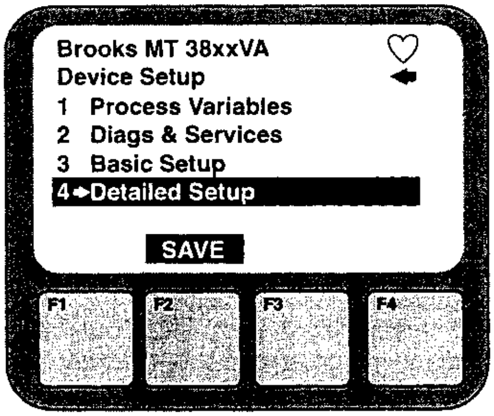
An alarm may be posted at a designated destination only when the alarm situation is occurring or posted until the alarm is acknowledged by the operator. The decision to 'latch or unlatch' the alarm is controlled by setting the 'alarm type' parameter. By utilizing this optional parameter, the operator can see that there is an alarm as it is occurring (unlatched) or even after the fact, in the case when the operator did not directly observe the unit alarm (latched).

The following are two examples of typical programming via a Fisher-Rosemount Model 275 hand-held communicator.

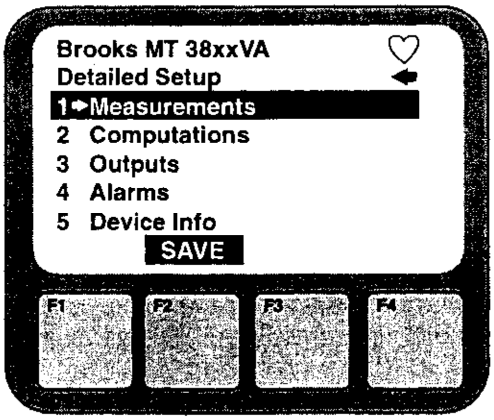
Example 1: Programming Flow Rate Units.



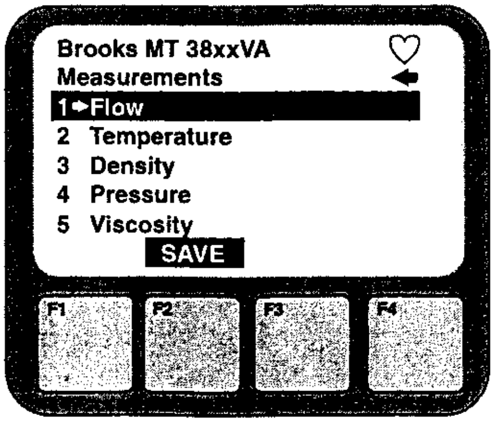
From the Online Menu, select *Device Setup.*



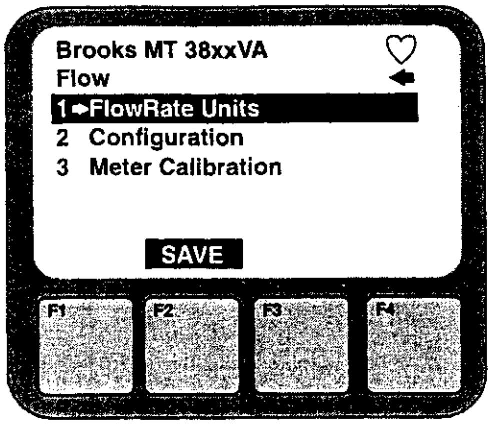
From the Device Setup Menu, select *Detailed Setup.*



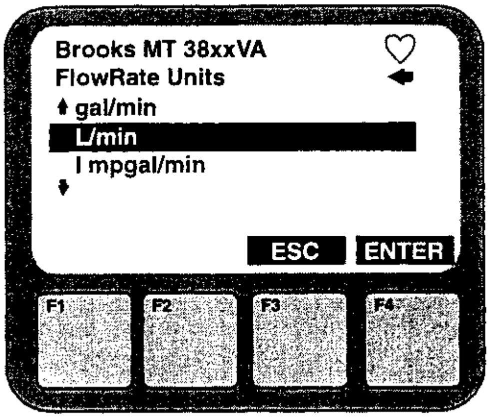
From the Detailed Setup Menu, select *Measurements.*



From the Measurements Menu, select *Flow.*



From the Flow Menu, select *FlowRate Units of Measure* (FlowRate UOM).



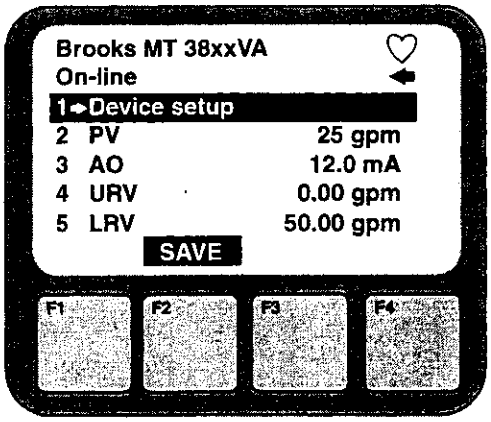
In Flow, scroll through list optional units. Highlight the FlowRate UOM desired. Press ENTER (F4) to enter the new information, and press SEND (F2) to send this information to the transmitter.

Note: Two Warning messages will appear.

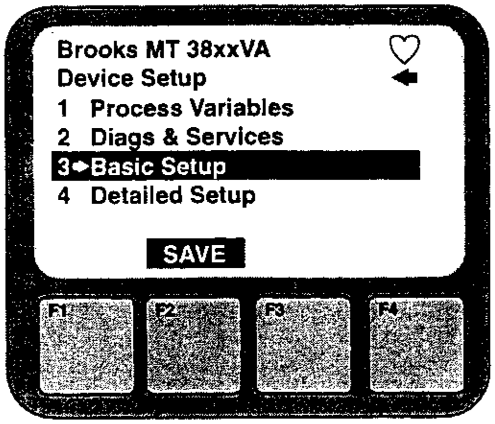
- Warning Pressing OK will change device output. Put loop in manual.
- Warning Return control loop to automatic control.

These warnings confirm changes to the programming and alert the user to make changes in other related fields.

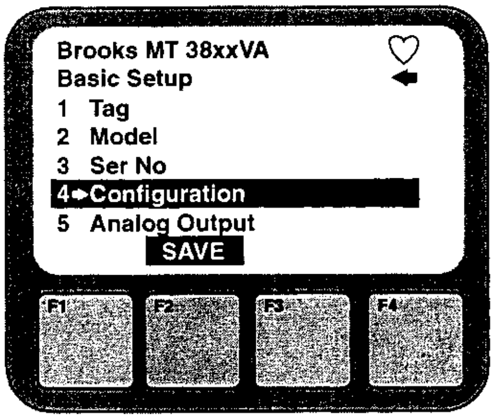
Example 2: Programming Low Flow Cutoff.



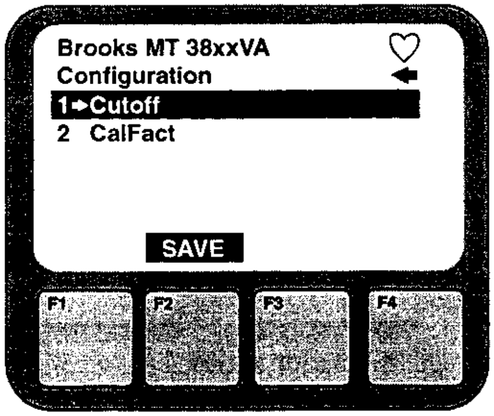
From the Online Menu, select *Device Setup*.



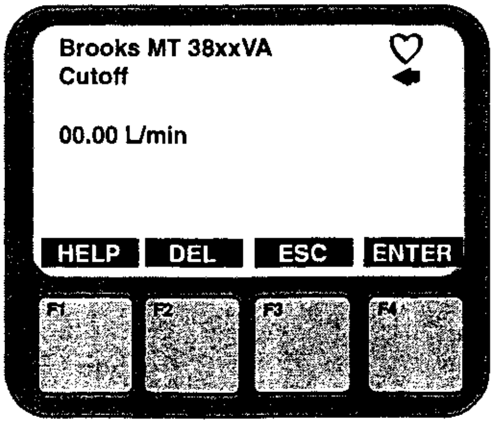
From the Device Setup Menu, select *Basic Setup*.



From the Basic Setup Menu, select *Configuration*.



From the Configuration Menu, select *Cutoff*.



Enter the Cutoff value in the same units specified in the FlowRate UOM. Press **ENTER** (F4) to enter the new information and press **SEND** (F2) to send this information to the transmitter.

3-4 Operation of the MT 3810 Flowmeter with a Smart Meter Manager Transmitter with Inductive Alarms (1 or 2 switches)

a. Start-up the meter as described in Section 3-2.
b. Start-up the transmitter as described in Section 3-3.
c. ,Start-up the inductive alarms as described in Section 3-5.

3-5 Operation of the MT 3810 Flowmeter with Inductive Alarms (1 or 2 switches)

a. Start-up the meter as described in Section 3-2.
b. To modify the alarm set points, remove the front cover with gasket of the indicator housing by removing the four screws.
c. Set the alarm position by loosening the two pointer screws, moving the pointer to the desired alarm setting and tightening the screws.
d. Replace the indicator housing cover with gasket and secure with the four screws.

Maintenance

4-1 General Service Information

⚠WARNING

If this equipment is not properly serviced, serious personal injury and/or damage to the equipment can result from potentially high operating pressures. Process line pressure should be removed prior to servicing.

There is no routine maintenance required for the Model MT 3810 flowmeter. However should it become necessary to replace, adjust or remove components of the flowmeter, specific recommendations must be followed.

4-2 Meter Float Replacement and Cleaning

Float replacement procedures are dependent on the meter size, connection type and fluid (gas vs. liquid) application. Please refer to the appropriate section below for instructions along with Figure 4-1 for referenced part numbers (#) appearing in parenthesis.

1. Flanged Connection

a. <u>Size 7 (1/2") Flanged Liquid or Gas Service</u>

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. With a small screwdriver, remove the spiral retaining ring (# 1) from the meter inlet.
3. Push the entire float assembly slowly downward and out of the meter inlet by pushing from the top with a round bar stock (3/4" or 19mm diameter).
4. Remove the float snap-ring to clean individual float assembly parts.
5. Reassemble the meter by reassembling the float assembly and inserting it into the bottom of the meter. Replace the spiral retaining ring (#1) in the meter inlet.

b. <u>Size 8 (1/2") Flanged Liquid Service</u>

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. With small screwdriver remove the spiral retaining ring (# 1) from the meter inlet.
3. Loosen the float assembly with two screwdrivers one on each end of the meter and turn to loosen the inlet and outlet screws (#2). Remove inlet screw (#2) at the bottom of the meter.
4. Remove the guide vane (#3) at the bottom of the meter and gently push the float assembly up and out the top/outlet side.
5. Reassemble by inserting the float assembly into the top of the meter. Replace the guide vane (#3) and secure the float assembly by tightening the inlet and outlet screws (#2). Replace the spiral retaining ring (#1) in the meter inlet.

c. Size 8 (1/2") Flanged Gas Service

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. With the help of a small screwdriver remove the spiral retaining ring (# 1) from the meter inlet.
3. Secure the damper from turning by inserting a 1/8" pin through the top guide cartridge. While holding the damper in place, remove the top/ outlet screw (#5).
4. Push the float assembly out through the inlet/bottom.
5. To clean the gas damper, unscrew the cylinder head (#6). Then remove the bolt (#7) and carefully take out the small piston so as to not damage the critical surfaces.
6. Reassemble the meter by assembling the damper with float assembly. Insert the float assembly with damper into the inlet/bottom of the meter. Secure the inlet/bottom screw. While holding the damper in place with a pin (1/8" diameter), insert and secure the top/outlet screw (#5). Replace the spiral retaining ring (#1).

d. Sizes 10 (1"), 12 (1 1/2"), 13 (2") Flanged Liquid Service

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. Loosen the float assembly with two screwdrivers one on each end of the meter and turn to loosen the inlet and outlet screws (#2). 3. Remove inlet screw (#2) at the bottom of the meter.
3. Remove the guide vane (#3) at the bottom of the meter and gently push the float assembly up and out the top/outlet side.
4. Reassemble by inserting the float assembly into the top of the meter. Replace the guide vane (#3) and secure the float assembly by tightening the inlet and outlet screws (#2).

e. Sizes 10 (1"), 12 (1 1/2"), 13 (2") Flanged Gas Service

1. With the help of a small screwdriver remove the spiral retaining ring (# 1) from the meter inlet.
2. Secure the damper from turning by inserting a 1/8" pin through the top guide cartridge. While holding the damper in place, remove the top/ outlet screw (#5).
3. Push the float assembly out through the inlet/bottom.
4. To clean the gas damper, unscrew the cylinder head (#6). Then remove the bolt (#7) and carefully take out the small piston so as to not damage the critical surfaces.
5. Reassemble the meter by assembling the damper with float assembly. Insert the float assembly with damper into the inlet/bottom of the meter. Secure the inlet/bottom screw. While holding the damper in place with a pin (1/8" diameter), insert and secure the top/outlet screw (#5). Replace the spiral retaining ring (#1).

2. NPT Connection

a. Size 7 (1/2") NPT Liquid or Gas Service

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. Unscrew the inlet fitting (# 4) at the bottom of the meter.
3. Push the entire float assembly slowly downward and out of the meter inlet by pushing from the top with a round bar stock (3/4" or 19mm diameter).
4. Remove the float snap-ring and clean individual float assembly parts.
5. Reassemble the meter by reassembling the float assembly and inserting it into the bottom of the meter. Reinstall and secure the inlet fitting(#4).

b. Size 8 (1/2"), 10 (1"), 12 (1 1/2"), 13 (2") NPT Liquid Service

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. Unscrew the inlet fitting (# 4) at the bottom of the meter.
3. Loosen the float assembly with two screwdrivers one on each end of the meter and turn to loosen the inlet and outlet screws (#2). Remove inlet screw (#2) at the bottom of the meter.
4. Remove the guide vane (#3) at the bottom of the meter and gently push the float assembly up and out the top/outlet side.
5. Reassemble by inserting the float assembly into the top of the meter. Replace the guide vane (#3) and secure the float assembly by tightening the inlet and outlet screws (#2). Reinstall and secure the inlet fitting (#4).

c. Size 8 (1/2") NPT Gas Service

1. Remove the meter from the process line and lay the meter horizontal on a table.
2. Unscrew the outlet fitting (# 4) at the top/outlet of the meter and remove the gas damper.
3. Unscrew the inlet/bottom fitting (#4) and slowly remove the float assembly.
4. To reassemble the meter, insert the float assembly into the inlet/bottom of the meter. Secure the inlet/bottom fitting (#4). Replace the gas damper and secure the outlet/top fitting (#4).

d. Size 10 (1"), 12 (1 1/2"), 13 (2") NPT Gas Service

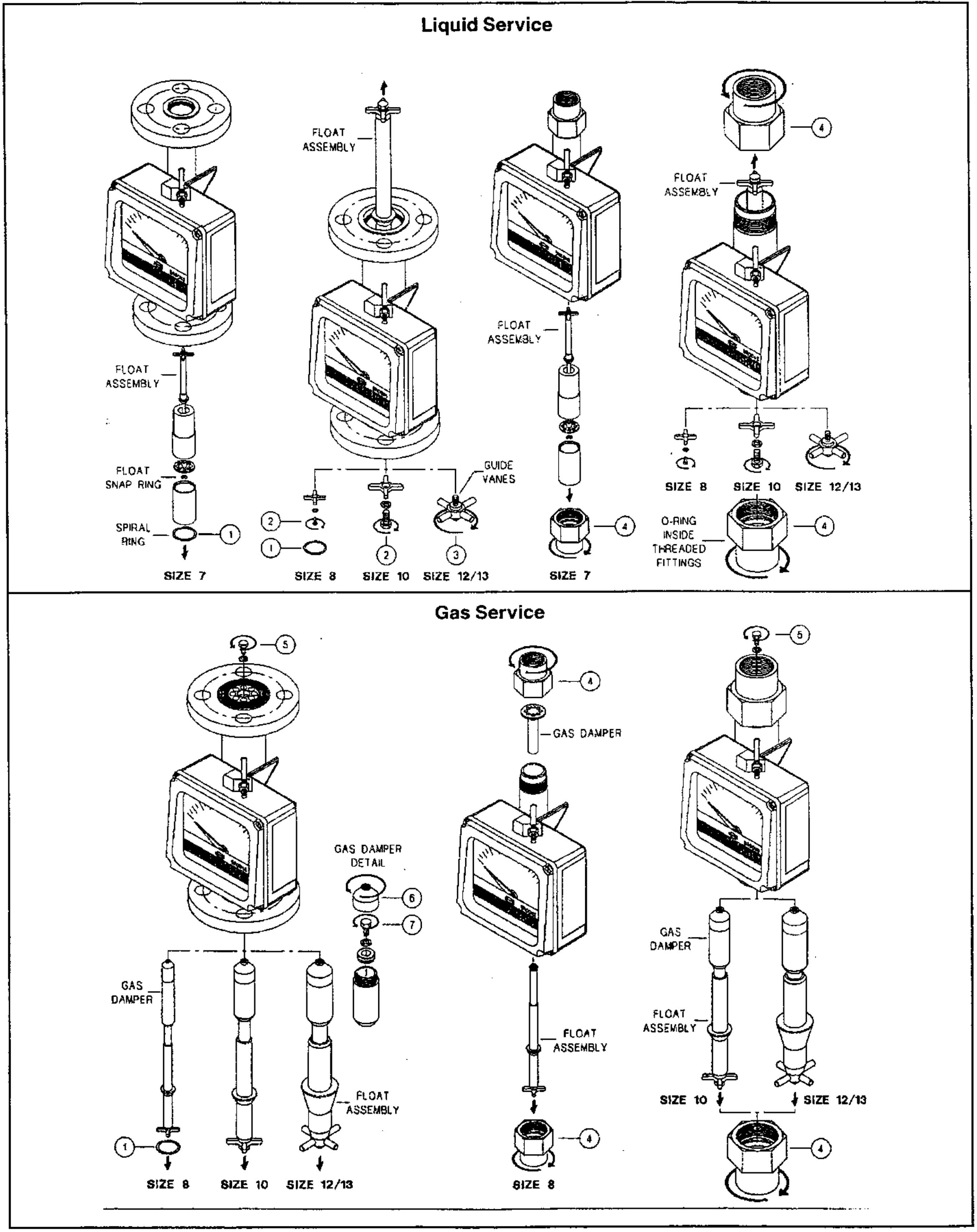
1. Remove the meter from the process line and lay the meter horizontal on a table.
2. Remove the top/outlet screw (#5).
3. Loosen the float assembly by holding the damper in place with a pin (1/8" diameter) in the top while loosening the inlet/bottom fitting. Gently push the float assembly out through the inlet/bottom.
4. To clean the gas damper, unscrew the cylinder head (#6). Then remove the bolt (#7) and take out the small piston carefully so as to not damage the critical surfaces.
5. Reassemble the meter by inserting the float assembly with damper into the inlet/bottom of the meter. Secure the inlet/bottom screw by holding the damper in place with a pin (1/8" diameter). Replace and secure the top/outlet screw (#5). Reinstall and secure the inlet fitting(#4).

4-3 Meter Indicator Reference Mark (Zero) Adjustment

This adjustment is performed with no process flow with the float resting on the guide vane or the inlet end fitting.

a. Completely stop fluid flow through the indicator.
b. Remove the four screws securing the indicator housing window and remove the gasket and cover.
c. Turn the slotted screw on the bottom of the point until the pointer is in line with the reference (zero) mark on the scale.
d. Replace the indicator housing cover with gasket and secure with the four screws.

Figure 4-1. Meter Float Replacement & Cleaning.



4-4 Smart Meter Manager Transmitter Replacement with or without Alarms and Pulse Output

The transmitter is a self contained unit matched specifically to the associated flowmeter. If there is a need to replace, please contact your nearest authorized Brooks Service Representative.

4-5 Inductive Alarm Replacement

a. Remove the front cover of the indicator housing by removing the four screws securing it.
b. The wires from the alarm switch(es) are plugged into the alarm terminal circuit board and must be unplugged for replacement.
c. Loosen the two screws securing the scale, with the alarm switches attached, and remove the scale.
d. Turn the scale over and locate the screw centered in the green alarm switch. Remove the screw being careful not to lose the nut on the outside of the alarm set bracket. Remove the alarm switch from support.
e. Place the switch on the bracket with the open end facing towards the center of the scale plate and the wires facing away from the scale plate.
f. Place the switch screw through the opening in the switch, and the support bracket. Use the nut to secure the screw and tighten.
g. Plug in the switches.
h. Replace the scale and tighten two clamping screws. Make sure that the alarm switch wires do not interfere with the alarm cam. Insure that the pointer is aligned with the 'R' or zero mark. If not refer to Section 4-3, Indicator Reference Mark (Zero) Adjustment.
i. Set the alarm position, by loosening the two pointer screws, moving the point of the desired alarm setting, and tightening the screws.
j. Connect the field wiring.
k. Replace the indicator housing cover and secure with four screws.

4-6 Smart Meter Manager Transmitter Replacement with Inductive Alarms

The transmitter is a self contained unit matched specifically to the associated flowmeter. If there is a need to replace, please contact your nearest authorized Brooks Service Representative. However, the inductive alarms may be replaced according to the procedure in Section 4-5.

4-7 Monitoring the Integrity of the SMM Electronics - Diagnostic Alarms

As part of its normal operations, the SMM continuously monitors its own internal health. Automatic diagnostics can trigger alarms indicating poor communications, memory integrity, or sensor problems. The user can define whether these malfunctions are serious and instruct that a 4-20 mA analog-signal be sent automatically to a receiving devices such as a DCS or PLC system.

a. Power Failure Alarm
The power failure alarm will occur when the current-loop is broken and then restored. In this case, the transmitter will raise the power-fail alarm to notify the user that there was a gap in data collection. The 4-20 mA loop provides all internal power for the SMM electronics. However, if power is lost, the setup parameters are internally stored in nonvolatile memory (lithium battery) and maintained in the event that external power is disconnected.

b. Database-Initialization Alarm will occur when the transmitter powers up and finds that the internal parameter database was not saved properly and must return parameters to the inherent defaults.

c. High Internal Temperature Alarm
Should the electronics unit exceed functional limits (70°C), this information will be indicated.

TRADEMARKS

Asset Management Solutions	Fisher-Rosemount Grp. of Companies
Brooks	Brooks Instrument Division, Emerson Electric Co.
HART	HART Communications Foundation
Fisher-Rosemount	Fisher-Rosemount Grp. of Companies
Managing The Process Better	Fisher-Rosemount Grp. of Companies
Smart Meter Manager	Brooks Instrument Div., Emerson Electric Co.
SMM	Brooks Instrument Division, Emerson Electric Co.
Teflon	E.I. DuPont de Nemours & Co.
Viton	E.I. DuPont de Nemours & Co.

GUARANTEE

If at any time, within one year after shipment but not thereafter, it is proved that any part of the equipment furnished by us was defective when shipped by us, we will repair or replace the same free of charge F.O.B. our plant. Notice of this claim must be made to us within one year after delivery. Our liability is limited to replacement of such defective parts or equipment. There are no guarantees or warranty expressed or implied other than those herein specifically mentioned.

Brooks Instrument shall not, in any event, be liable for any consequential damages, secondary charges, expenses for erection or disconnecting or losses resulting from any alleged defect in the apparatus.

It is understood that corrosion or erosion of material is not covered by our guarantee.

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PEPPERL+FUCHS

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E-ZY PURGE PANELS FOR US-320100 / US-420100

TYPE "Z" AND "Y"

INSTALLATION MANUAL

Models Covered:

US-320100-L-YZ
US-320100-R-YZ
US-320100-T-YZ
US-320100-B-YZ
US-320100-P-YZ
US-320200-U-YZ

US-420100-L-YZ
US-420100-R-YZ
US-420100-T-YZ
US-420100-B-YZ
US-420100-U-YZ

US-335211
US-335211-90

EZY02/00A

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DEFINITIONS

The following definitions are in accordance with the ISA-RP12.4-1996 and NFPA 496-1998 documents.

Alarm: A piece of equipment that generates a visual or audible signal that attracts attention.

Enclosure Volume: The volume of the empty enclosure without internal equipment.

Flammable Limits: The lower (LFL or LEL) and upper(UFL or UEL) percentages by volume of concentration of gas-air mixture that will form an ignitable mixture.

Hazardous (Classified) Location: A location in which fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, comestible dust, or easily ignitable fibers or flying.

Ignition Capable Equipment: Equipment that under normal operating conditions, produce sparks, hot surfaces or a flame that can ignite the hazardous area.

Ignition Temperature: The autoignition temperature of a hazardous location.

Indicator: Equipment that shows flow or pressure.

Maximum Operating Pressure: The maximum internal pressure permitted for an enclosure.

Pressurization: The process of supplying an enclosure with a protective gas with or without continuous flow at sufficient pressure to prevent the entrance of a flammable gas or vapor, a combustible dust, or an ignitable fiber.

Protective Gas: The gas used to maintain pressurization or to dilute a flammable gas or vapor.

Protective Gas Supply: The compressor, blower, or compressed gas container that provides the protective gas at a positive pressure. The supply includes inlet (suction) pipes or ducts, pressure regulators, outlet pipes or ducts, and any supply valves not adjacent to the pressurized enclosure.

Purging: The process of supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptable level.

Specific Particle Density: The density of individual dust particles.

Type X pressurizing: Reducing the classification within the protective enclosure from a Division 1 to nonclassified.

Type Y pressurizing: Reduces the classification within the protective enclosure from a Division 1 to Division 2.

Type Z pressurizing: Reduces the classification within the protective enclosure from a Division 2 to nonclassified.

GENERAL DESCRIPTION

Type Z, Class I, Division 2 / Class I, Zone 2 locations are where flammable liquids are processed but are normally contained or confined in a closed container or system, and are only present outside the container or system when there is an abnormal condition such as a rupture or breakdown of the system. (See Article 500-5(b) of NFPA 70, National Electrical Code).

The P+F Type Z, E-ZY Purge system allows general purpose devices to be operated within a pressurized NEMA 4 or 12 enclosure located in the hazardous area. Explosive gases are flushed out of the protective enclosure by sending a protective gas such as instrument air or an inert gas through the system until 4 enclosure volumes have been exchanged. (Exception: if a Class I motor is in the enclosure, 10 volume changes must be performed. After the purging cycle is completed, power can be applied to protective enclosure. If the pressure drops below a minimum value (as specified in the NFPA 496-1998 standard), immediate attention is required.

Type Y, Class I, Division 1/ Class I, Zone 1 locations are where flammable liquids are always or periodically present. (See Article 500-5(a) of NFPA 70, National Electric Code).

The P+F Type Y, E-ZY Purge system allows devices rated for Class I, Division 2 / Class I, Zone 2 to be located in the protective enclosure and operate in a Division 1 area. Explosive gases are flushed out of the protective enclosure by sending a protective gas such as instrument air or an inert gas through the system until 4 enclosure volumes have been exchanged. (Exception: if a Class I motor is in the enclosure, 10 volume changes must be performed. After the purging cycle is completed, power can be applied to protective enclosure. If the pressure drops below a minimum value (as specified in the NFPA 496-1998 standard), immediate attention is required.

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COMPONENTS FOR CLASS I, TYPE Y & Z E-ZY PURGE PANEL

Enclosure volume must be less than 15 cubic feet.

E-ZY Purge panels provides the basic components to purge and pressurize a protective enclosure of less than 15 cubic feet of volume.

US-320100 PANEL

* Regulator: Provides regulated protective gas to the protective enclosure.

* Pressure Guage: Pressure of regulated protective gas.

* Filter: Filter for regulated protective gas supply

* Purging Valve: Ball valve for supplying high flow rate of protective gas supply for purging.

* Pressurization Valve: Needle valve for supplying a continuous protective gas supply for pressurization.

* Differential Pressure Gauge: Indicates internal pressure. The gauge is is only used in verifying internal pressure and is not used as an alarm indicator.

* Start-Up Labels: The start-up labels will provide the correct procedure for purging and pressurizing the protective enclosure.

* Warning Labels: Stainless steel label must be placed onto the protective enclosure and indicates this is a pressurized enclosure.

US-420100 PANEL

* Regulator: Provides regulated protective gas to the protective enclosure.

* Pressure Gauge: Pressure of regulated protective gas.

* Filter: Filter for regulated protective gas supply

* Purging Valve: Ball valve for supplying high flow rate of protective gas supply for purging.

* Pressurization Valve: Needle valve for supplying a continuous protective gas supply for pressurization.

* Differential Pressure Gauge: Indicates internal pressure. The gauge is is only used in verifying internal pressure and is not used as an alarm indicator.

* Start-Up Labels: The start-up labels will provide the correct procedure for purging and pressurizing the protective enclosure.

* Warning Labels: Stainless steel label must be placed onto the protective enclosure and indicates this is a pressurized enclosure.

* Differential Pressure Switch: Provides a contact output when the pressure inside the protective enclosure drops below 0.2" water pressure. The contact output is used to drive an alarm for pressure loss inside the protective enclosure.

US-335211 VENT

A pressure relief vent is required for all pressurized systems regardless of the class and division of the installation. The US-335211 relief vent has a spark arrestor screen for hazardous area mounting and acts as a relief vent during and after purging. The pressure relief vent must be mounted in a upright position.

Before operating the E-ZY purge panel, the vent should be checked to make sure the ball inside the vent moves freely. This operation should be done before the protective gas is supplied to the protective enclosure. A warning label on the vent indicates this testing procedure.

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INSTALLING PANELS TO PROTECTIVE ENCLOSURE

Good engineering practices should be conducted when installing the E-ZY Purge panels. Below are some practices to consider.

- Use 3/8" or 5/16" bolts to mount the panel to the protective enclosure. A sealant may be applied to the bolts so they will not leak.
- Each panel will have two connections to the protective enclosure. Both of them on the panel will be a 1/4" SWAGELOK fitting. Minimize the number of bends for each tubing so that the pressure loss is reduced to a minimum. This is especially important for the protective gas supply entering into the protective enclosure.
- The 1/4" tubing should not have a wall thickness greater than 0.035".
- If the hazardous vapors are heavier than air, then try to place the vent near the bottom of the protective enclosure and the protective gas supply near the top. If the hazardous vapors are lighter than air, place the vent near the top of the protective enclosure and the protective gas supply near the bottom.
- Make sure all entrances to the protective enclosure are sealed. All wiring going to and leaving the protective enclosure must be in accordance with the wiring methods for that area.
- Mount stainless steel warning plate in a place that is highly visible to all personnel.
- The protective enclosure must not have an external surface temperature which exceeds 80% of the hazardous vapor's ignition temperature.
- The equipment within the protective enclosure must not exceed 80% if the hazardous vapor ignition temperature, unless it can be proven it will not ignite the hazardous vapor present or a warning label indicating that the enclosure can not be opened for a specified time to allow for cooling of the equipment and the door can not be opened without a tool.
- Any windows or displays on the protective enclosure must be shatterproof.
- The enclosure should meet or exceed NEMA 4 or 12 ratings. The protective enclosure should withstand a internal pressure of 6" water pressure.
- For Type Z purging, equipment in the protective enclosure can be general purpose equipment. For Type Y purging, equipment in the protective enclosure has to have a Class I, Division 2 / Class I, Zone 2 rating.

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- If multiple enclosures are connect together and operated by one E-ZY panel, the combined volume must not exceed 15 cubic feet. The enclosure should be connected in series with the vent and the E-ZY panel separated by the first and last enclosure.
- Verify that the protective gas supply can handle the flow rate required. The acutal flow rate for the 1/4" panel is 7.5 SCFM
- The supply pressure must be at a minimum of 80 psig and the regulated pressure must be at 60 psig minimum.
- The pressure relief vent, US-335211 must be mounted in a upright position.

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INITIAL START-UP PROCEDURES

1. Turn off the purging valve and fully close the pressurization valve by turning the know clockwise (CW).
2. Connect the protective gas supply to the regulator-filter.
3. Test the pressure vent by making sure the ball in the shaft moves freely.
4. Verify there is 80 psig supply pressure and regulator is set at 60 psig minimum.
5. Adjust pressurization valve so that the differential pressure gauge reads 0.3"" water pressure
6. Turn on the purging valve and verify that there is flow.
7. Energize power to protective enclosure
8. Verify function of the differential pressure switch on the US-420100 or other loss of pressure devices by adjusting the pressurization valve clockwise (CW) so the differential pressure gauge drops below 0.2" water pressure.
9. Remove all test instruments.

START-UP INSTRUCTIONS

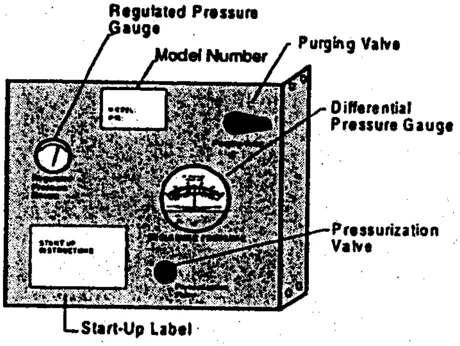
1. With protective enclosure power off, and protective gas supply turned off
2. Test protective vent in accordance to the instructions on the vent and seal enclosure.
3. Set regulator to 60 psig minimum.Adjust pressurization valve so that the differential pressure gauge reads 0.3" water pressure
4. Turn on the purging valve for specified amount of time specified on the start-up label.
5. After purging has been completed, close purging valve.

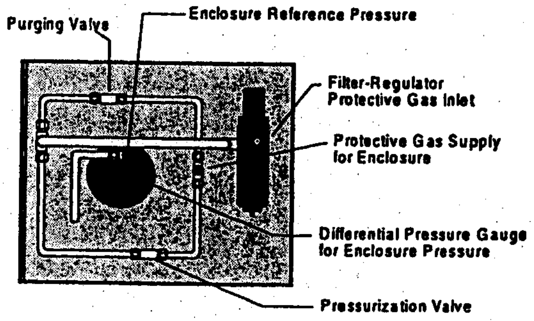
6. Wait for differential pressure gauge to reach its pressurization pressure. If low pressure alarm is not on, and differential pressure gauge is above 0.2" water pressure, energize power to protective enclosure.

7. Loss of pressure requires immediate response unless power is deenergized.

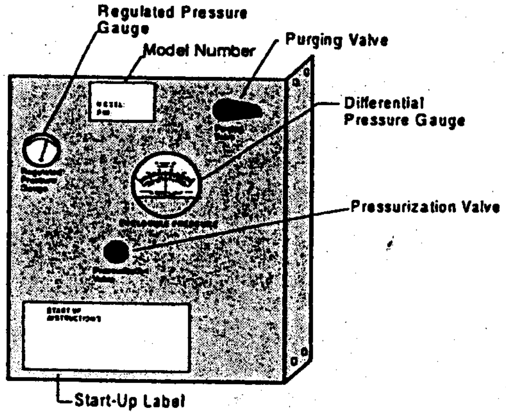
TECHNICAL DATA:

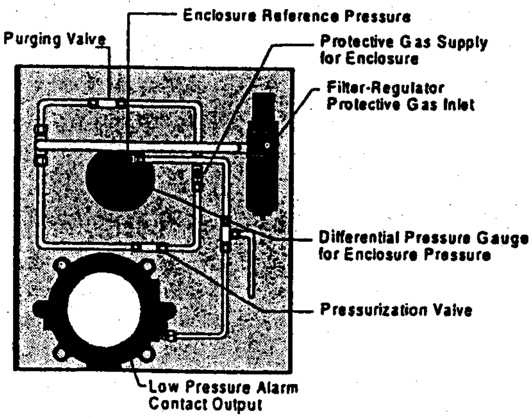
US-320100





US-420100





LOW PRESSURE ALARM (US-420100)

Housing:	Anodized cast aluminum NEMA 7& 9, groups C & D
Diaphragm:	Molded flourosilicone rubber
Calibration Spring:	Stainless Steel
Electrical Connections:	SPDT contact output, 15A, 480VAC/60Hz
Conduit Connections:	1/2" NPT

ENCLOSURE VOLUME REQUIREMENTS: ≤ 15 cubic feet

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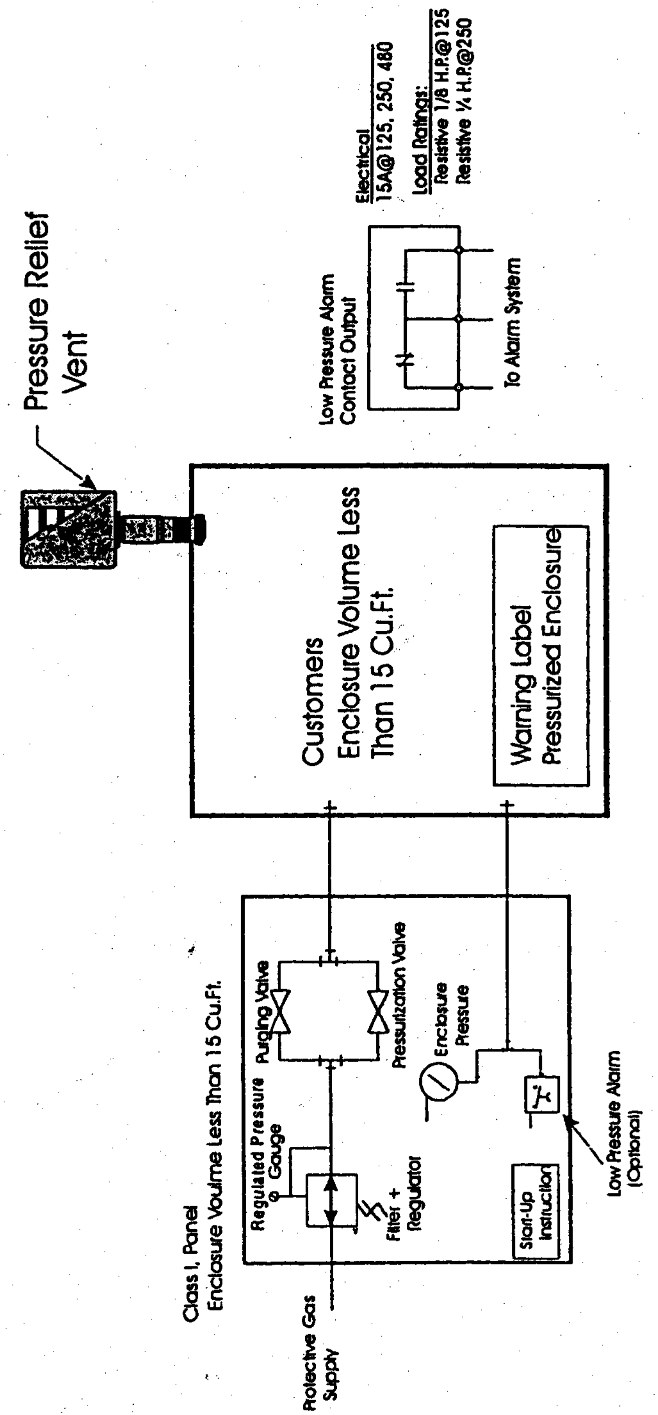
FILTER-REGULATOR:	
Pipe Size:	1/4" NPT
Bowl Size:	1.5 oz.
Element:	0.1 Micron ultra fine coalescer
Pressure Gauge:	Indicates regulated pressure
Maximum Pressure:	120 psig
Low Pressure Setting:	0.2" water pressure
PURGING VALVE:	2-way ball valve
Size:	1/4"
Material:	
Body:	316 stainless steel
Handle:	Nylon with bronze insert
Turn ratio:	1/4 turn ON-OFF
Flow Rate:	5 SCFM @60psig
PRESSURIZATION VALVE:	1/4" Needle valve
Material:	
Body:	316 stainless steel
Packing:	TFE
Handle:	Phenolic
Flow Rate:	Dependent upon enclosure integrity
DIFFERENTIAL PRESSURE GAUGE:	
Range:	0-1" water pressure
Burst Pressure:	15 psig
Danger Zone:	0-0.20" water pressure
Tubing Connection:	1/4" Stainless steel SWAGELOK fitting
TEMPERATURE:	-14 °F TO +120 °F
PANEL MATERIAL:	304 Stainless steel
FITTINGS:	316 Stainless steel

RATINGS:

US-320100-_-YZ,	
'Y' Purge	Class I, Division 1, Grp's A-D / Class I, Zone 1, Grp IIC
'Z' Purge	Class I, Division 2, Grp's A-D / Class I, Zone 2, Grp IIC
US-420100-_-YZ,	
'Y' Purge	Class I , Divison 1, Grp's C-D / Class I, Zone 1, Grp IIB
'Z' Purge	Class I, Division 2, Grp's C-D / Class I, Zone 2, Grp IIB

PNEUMATIC / ELECTRICAL CONNECTIONS



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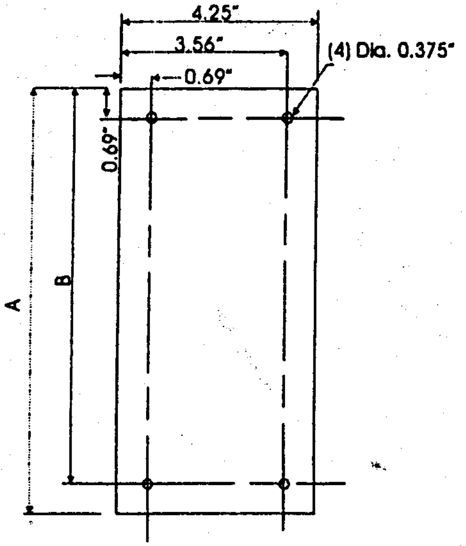
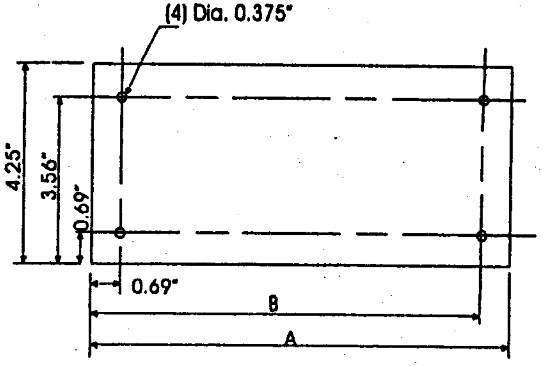
DIMENSION OF THE MOUNTING PANEL

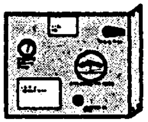
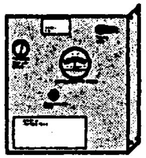
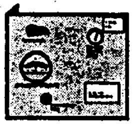
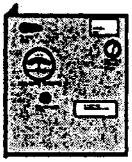
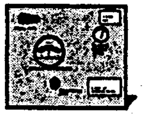
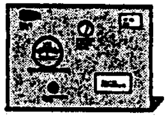
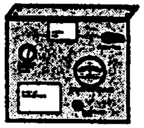
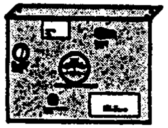


Left 'L' or Right 'R' Mount



Top 'T' or Bottom 'B' Mount

MODEL	US-320100		US-420100	
MOUNT	Left or Right	Top or Bottom	Left or Right	Top or Bottom
A	10.00"	11.00"	15.00"	16.00"
B	9.31"	10.31"	14.31"	15.31"

	LEFT (-L)		RIGHT (-R)		TOP (-T)		BOTTOM (-B)	
								
MODEL	US-320100	US-420100	US-320100	US-420100	US-320100	US-420100	US-320100	US-420100
HEIGHT	10.0"	15.0"	10.0"	15.0"	10.0"	10.0"	10.0"	10.0"
WIDTH	11.0"	11.0"	11.0"	11.0"	11.0"	16.0"	11.0"	16.0"
DEPTH	5.8"	5.8"	5.8"	5.8"	5.8"	5.8"	5.8"	5.8"

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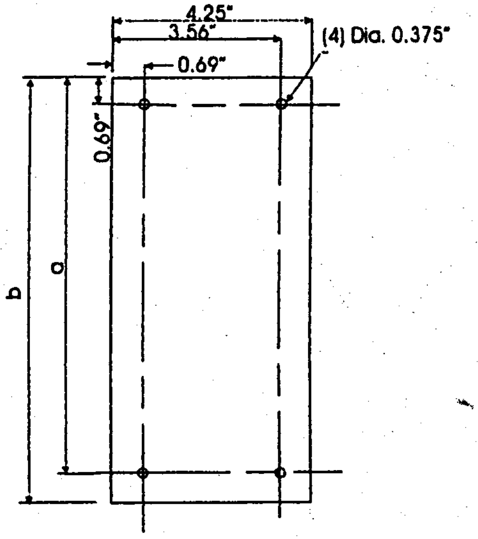
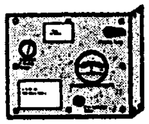
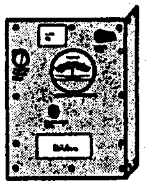
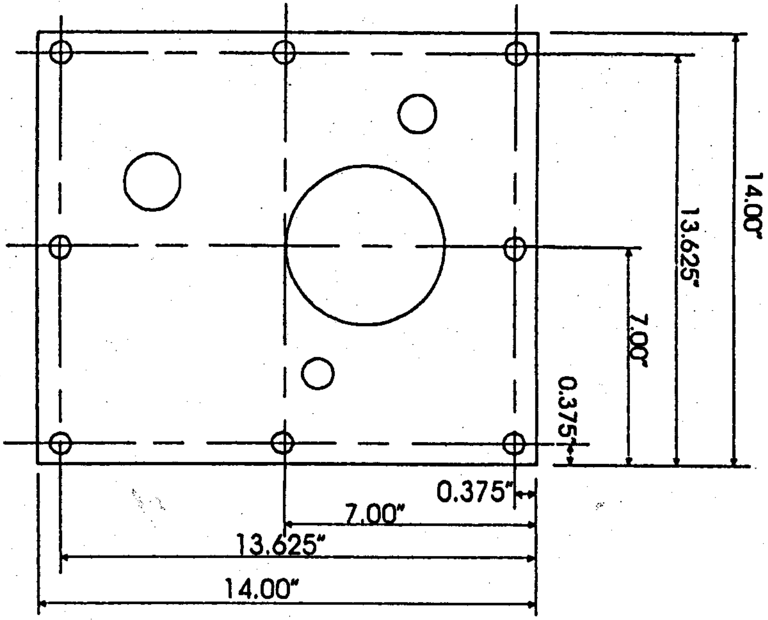
DIMENSION FOR UNIVERSAL



MODEL	US-320100	US-420100
MOUNT	Universal	Universal
a	13.31"	13.31"
b	14.00"	14.00"

	UNIVERSAL (-U)	
		
MODEL	US-320100	US-420100
HEIGHT	14.0"	17.0"
WIDTH	14.0"	14.0"
DEPTH	5.8"	5.8"

DIMENSION FOR PANEL MOUNT



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	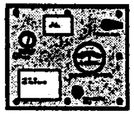	
MODEL	US-320100	
HEIGHT	14.0"	
WIDTH	14.0"	
DEPTH	5.8"	

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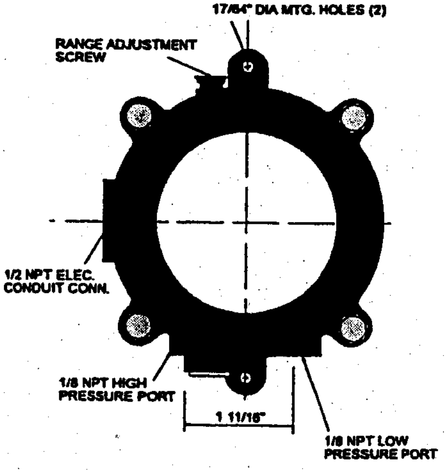
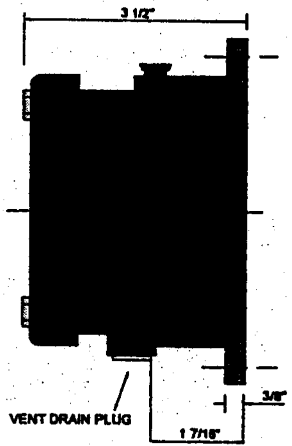
EXPLOSION PROOF LOW PRESSURE ALARM





The explosion proof low pressure differential pressure switch is provided on the model US-420100 E-ZY Purge panel.

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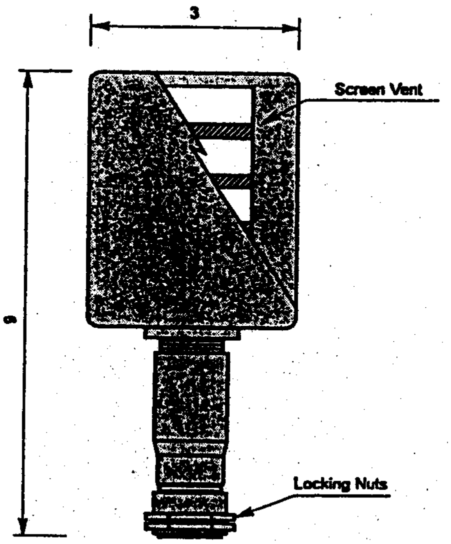
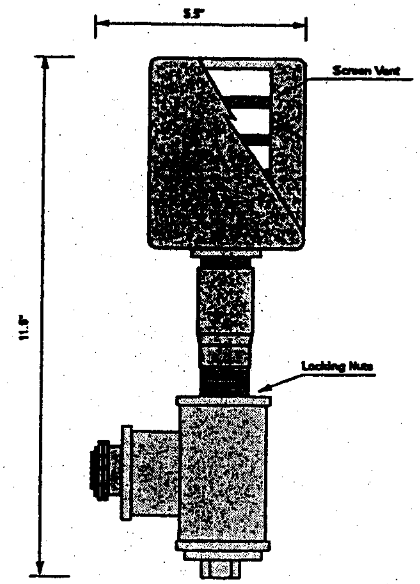
PRESSURE RELIEF VENT US-335211, US-335211-90



MODEL: US-335211



MODEL: US-335211-90

TECHNICAL DATA

MAXIMUM FLOW RATE:	15 SCFM
ENCLOSURE PRESSURE; AT PURGING FLOW RATE:	3.0 water pressure
EXHAUST PORT:	Spark Arrestor, domed
TEMPERATURE:	-4 °F to +158 °F
MATERIAL:	Body - Aluminum, Spark arrestor screen - Stainless steel
MOUNTING:	
US-335211	Single mounting hole, 1" NPT with mounting nut and gasket, must be mounted upright.
US-335211-90	Single mounting hole, 1" NPT with mounting nut and gasket, with right angle hardware must be mounted upright.

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The pressure relief vent US-335211 is required for all pressurized systems. The US-335211 provides an exhaust for the protective gas during the purge cycle and acts as a relief vent. The spark arrestor screen is made of stainless steel and provides safe venting for Type Y, Division 1 areas. The main component of the vent is a PVC ball (UL94V E0) that rises when the pressure inside the enclosure reaches approximately 1.4" water pressure. During purging, the protective gas enters the protective enclosure and causes the ball to rise, allowing the hazardous vapors and gases to leave the enclosure. After purging if the enclosure pressure drops below 1.2" water pressure, the

PVC ball will settle in the chamber a provide a seal. This operation is dependent on gravity and must be mounted in an upright position. Right angle vents, US-335211-90 provide side mounting.

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RECOMMENDED SPARE PARTS LIST

SERIAL #: 200001-2078-1-2 **MODEL#:** 1OT-2440-GOLSP

DESCRIPTION		**PART NUMBER**
PUMP SEAL		250-010-0225-S
PUMP IMPELLER		250-010-0225-7-1/4”
PUMP MOTOR	3 HP	250-010-0225
HEATER	24 KW	270-030-0339
EXCHANGER	16.5 SQ. FT.	270-250-0165
RELIEF VALVE	SET @ 125 PSIG	290-030-0184
SOLENOID VALVE		290-010-0206
AIR/FILTER REGULATOR		300-040-0156
CONTROL VALVE		290-120-0608
STRAINER		300-025-0098
PRESSURE GAUGE		310-010-0131
TEMPERATURE INDICATOR		310-020-0006
HEATER FUSE	40A	580-010-0293
PUMP MOTOR FUSE	10A	580-010-0292
PRIMARY FUSE	3.5A	580-010-0291
CONTROL FUSE	6.25A	580-010-0290
TEMPERATURE SWITCH		560-010-0100
RTD		610-030-0160
SCR		550-010-0094
FLOW METER	½”	310-040-0216

FLOW METER	1-1/2”	310-040-0220