Messrs. :
Customer :

Plant Name :

OPERATING & MAINTENANCE MANUAL

Service :

IMPORTANT
To assure safe and proper operation, be sure to read this "INSTRUCTION MANUAL" and the annexed "SAFETY PRECAUTIONS" prior to installing and using your pump.

No	Contents of Revision	Date of Rev.	Revised by	Reviewed by	Approved by

Prepared by		Date	DEPT.	Pump Type & Size	MHD 65/10 E	
Reviewed by		Date	DEPT.	Product No.		
Approved by		Date	DEPT.	Document No.		Rev -

SAFETY PRECAUTIONS

- After reading through this paper, be sure to keep it in the place exposed to view at all times for operators.

Concerning the safety precautions, this paper describes the contents of WARNING by the use of the following symbols and sign.

Indicating the contents where a possibility of leading to serious results such as a danger of injuries which persons may undergo in causes of mishandling due to neglect of this display is conceivable.

The contents given below should always be followed since any of them covers important motes on safety.

WARNING

1. General

1) Never allow any persons other than service engineers to engage in disassembly or repair, or remodeling work.
2) Never work alone and be sure to put on helmet, safety goggles ear plugs, safety shoes, etc. in conformity with the Labor Safety and Health Law, etc.
3) Prior to carrying out any sparking work such as welding, etc., make sure that where are no dangers of fire and explosion hazards.
4) Check the place where emission of toxic gas and deficiency of oxygen are conceivable, such as pit, manhole, etc. before starting on work and make sure of safety.
5) When carrying out the work for centering check, disassembly, etc., be sure to turn OFF the motor switch and affix a tag indicating "NO POWER ON" or the like to the switch so that the switch will not be turned ON by mistake.
6) Before starting on work, be sure to conduct checking of sliding outfits such as crane, wire rope, etc. unfailingly.
7) Install safety fence around the working area and secure an emergency passageway.
8) Since any split oil on the floor, passageway, etc. may lead to a cause of slippage etc., wipe it off forthwith.
9) Shaft seal parts will not function to stop the pumped-liquid completely. When handling such a liquid which may cause serious troubles to the human body, therefore, do not touch the splashing liquid from shaft seal parts.
10) Keep away from the casing of the pump that is handling such a hot liquid as may lead to a danger of scalds if coming in contact with the human body.
11) Do not gain access to rotating parts recklessly since there is a possibility of scattering caused by breakage of rotating parts.
12) Take precautions against the possible breakage and scattering which may be caused if leaning against or stopping on the guard.
13) Do not open the terminal cover of electrical devices including motors as there is a danger of electrification while they are being energized.

2. Handling

Where both pump and motor are assembled on the common bed, never hang a wire rope on the eyebolt of the motor. Furthermore, do not gain access to the underside of the suspended pump.

3. Direct-coupling

For the type of coupling applied with safety cover (coupling guard), fix the safety cover securely to the predetermined position with clamping bolts.

4. Maintenance

When carrying out the work for replacement of gland packing or mechanical seal, be sure to turn OFF the motor switch and affix a tag indicating "NO POWER ON" or the like to the switch so that the switch will no be turn ON by mistake.

5. Disassembly and Reassembly

1) Before carrying out the disassembly work, be sure to turn OFF the motor switch and affix a tag indicating "NO POWER ON" or the like to the switch so that the switch will not be turned ON by mistake.
2) Shut off the valves on the suction side and discharge side totally and, in the case of hot liquid, discharge the pump interior liquid from drain valve at the point when the casing temperature has come down to the room temperature or so.
3) Where the pumped-up liquid is a chemical solution, it may lead to a danger or causing injuries such as inflammation and the like if adhering to the human body. To prevent this, make sure that the casing interior liquid has been discharged thoroughly.
4) When removing parts and partly-assembled components, hang wire ropes to the positions as shown in the instruction manual and use a chain block, etc.
5) When handling hot components such as ball bearing, Coupling, etc., be sure to put on protective gloves.

Prior to operating the pump

Thank you for your having adopted our Torishima pump.

This Manual describes the handling cautions to be absolutely followed for safety and efficient operation of the boiler feed water pump throughout a long period.

Operators and maintenance men are requested to carefully read this Manual for understanding of the pump outlined construction and maintenance-inspection procedure.

Furthermore, operators and maintenance men are recommended to execute the following to catch pump trouble or fault at the earliest and to smoothen periodic inspection.

1) Periodically record and keep the operation data individually for each pump to grasp precisely normal data values and to thereby facilitate checking of pump fault/defect in routine inspection.

2) Keep the test run records after installation of new pump and those after each further periodic inspection and grasp aging chance from those recorded values so as to be referred to in deciding periodic inspection interval and inspection items and in forecasting what parts should be replaced in next periodic inspection.
For the purpose, it is recommended to add the outlined contents of periodic inspection to post-periodic inspection test run records.

1. Installation and Centering

1.1. Pump installation

1.1.1. Lifting up the pump unit

As illustrated in fig.1, hook a lifting wire on the tie bolt nuta in lifting up.

In this case, dont apply the wire to the casing flange and the bearing bracket.

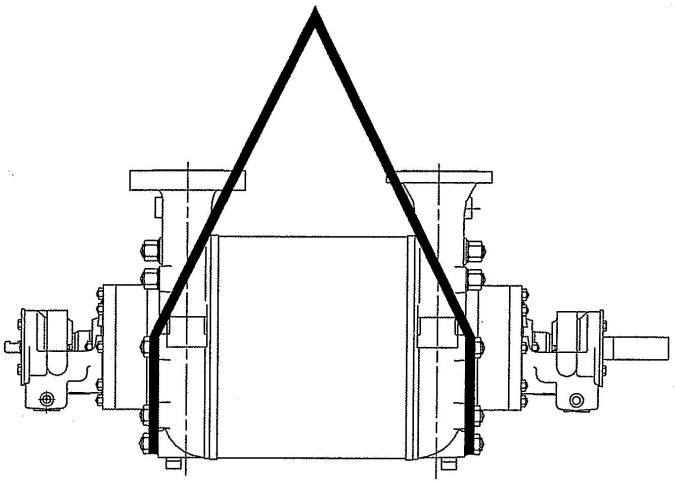


Fig. 1 Lifting up the pump

1.1.2. Installation of the pump onto base plate

Install the pump onto the base plate and then follow the following sequence, considering thermal expansion of the pump.

Tighten tighly other side pump foot fixing nut and drive a pin between the pedestal and the pump support foot.

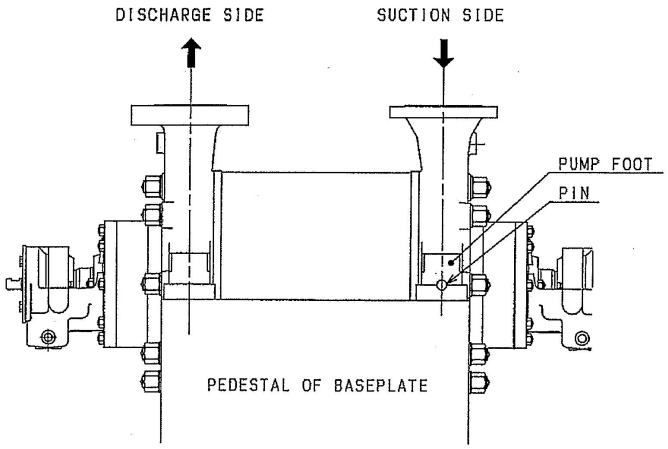


Fig. 2 Fixing the pump foot

1.2. Centering for detail

This pump uses a disc coupling

Refer to the coupling instruction manual.

1) Set a centering jig with dial gauge on the coupling set and adjust its run out to 0.05 mm max in both side face and 0.1 mm max. In peripheral face while reading indications on the dial gauge.
2) Adjustment of the coupling hub faces spacing

Coupling hub face to the face spacing	: 155 mm
Spacing tolerance	: ± 0.5 mm

Adjust the relative position of the pump to the motor with the pump shaft pulled toward the suction side so that the specified coupling hub face spacing is secured. Because the rotating assembly has an axial clearance (play)

2. Pump Outline

2.1. Pump specification and outlined construction

Refer to the following data sheet and drawings for the details.

2.2. Axial thrust balance

This pump adopts a balance disc system for balancing axial thrust, wherein axial thrust acting on the impeller is perfectly balanced by outomatically changing axial clearance in the balancing disc.

This is most important point in maintenance control of this pump model. (Refer to section 4)

The balancing disc system is automaticallty to change axial clearance in the balancing disc and to balance axial thrust by permitting th elifted prerssure to flow between the balancing disc and the balancing disc seat, providing the features as follows.

a) Axial thrust balanced automatically and perfectly.
b) No thrust bearing necessary.
c) Shaft position retained automatically.
d) Water must always be discharge for balancing axial thrust.
e) Simple construction and short overall length, compared with other system.

f) Internal pressure acting on the discharge side stuffing box is low, almost equal to the suction pressure of the pump. This is convenient for maintenance of the pump.

g) Good care must be paid to radial clearance in the balancing disc seat and the balancing disc.

2.3 Minimum flow rate

If the pump is operated in the condition of 0 (zero) or extremely low discharge quantity, most of the power which is transmitted from drive unit (motor) is transformed to heat, due to significantly low pump efficiency, causing the temperature of lifted liquid in the pump to raise abnormally.

In the case of boiler feed water puymp, temperature rise is very remarkable because of high temperature of lifted liquid, small discharge quantity and high horse power.

For this reason, the pump operation under discharge quantity less than a given rate should be avoided.

This operable minimum discharge quantity is called “MIN. FLOW”, indispensable for boiler feed water pump.

3. Operation

3.1 Prior check items for operation start

Check the following without fail before putting the pump in initial operation.

1) Tightening of bolts and nuts in pump, motor and connection flanges
2) Rotational direction of motor (released from direct-coupling)

   Correct rotational direction is counterclockwise viewing from the gear coupling side
3) Center alignment of gear coupling, and lubrication oil level
4) Connection of minor pipings
5) Condition of various meters/gauges

3.2 Prepatory operation for starting

1) Check the lubrication oil level in each bearing unit (pump)
2) Check the lubricant in the bearing unit of the motor

3) Water feed into cooling water line

4) Open/close trhe main pipeline valve as instructed below:

Suction line valve, balance pipeline valve, MIN. FLOW line valve -> OPEN

Discharge line valve -> CLOSE

5) Checking that the gland is clamped with uniform clamping torque by use of a clearance gauge.

6) Opening/closing and checking or minor pipeline valves

7) Air purging and checking (pump, main pipeline, pressure gauge piping)

8) Checking smooth rotation of pump/motor by hand

9) Checking that other starting conditions are ready.

3.3 Checking in inching mode

Prior to test run of the pump after initial installation or periodic inspection or putting the pump in continuous operation after long-period shutdown (rest), turn ON/OFF the motor switch in inching mode to check the following.

1) Smooth stop of pump and motor rotors

2) Each bearing unit to be free from abnormal noise

3) To be free from leakage of lifted water and lubrication oil

4) Pressure gauge to be always in normal run

3.4 Various checks under MIN. FLOW condition

If no abnormally be found upon checking in inching mode, put the pump in continuous operation to check the following.

1) Abnormal noise

2) Flow of MIN. FLOW line

3) Indication on each pressure gauge

4) Leakage from shaft seal to be within permissible rate

5) Amperage to be as rated

6) Temperature of each bearing unit

7) Vibration

Notes

1) Measure and record pressure in each pump component, temperature of each bearing unit, motor current, atmospheric temperature and flow rate at an interval of a given time.

2) Mechanical running-in shall be continued till the temperature of each bearing unit stabilizes. Usually the estimated running-in time approx. 2 hours.

3) In the case of continuous circulation operation in closed cycle using the overheat preventive (MIN.FLOW) line, it is forecasted that the temperature of the tank water rises in comparatively short time. Therefore, control the cooling water feed rate, with good attention to the water temperature.

3.5 Shutting down the pump

When shutting down the pump, measure and record the time from the motor switch OFF till complete stop of the rotor. Also, check that the pump stops smoothly subsequent to stop of the motor.

3.6 Normal running

Time to time, check the above items while the pump is in normal running.

Also, refer to section-4 “maintenance and inspection” for the check items during normal running.

4 Maintenance and Inspection

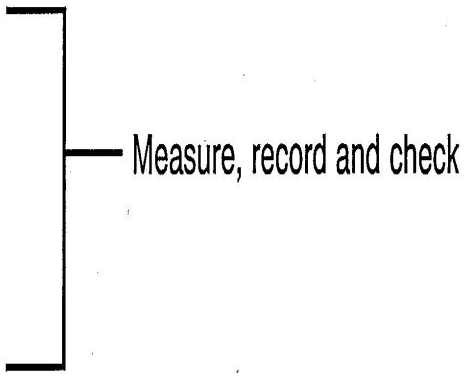
4.1 Routine Inspection

Check, measure and record the check items below in the routine inspection and preset the standard values based on the measured / recorded data so as to find abnormally / fault as early as possible.

ROUTINE INSPECTION ITEMS

1. Oil level in pump bearing unit
2. Abnormal noise from pump bearing unit (by a noise sensing bar)
3. Leakage from shaft seal
4. Leakage from the connections of main pipeline and minor pipings.
5. Flow from the flushing outlet of shaft seal

6. Water feed into cooling water line
7. Ambient temperature
8. Temperature of bearing unit
9. Discharge quantity
10. Amperage
11. Pressure in each pump component
12. Differential pressure in strainer



4.2 Periodic Inspection

Measure and check items below at an periodeic inspection inrterval which is predetermined per your inspection control system, and record.

PERIODIC INSPECTION ITEMS

1. Ambient temperature
2. Temperature of bearing unit
3. Discharge quantity
4. Amperage
5. Pressure in each pump component
6. Differential pressure in strainer
7. Vibration amplitude
8. Pump shutdown time. (from motor OFF till complete stop)
9. Direct-coupling

4.3 Replenishing and Refilling Lubrication Oil

Refer to * subsection 4.5.3) –Lubrication " for lubricating oil replenishing/ refilling (replacement) procedure.

4.4 Periodic inspection (overhaul, inspection)

1) Let us have the content and time of periodic inspection, together with the information of necessary replacement parts.

   Further, record and keep the part names replaced in the inspection.

2) Record and keep the data of test run, after periodic inspection

3) Take the opportunity of periodic inspection to check and adjust each pipeline valve.

4.5 Maintenance and Inspection Procedure

1) Rotor Position indicator

It is not too much to say that proper running of the pump de[ends on whether or not the balancing disc (6010) / balancing disc seat (6020) is in normal condition. A thrust gauge as illustrated in fig.3 is provided on the counter-coupling side bearing unit to enable to check the disc/ seat for normal condition during pump running.

Thrust gauge cover (6230) is mounted on end cover (3610) of the pump and 3 position indication marks are scribed there on perpendicularly to the axial center of the pump. And the center mark of these represent the rotor position during pump running, showing that the balancing disc/balancing disc seat is still in new condition. On the other hand, one of remaining two marks (lines) which is 1.5 mm spaced from the center mark in direction to the pump shows the maximum permissible wear position of the balancing device.

If thrust gauge bar (6240) of the indicator matches the inward mark on the thrust gauge cover (6230). It means that the wear depth of the balancing device has reached the permissible limit. In such case, therefore, balancing disc and balancing disc seat must be replaced with new one.

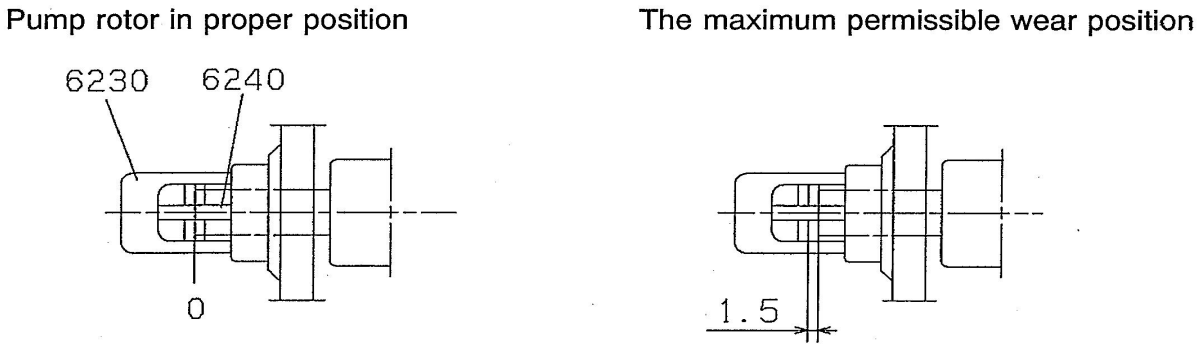


Fig.3 Rotor Position Indicator

2) Adjustment of balancing pressure

In order to prevent the failures due to the vaporization of the pumped water at the balancing device, the throttle valve of the balancing piping line should be adjusted to the following value.

Balance water pressure = Suction pressure + 0 ～ 1.0 kg ／ cm^2G

Balance water pressure may sometimes exceed the specified value even when the throttle valve is fully opened as this is the total of the static pressure up to the deaerator plus the total loss pressure of the balance piping line including the throttle valve. You may keep the operation running even when the balance pressure exceeds the specified value as it will cause no trouble.

You had better make the adjustment of balance water pressure at the initial cold water operation with further fine adjustment later when the water temperature is raised. During the operation for a long period, the clearance between balancing disc seat (6020) and balancing disc (6010) will decrease, so the increased discharging volume of the balance water cause of the resistance in the pipe passage.

As the time the balance water pressure can be adjusted up to the full open level of the throttle valve.

Keep the pressure control valve (throttle valve) fully opened prior to adjusting the balance pressure, and after start up of the operation, slowly close it for pressure control. Never hold the throttle valve fully closed.

3) Lubrication

3) -1 The shaft is supported with two roller bearings in perpendicular direction to it.

Roller bearing (3220) is fixed to bearing housing (3500).

Lubrication system is oil-bath.

3) -2 Oilling into the bearing housings

Pour lubricating oil from the hole of air vent (6701). Check the amount of oil by the oil gauge. On operating, check the oil level periodically and confirm whether oil level is between the lines marked on gauge. Lubricate, if necessary.

The bearing temperature should not exceed 80^0 C

3) -3 Specification of oil

Turbine oil ISO VG32

3) -4 Lubrication times

First oil changes after the first 300 hours of operation, subsequent oil change after 3000 hours of operation approx. But at least once a year. Topping up of the oil fill at least once a monthl,

4) Shaft seal

Gland packing to be inserted in the stuffing box must be such a material suitable to a hot water pump. Adequately clean the packing chamber and the packing sleeve. And apply molybdenum, disulfide to them. Insert and push packing rings, one by one, into the packing chamber by means of gland. In this case, the butt joint of each ring must deviate 90^0 from other rings, as illustrated in fig.4.

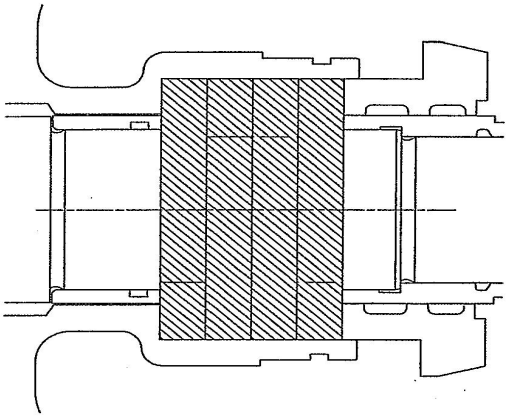


Fig.4 Gland Packing Rings

After the gland packing rings inserted, lightly push each ring with both of the gland and the gland nuts. Thereafter, loosen the nuts and retighten them by hand.

Then, when the suction pressure is acting on the gland packing, check that the gland is clamped with uniform clamping torque (without bias tightening), by use of a clearance gauge.

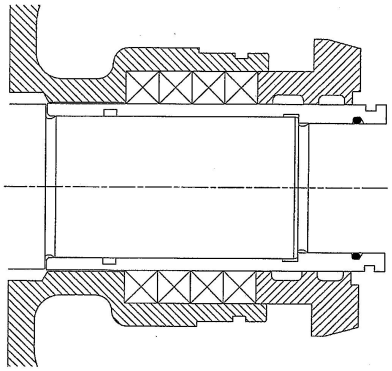


Fig.5 How to Check Uniformity in Gland Clamping

5. Overhaul and inspection

5.1 General

Caution: prior to overhauling, cut off the power supply into the pump motor, without fail to avoid that the power switch turns ON incidentally during overhaul.

Fully close the suction line, discharge line, MIN. FLOW line and other gate valve. Cool down the pump casing until its temperature comes down to the level of ambient temperature and further, hold the casing in negative pressure after complete drain-out. Remove the gear coupling guard after complete discharge of the lubrication oil from there. Separate the coupling halves and take out the spacer sleeve. Thereafter, draw out the gland packing rings, one by one, from the stuffing box. Measure and record the center alignment (parallelism and squareness) between the coupling halves for further reference in reassembling. (refer to centering instruction) also disconnect the minor piping. Refer to the sectional drawing in overhauling and reassembling.

5.2 Overhauling

5.2.1 Overhauling the pump

5.2.1.1 Bearing unit

1. Remove thrust gauge cover (6230) and thrust gauge bar (6240).
2. Return the bend of washer (9310).
3. Remove bearing nut (9230).
4. Pull out the roller bearing inside from the bearing housing (3500).
5. Pull out the coupling hub using a puller jig.
6. Unscrew stud bolt nut (9200.1) and remove bearing housing (3500).
7. Loosen deflector (5070) setting bolt and draw the detector out of the shaft (2100).

5.2.1.2 Shaft seal

1. After unscrewing the gland nut, remove gland (4520).
2. Remove stuffing box housing (4510) and jacket cover (1650).
3. Draw distance sleeve (5250) and packing sleeve (5240) from the shaft.

5.2.1.3 Balancing device

1. Draw out loose collar (5050), sprit ring (5010) and spacer ring (5040).
2. Pull out balancing disc (6010).

3. Draw out balancing disc seat (6020) from the discharge casing (1070)

5.2.1.4 Pump body

1. Unscrew the pump support foot and guide block mounting bolts respectively and then move and put the pump onto a assembly stool by lifting.

2. Remove lagging plate (6801).

3. Loosen tie-bolt nuts alternatively in symmetric position at the discharge side, to such an extent that the initial tightening torque remains slightly in each tie bolt.

4. Draw out tie bolts (9050) completely.

5. Support the suction casing (1080) with wooden squares or assembly stools in such a condition that internal pump components can be overhauled without interference. (see Fig.6)

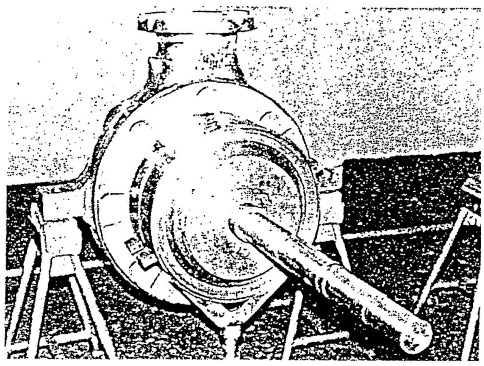


Fig.6 Pump supported at its Suction Casing

6. Remove diffuser last stage (1711) together with discharge casing (1070) from stage casing (1080) and then lift them up, with good care not to damage the seal surfaces thereof.

Note : Put stage No. And match mark on each stage casing, before overhauling the stage casing can be assembled up pursant to these stage No. And match marks.

7. Draw the last stage impeller (2300) from the shaft (2100).

8. Disassemble other remaining stage casings (1080), stage impeller (2300) and stage sleeve (5210) together with remaining stage diffuser (1710).

9. After disassembling the last stage casing (1080), draw shaft (2100) together with 1st impeller (2300) out of suction casing (1060). Thereafter, draw the 1st impeller (2300) out of shaft (2100).

10. Overlay the disassembled stage casings (1080) in such way as protects their sealing surfaces from flaw/damage. (see Fig.7)

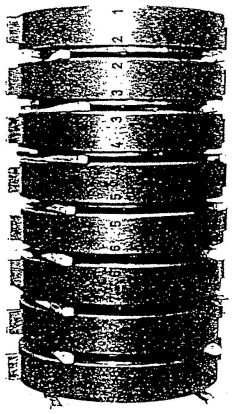


Fig.7 Overlaid Stage Casings

5.2.2 Inspection of pump components

5.2.2.1 Shaft (2100)

Set the shaft on the lathe and examine its center deviation (run-out) at the both ends.

The maximum permissible run-out of the shaft shall be 0.05 mm.

As a rule, further re-use of the distorted shaft shall not be allowed, wheter repaired or not repaired by cold or hot straightening. If this run-out exceeds the maximum permissible value, the shaft must be replaced with new one.

Note : Its important to center the shaft on the lathe (between the chuck device and tail stock of the lathe). Otherwise, run-out cannot be measured precisely

5.2.2.2 Casing (1060/1070/1080) and impeller (2300)

Be sure to check that all the sealing surfaces of suction casing (1060), discharge casing (1070), stage casing (1080) and impeller (2300) are free from surface flaw / damage.

For checking the plane parallelism and squareness among these sealing surfaces, put a micrometer alternatively on the peripheral surfaces at 4 equally-spaced points. Permissible deviation from the perfect parallelism shall be 0.02 mm Min. Damaged sealing surface is corrected with the lathe. Rough on the surface must not exceed 0.8 μ (super-finish processing).

As for the sealing surface in adjacent stage casings (3rd stage and 6th stage), the distance on the sealing surface in the top part is processed so that only a constant amount may narrow more that it in the bottom. Because to make pump casing agree with deflection of shaft and adjust. These stage casings mark the character “OBEN” to an outside top part. And, the order of the standard title is marked to the relating sage casings. When the sealing surface of these stage casings is finished up. Its necessary to maintain the difference in dimension between the top part and the bottom

5.2.2.3 Roller bearing (3220)

However slight discoloration or ruct or crack it can be seen at the bearing, it must be replaced with new one.

5.2.2.4 Shaft seal

When the depth of the hollow that can be done by sliding with the ground packing became 1.5 % or more of the size of the outside diameter of the packing sleeve (5240). Its exchanged for the new one.

Once stuffing box packing (4610) were taken out from the stuffing box housing (4510), they must be replaced with new ones.

5.2.2.5 Balancing device (disc/seat)

Check the inner surface of balancing seat (6020) for existence or not of circumferential flaw. If flaw be found upon checking, remove it by lathe-turning. However, the seat clearance which increases due to lathe-turning shall not exceed the maximum permissible value shown in table 1 “rotor clearance”.

Also, check balancing disc (6010) and balancing disc seat (6020) for existence of surface flaw. If sliding flaw mark be found on the balancing disc and seat, remove it by lathe-turning. After lathe-turning, the sliding surface must keep adequate center accuracy, measuring it based on the inside diameter.

The amount of the exchange standard wear-out of the thickness of sliding surfaces of balancing disc (6010) (amount of the processing) is 2 mm.

When sliding surfaces are corrected and processed, the squareness and the parallelism are processed so as not to ruin it. A permissible value of the squareness and the parallelism is 0.02mm

5.2.2.5.1 Checking contact surfaces of balancing device

The contact surfaces of the balancing device must be checked after repair or replacement of disc and seat (6010/6020).

Apply thin coat of marking ink to the axial sliding surface of balancing disc (6010).

Clean the axial sliding surface of balancing disc seat (6020) throughout its entire area.

In Reassembling the balance device, follow the instruction in Para.5.3.3.

In Reassembling the packing sleeve (5240), stuffing box housing (4510) and bearing unit , follow Para.5.3.5.

Note :

Don’t forget to fit O-rings. Take up the rotor, and then push-in it toward the suction side while slowly turning it. Thereafter, reversely pull the rotor backward (toward the discharge side). After pulling, demount balancing disc seat (6020) and all other parts located before it.

After that, carefully observe the sliding surface of balance disc seat (6020) to check the ink coated on balancing disc (6010) is equally transferred onto the entire surface or otherwise, at least, more than 3/4 of the total sliding peripheral sliding surface area. If this requirement is not met upon checking, balancing disc seat (6020) must be re-repaired by lathe turning. Thereafter, the contact surface thereof must be rechecked in the same way as the above.

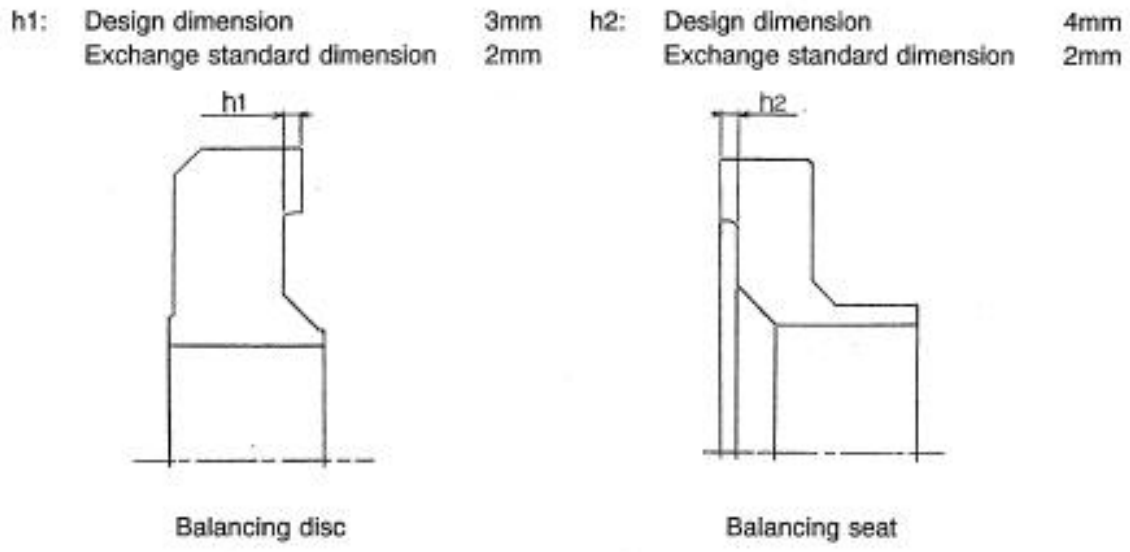


Fig.8 Dimension on sliding surfaces of balancing disc and balancing seat

5.2.2.6 Dynamic balance of rotor

After some rotor part was repaired or replaced with new one, the rotor must be dynamically balanced.

Assembling the rotor to check dynamic balance

- Assembling from shaft drive side

  1. Fit key (9400.2) and insert packing sleeve (5240) with no O-ring (4120.3) to the shaft (2100)

  2. Insert distance sleeve (5250), deflector (5070), spacer peace (5041), roller bearing inside and fix them by bearing nut (9230).

- Assembling from counter-drive side

1. Fit impeller key (9400.4)

2. Insert stage sleeve (5210) and stage impeller (2300), one by one, in the shaft (2100).

3. Insert balancing sleeve (5252), balancing disc (6010), with no O-ring (4120.7), insert spacer ring (5040), spit ring (5010) and fix them with loose collar (5050), in this condition, check that axial clearance between impeller (2300) and balancing sleeve (5252) is approx. 0.3-0.5 mm

4. In the same way of drive slide, insert packing sleeve (5240), spacer sleeve (5250), deflector (5070), spacer peace (5041), roller bearing inside and fix them with bearing nut (9230.2).

5. Prior to dynamic-balancing, measure run-out of the rotor at the impeller (2300) and the bearing unit respectively. The permissible run-out shall be 0.07 mm max.

6. After completion of the above checks and repairs, overhaul again the rotor in reverse sequence of the above.

5.2.2.7 Rotor clearances

	Clearance in new rotor, against diameter (mm)	Max. permissible clearance against diameter (mm)
Casing wear ring (5020) and Impeller (2300)	0.25 ~ 0.42	1.0
Diffuser (1710) and Stage sleeve (5210)	0.30 ~ 0.40	1.0
Balancing disc seat (6020) and Balancing sleeve (5252)	0.30 ~ 0.38	0.8

Table 1. Rotor Clearances

Note :

If any of the masured values exceeds the maximum permissible value specified in Table 1, sliding parts must be replaced with new ones.

5.3 Reassembling

5.3.1 Reassembling the pump

Reassembling should be performed by an experienced and skilled maintenance man. Apply roper coat of graphite or similar lubricant to the fit-in portion of each pump component, prior to reassembling. Similarly, apply it to screwed joints and screw crest, too. Check all O-rings and the shaft seal ring (impeller end face) for surface flaw mark. If necessary upon checking, replace them with new ones.

Preliminary step prior to reassembling

To obtain E1 = E2, check axial face-to-face distance "E" between each stage casing (1080) and corresponding stage impeller (2300) . (see Fig.9)

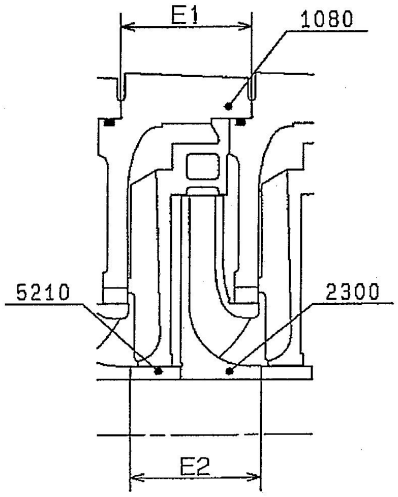


Fig.9 Verification of Face-to-Face Distance（Clearance）in each stage

If further minor machining of the stage sleeve (5210) is deemed as necessary, refining the stage sleeve end faces of the boss by lathe-turning, after having chucked it at single end. In this case, tolerance in the plane parallelism shall be 0.02 mm.

Note :

Take good care not to damage contact surface of stage casing (1080), impeller (2300) and stage sleeve (5210). In addition, clean adequately all pump construction parts.

5.3.2 Reassembling the pump body

1. Coat the shaft (2100) with molybdenum disulphide or a similar approved liquid.

2. Insert key (9400.2) and packing sleeve (5240) with O-ring (4120.3)

3. Insert key (9400.3) for 1st stage impeller, slip 1st impeller (2300) onto the counter-drive end of the shaft (2100).

4. Insert the shaft (2100) together with impeller (2300) into suction casing (1060)

5. Insert O-ring (4120.5) in suction casing (1060)

6. Mount stage casing (1080) together with diffuser (1710), insert stage sleeve (5210) and impeller (2300) into shaft

7. Mount the other stages in the same way. (stage = impeller, stage sleeve, and stage casing with diffuser and O-ring)

8. After mounting each stage check the overall axial clearance Sa1+Sa2 (6.5 mm) of the impeller. (Fig.10)

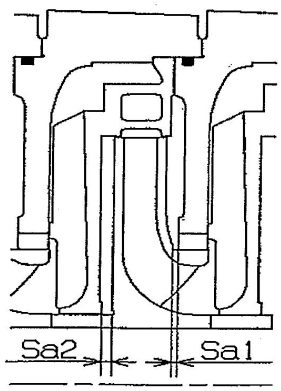


Fig.10 Total Axial Play

9. Insert last stage diffuser (1711) and O-ring (4120.6) in the discharge casing (1070).

10. Mount the discharge casing (1070) complete with last stage diffuser (1711).

11. Slip washer (5500) onto the suction end tie bolts (9050), screw hexagonal nut (9200.2). insert tie bolt (9050) into the casing (1060) from suction side.

12. At the discharge end, coat the screw threads and washer (5500) with molybdenum disulphide, and tighten the hexagonal nut (9200.2) by hand with the aid of a standard short open-ended spanner up to the point where contract between the metallic sealing faces of adjoining stage casings (1080) is ensured

13. Place the pump on its base plate, make sure that the pump feet seat flush on their seating faces on the base plate.

14. Tie bolt (9050) is tightened by the torque 200 N.m. it mnakes a start point there, division lines “SKT” showing the nut tightening degree are punched on the top of the bearing housing (3500).further tighten each hexagonal nut (discharge casing side) by turning it clockwise by turns equivalent to the number of punched division lines. These hexagonal nuts shall be tightened gradually, alternatively and uniformly in symmetric position. When great tightening torque is required, use a few chain blocks to turn the spanner wrench to tighten the nut by lever action.

5.3.3 Reassembling the balancing device

1. After cleaning all assembling parts completely, coat thinly sliding face of balancing device with molybdenum disulphide or oil.

2. Mount gasket (4000.3) between discharge casing (1070) and balancing disc seat (6020), screw hexagon socket head cap screw (9140.1).

3. Measure and adjust the positions of balancing sleeve (5252) as instructed in Para.5.3.4 “adjustment of rotor position”

4. Fit O-ring (4120.7) in the groove of balancing sleeve (5252) and insert it through the shaft (2100).

5. Fit O-ring (4120.7) in the groove of balancing disc (6010) and insert it through the shaft (2100) with key (9400.5)

6. Fit spacer ring (5040) and split ring (5010) in the groove of shaft (2100) and insert loose collar (5050).

5.3.4 Positional adjustment of rotor

First displace the rotor toward the pump discharge slide till it comes into contact with the discharge casing. Then, displace it in reverse direction (that is, toward suction side) by approximately 1/3 to ½ (approx. 3 mm) of the total axial displacement. (See Fig. 11)

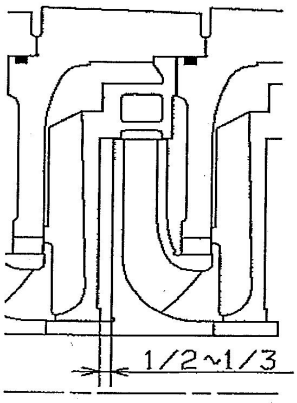


Fig.11 Rotor Position at Measuring Start

Note : The shown rotor position shall remain unchanged in subsequent measuring

5.3.5 Adjustment of rotor

(1) Measuring the distance “a” between the contact surface of balancing disc seat (6020) and the hub face of last stage impeller. (see Fig.12)

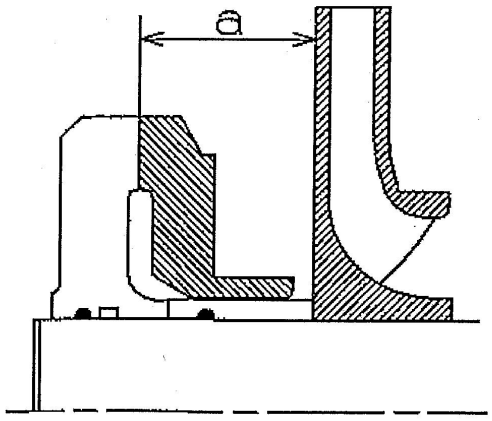


Fig.12 Adjusting Distance "a" in Rotor

(2) Measure the distance “b” between the contact surface of balancing disc (6010) and the end face of balancing sleeve (5252). (see Fig.13) refinish (adjust) the balancing sleeve (5252) so that b=a – 0.3-0.5 mm is reached. In this case, re-finishing shall be performed carefully not to interfere with the paralellism of the balancing sleeve (52520 and faces. The end face to face parallelism shall be 0.02 mm max.

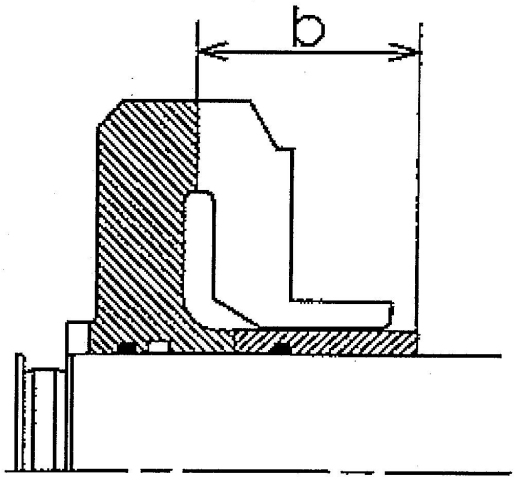


Fig.13 Adjusting Distance "b" in Rotor

(3) Insert balancing disc (6010) in the shaft (2100)

Measure the distance “c” with balancing disc (6010) kept in contact with balancing disc seat (6020). (See Fig.14) . Refinish spacer ring (5040) so that “c” = the length of spacer ring (5040). In this case, refinishing must be performed carefully not to interfere with the parallelism of the ring and faces. The end face to face parallelism shall be 0.02 mm max.

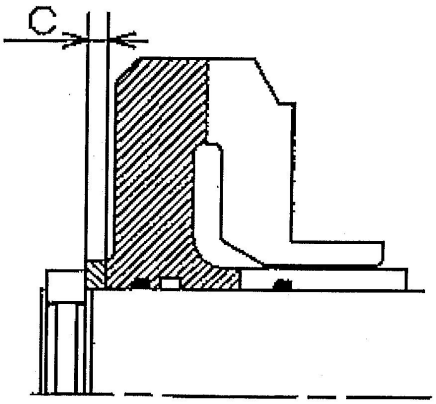


Fig.14 Adjusting Distance "c" in Rotor

5.3.6 Reassembling the shaft seal

1. Fit key (9400.2/6) in shaft (2100), and insert packing sleeve (5240) with O-ring (4120.3). Then, insert O-ring (4120.2) and distance sleeve (5250) in shaft (2100).

2. Insert stud bolt (9020.1) in suction casing (1060) and discharge casing (1070). Mount stuffing box housing (4510) together with gasket (4000.2)

3. Fit O-ring (4120.4) in the groove of stuffing box housing (4510) and fix jacket cover (1650) together with gasket (4000.1) by hexagonal socket cap screw (9140.2)

4. Screw stud bolt (9020.2) to jacket cover (1650).

5. Mount gland (4520) in packing sleeve (5240)

6. Insert deflector (5070) in distance sleeve (5250).

5.3.7 Reassembling the bearing unit

1. Mount bearing housing (3500) with roller bearing (3220) outside and fix it with hexagonal nut (9200.1)

2. Insert spacer ring (5041) and then fit roller bearing inside. Compare end face of inside with that of outside, adjust distance sleeve (5250) to be 2 mm back at suction side and 2 mm front at discharge side comparing end face of roller bearing inside with that of outside. (considering wear of balancing disc (6010), balancing disc seat (6020))

3. Insert washer (9310) in shaft (2100) and fix it with bearing nut (9230.1/2)

4. Bend washer (9310) on the groove of bearing nut.

5. Screw pivot for indicator 6240) in shaft (2100)

6. Mount bearing end cover (3610) together with rotor position indicator (6230) and O-ring (4120.1)

7. Check the scribed marking on the rotor position indicator (6230) with the balancing disc (6010) abutting against the balancing disc seat (6020), if necessary, screw a new marking on the indicator.

8. Mount bearing cover (3600) in bearing housing (3500) together with O-ring (4120.1)

9. After inserting coupling, align.

10. Lubricate oil into bearing housing (3500)

5.3.8 Coupling

When the coupling hubs are mounted in warm condition, they should be pre-heated in an oil bath or an electric hot plate to between 120 and 150^0 C before mounting.

6. Troubleshooting

Possible troubles	Possible causes and countermeasures (Refer to Item Nos. listed below)
Short discharge	1, 2, 3, 4, 5, 6, 7, 8, 9, 23
Overloaded motor	9, 10, 11, 18, 22, 23
Abnormally high temperature of bearing unit	16, 18, 19, 20, 21, 26
Leakage from pump	15, 18, 24
Overleakage from shaft seal	13, 14, 15, 16, 17, 18
Abnormal rotation of pump	3, 6, 7, 9, 10, 12, 16, 17, 18, 20, 25, 26 27
Overrise of internal temperature in pump	3, 6, 27
Nonuniform balancing water discharge pressure and quantity	3, 6, 9, 19, 28

Possible causes and countermeasures

1. Abnormally high discharge pressure

- Open the discharge valve till the rated operating point is reached

2. Abnormally high back pressure.

- Replace with larger size impeller

- Check pipeline for clog with dust

3. Incomplete air purging from pump or pipeline, or short priming

- Perform complete air-purging and complete priming

4. Clogged suction pipeline or impeller

- Remove deposited matters from pump or pipeline

5. Air pocket in pipeline

- Modify piping layout

- Add an air vent valve, if necessary

6. Too low NPSH (force lift)

- Check water level in a suction pump

- Open suction line control valve.

- When friction loss in suction pipeline is excessively great, change it into a different suction line, if necessary.

- Check suction line strainer

- Check pressure drop velocity for excess to the permissible data

7. Reverse rotation

- Interchange two of three-phase power wires

8. Very low rotational speed

- Increase supply voltage

9. Over wear of pump internals

- Replace worn parts with new ones

10. Pump back pressure lower than the specified value in ordering

- Adjust properly to rated point by means of discharge line control valve

- If overload continuous, re-machine impeller if deemed as necessary.

11. Specific gravity or viscosity of pumping liquid higher than those specified in the purchase specifications

12. Faulty coupling

- Replace with new set

13. Wear of shaft seal

    - Check shaft seal condition and replace it with new one, if necessary.

14. Slotted or scratched or roughed surface of packing sleeve

    - Replace it with new one

15. Short cooling water or dirty and clogged cooling chamber

    - Increase cooling water flow rate

    - Clean cooling chamber

    - Purify cooling water

16. Abnormal rotation pump

    - Normalize suctioning condition

    - Check center alignment of pump unit and re-center it if necessary

    - Readjust dynamic balance of pump motor

17. Imperfectly centered pump unit

    - Check center alignment between coupling halves and make re-centering if necessary

18. Distorted pump

    - Check piping connections and pump mounting bolts

19. Axial over thrust

    - Replace casing wear ring with new one

20. Low level lubrication oil or improper quality of lubrication oil

    - Increase oil level or use lubrications oil of better quality

21. Coupling spacing not secured as specified

    - Adjust properly it as per the data given in outline drawing

22. Too low operating voltage

23. Single phase running of motor

    - Replace faulty fuses

    - Check cable connector

24. Loose tightening bolts

- Retighten bolts
- Replace gaskets with new ones

25. Imbalanced rotor

- Clean rotor
- Readjust dynamic balance of rotor

26. Faulty bearings

- Replace it with new one

27. Short flow rate

- Increase it up to required minimum flow

28. Wear of balancing device

- Check rotor clearance and balancing device