NMC 21

NYK Maritime College

NYK SHIPMANAGEMENT

Purifier Training

NYK SHIPMANAGEMENT PTE LTD
1 Harbour Front Place, #15-01 Harbour Front Tower One,
Singapore 098633, Tel: 65-6416 7500, Fax: 65-6416 9921

Applicable Trainees: Engine Officers

Objectives of the Training:

After completion of the training, the trainees should understand the followings:

1) Principle of Separation

2) Method of selection of Gravity disc

3) Basic operation of Separation

4) Maintenance works

5) Case Studies

Duration of Training: 1 Day

Course Schedule:

	Contents of the Course	Contents of the Course
	AM	PM
1st Day	Lecture on Principle, Operation, etc.	Maintenance works on actual separator

Contents and Syllabus

1. Principle of Separation: The separation process is required

1. to separate solid particles from a liquid, e.g. sludge / dirt from oil

2. to separate liquids of different densities which are mutually insoluble e.g. water from oil.

1.1 Centrifugal Force and Discs:

When removal of Water and Solid impurities from a Liquid mixture is required, it can be performed in two ways. These two processes are:

a) Separation due to Gravity force:

In this process, the main Separating Force between a water particle and an oil particle is equal to the difference between the gravitational forces acting on them. This can be explained by the following examples:-

Example No. 1 : When a mixture (except the emulsified mixture) of oil, water, and sediment stands undisturbed in a container, gravity tends to form an upper layer of oil, an intermediate layer of water, and a lower layer of sediment. These layers form because of the difference in specific gravity of the materials in the mixture. An oil-and-water

interface will form at o'-o. This has been explained in the Figure 1.1.

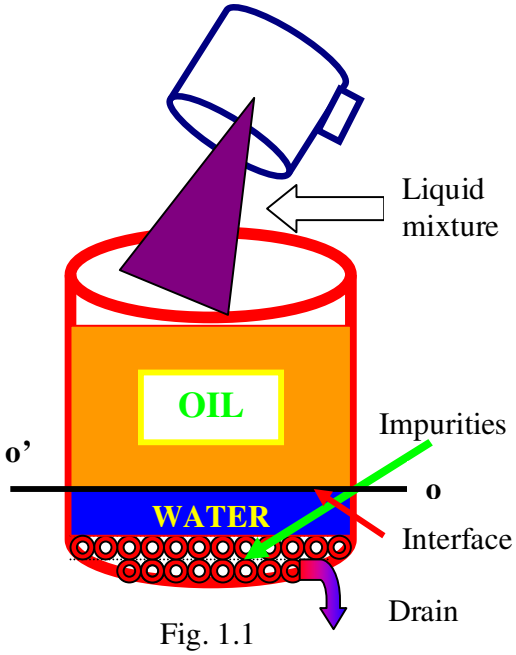


Fig. 1.1

The Separation force between two liquids or between liquid and solid particles is directly proportional to the Difference in their Densities. The higher is the difference, the faster will be the separation rate.

Example No. 2:

Case 1: If we take a U-tube and pour water from 'a' side, the top surface of water will be at the same level in both sides.

Case 2: If now Oil is poured from 'b' side in the same 'U' tube, the top surface of water and oil will be at different levels. This is due to the difference in their densities (or specific gravities). An oil-and-water interface will form at o'-o.

This has been shown in Figure 1.2.

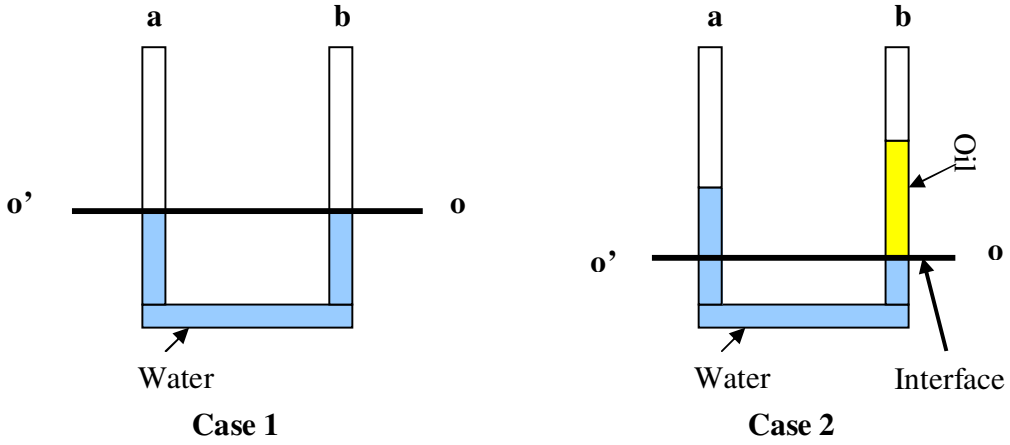


Fig. 1.2

ase 3: Now, an inlet for supplying mixed liquids is installed at the interface o'-o and two outlets are installed, one on the oil side and another on the water side, on the same U-tube. In case, water is supplied at the position 'o', then only Water comes out from water outlet.

Case 4: In case, a mixture of oil and water is supplied at the position 'o', oil and water will separate out due to difference in their densities or specific gravities. Now, Oil will come out from the oil outlet and water at water outlet. The interface position will be maintained at o'-o.

This has been explained in the Figure 1.3.

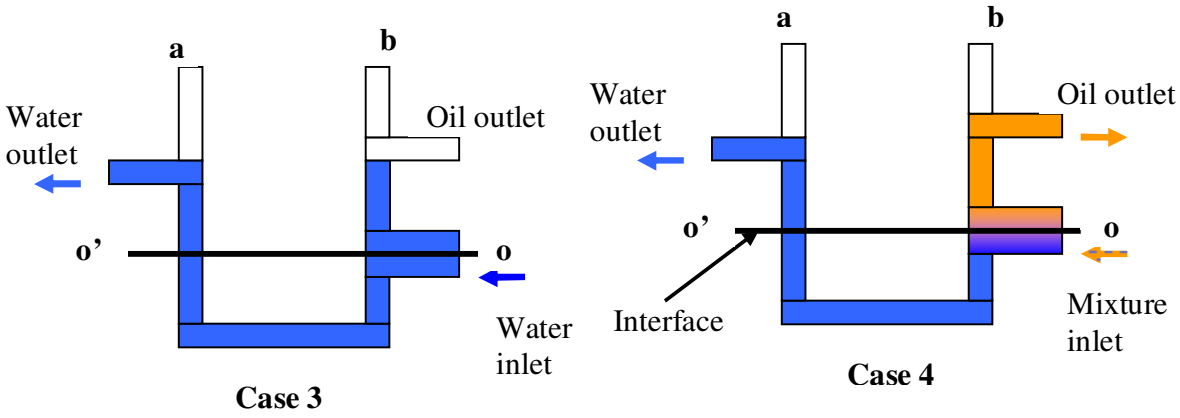


Fig. 1.3

This type of Separation normally takes place in oil settling tanks and service tanks. As the difference in their densities is very less, the separation process is very slow and not sufficient to provide oil in a condition, which can be used directly in the system.

b) Separation due to Centrifugal force:

In this process, the main Separating Force between a small volume of Water or small amount of solids and the surrounding Oil is equal to the difference between the centrifugal force acting on the water or solid particles and the centrifugal force acting on the oil particles due to difference in their densities. This has been explained by the following examples:-

Example No. 1 : If a liquid mixture containing oil, water and some solid impurities is filled up in a container or tank and it is rotated, they will separate out after a while and

will occupy different positions in the container. An oil-and-water interface will be formed at o'-o. This is due to different Centrifugal force, arising due to difference in their

Densities (or Specific gravity), experienced by them. This phenomenon has been explained in the Figure 1.4.

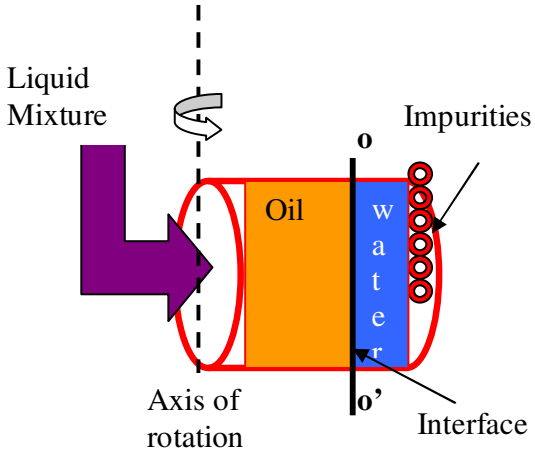


Fig 1.4

The Separation force between two liquids or a liquid and solid particle is directly proportional to the difference in their Densities and the square of Linear velocity. This method of separation is very useful when the difference in densities of water and oil in a mixture is very less. Since the separation force is directly proportional to square of linear velocity, it can be increased many fold by rotating the container at permissible high speeds.

The main idea of this separation process is to displace all water particles or solid contaminants in the oil on the outward side of oil/water interface so that water and solid contaminants can be removed from separate outlets.

The large water particles will experience a greater separating force than the smaller size water particles. Thus, the large particles get separated out faster than the smaller size particles and quickly reach a position outward of oil/water interface. The smaller size water or solid particles take long time to separate out and hence, for effective separation process, very careful monitoring of separation process is required.

Example No.2:

Case 5: If the "U" tube in 'Case 4' above is kept horizontally and rotated at high speed, the centrifugal force instead of gravity force acts on the oil/water/solid particles. Since the centrifugal force on the water or solid particles is greater due to higher density than that acting on the oil particles, the water or solid particles move out and reach a position outward of oil-and-water interface. This has been explained in the Figure 1.5.

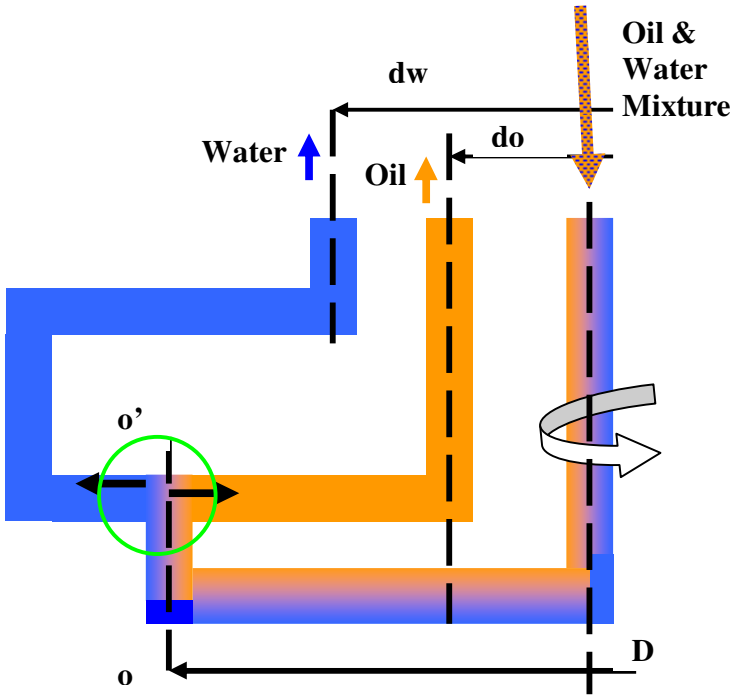


Fig. 1.5

In the above diagram, an oil-and-water mixture is supplied to "U" tube, the oil-and-water interface o'-o is formed at diameter "D", water discharge will be at diameter "dw" and oil discharge at diameter "do". Since the Centrifugal force is much higher than the gravitational force, the separation of liquids and solids from the mixture will be faster.

Case 6: If the rotating "U" tube is replaced with a rotating bowl of centrifuge. The position of oil - and - water interface at diameter "D" and discharge of lower density separated oil is fixed at diameter "do" for a given density mixture. If density of mixture, being separated, changes, the position of oil-and-water interface will also change. This has been explained in the Figure 1.6.

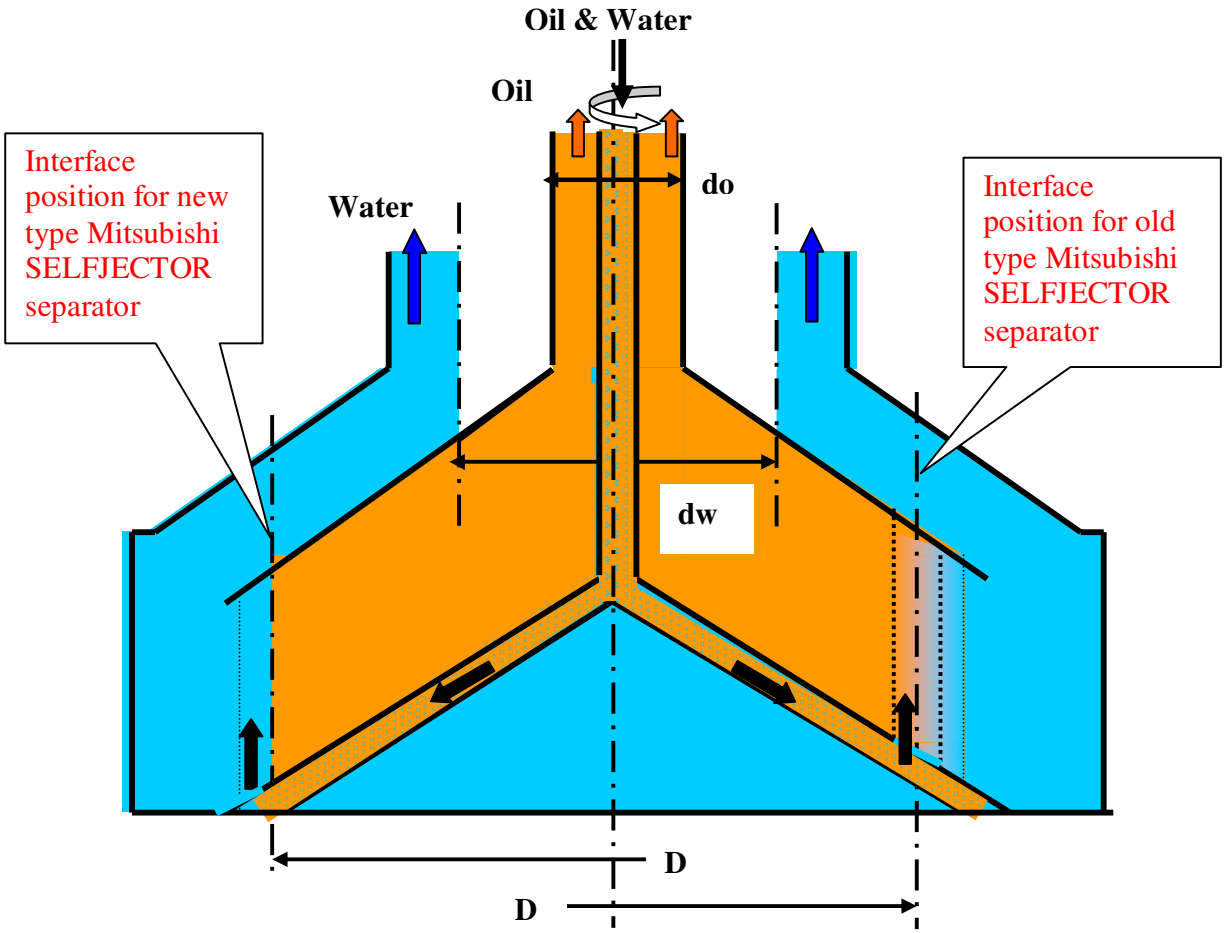


Fig. 1.6

In that case, by adjusting the position of water outlet "dw", the position of oil-and water interface can be maintained at an optimum position to achieve best purification.
The position of the interface is adjusted to maintain it within a safe range by altering the outlet diameter of the water side. This is achieved by exchanging the Gravity disc.

Thus it is evident from above examples that in the purification of fuel, centrifugal force is the fundamental principle of operation. Centrifugal force is the force that is exerted upon a body or substance by rotation. Centrifugal force impels the body or substance outward from the axis of rotation.

A centrifugal purifier is essentially a container which is rotated at high speed while contaminated oil is forced through, and rotates with, the container. However, only materials that are insoluble in the oil can be separated by centrifugal force, distillate (e.g. Gas oils) cannot be separated from lubricating oil, nor can salt be removed from seawater by centrifugal force. Water, however, can be separated from oil because water and oil do not form a true solution when they are mixed. Furthermore, there must be a difference in the specific gravities of the materials before they can be separated by centrifugal force.

If the oil, water, and sediment are placed in a container which is revolving rapidly around a vertical axis, the effect of gravity is negligible in comparison with that of the centrifugal force. Since centrifugal force acts at right angles to the axis of rotation of the container, the sediment with its greater specific gravity assumes the outermost position, forming a layer on the inner surface of the container. Water, being heavier than oil, forms an intermediate layer between the layer of sediment and the oil, which forms the innermost layer.

The separated water is discharged from water outlet and the oil is discharged from clean oil outlet. The solids remain in the rotating unit. Separation by centrifugal force is further affected by the size of the particles, the viscosity of the fluids, and the time during which the materials are subjected to the centrifugal force. In general, the greater the difference in specific gravity between the substances to be separated and the lower the viscosity of the fuel, the greater will be the rate of separation.

The efficiency of a separation process depends upon:

> Flow rate
> Settling area i.e. gap between the Discs
> Settling velocity
> Viscosity or Separation temperature
> Density or Specific gravity of liquid to be treated
> Size of the contaminants

1.2 Importance of oil-and-water interface:

If the separator is running as purifier, it is necessary to hold the oil-and-water interface in the bowl within a definite range. The position of the interface is controlled by varying the outlet diameter of the heavy liquid (water) side, which in turn is achieved by the use of gravity discs of different inside diameters.
If a gravity disc of large inside diameter is fitted, it moves the interface outward and vice versa. The location of Gravity disc has been shown in the Figure 1.7.

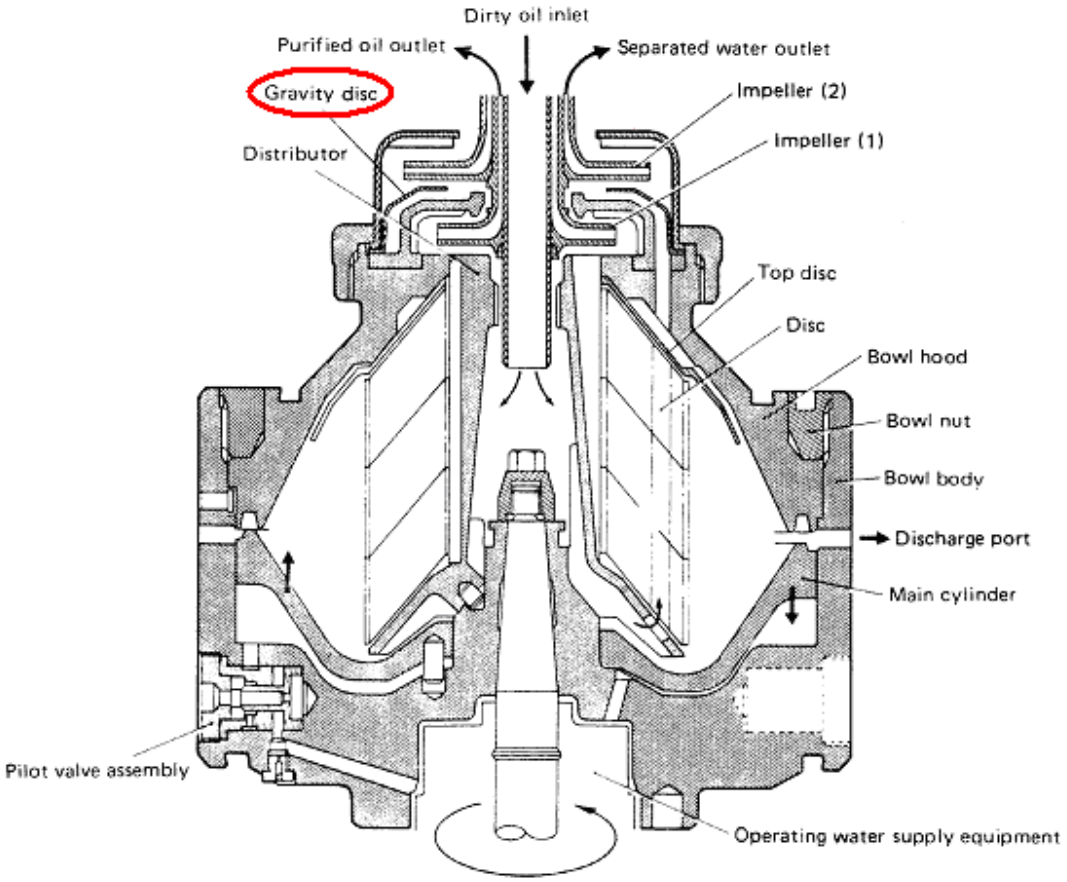


Fig. 1.7 For Separator model SJ20T~60T

The following factors affect the position of Interface:
> Size of Gravity disc
> Density or specific gravity of oil, Viscosity of oil, Temperature of oil & Flow rate
In order to get the best possible separation result, Water must never enter the disc stack.

The movement of Interface according to change in any one of Input conditions has been explained with the help of Figures 1.8 and 1.9.

Case 1:

Change in Input Condition	Effect in Output condition
Too small Gravity disc	Interface will move inside
Decrease in oil density	Water coming in clean oil outlet
Decrease in oil viscosity	Water blocking the disc stack
Decrease in flow rate	Finally, risk of bad separation
Increase in oil temperature	

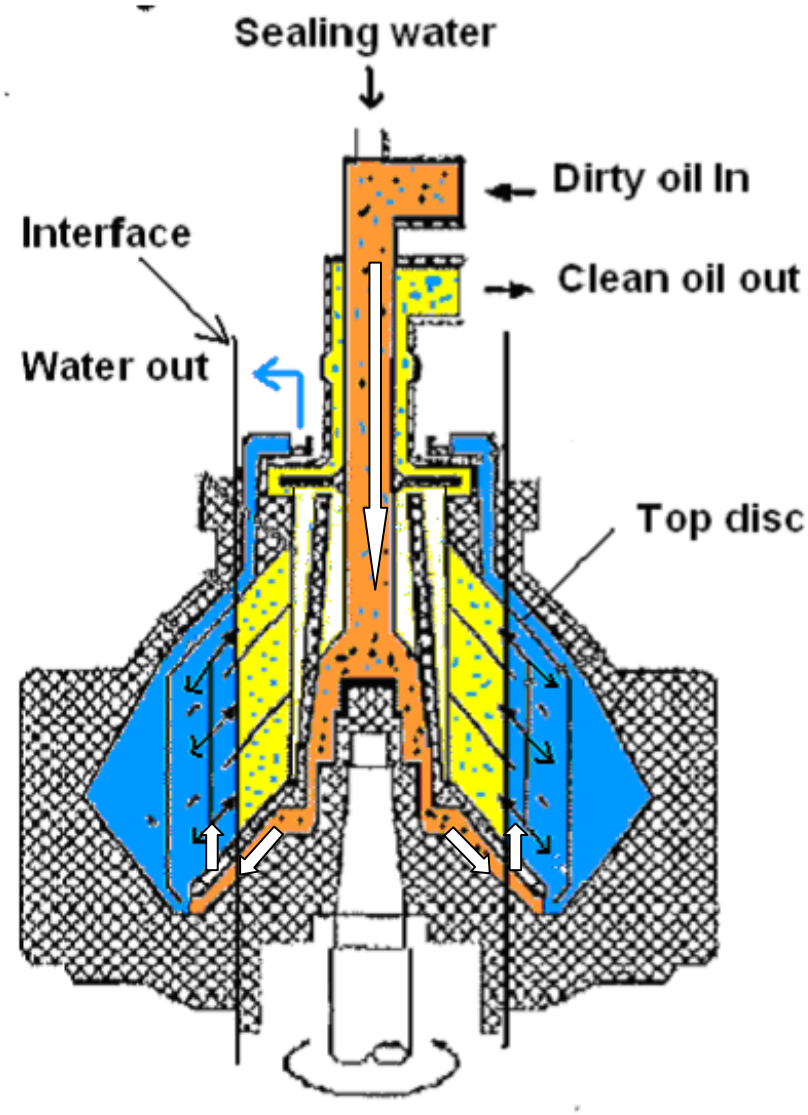


Fig. 1.8

Case 2:

Change in Input Condition	Effect in Output condition
Too big Gravity disc	Interface will move outside
Increase in oil Density	Risk for broken water seal
Increase in oil Viscosity	Oil in Water outlet
Increase in Flow rate	Finally, loss of oil
Decrease in oil Temperature	
Dirty Disc stack	

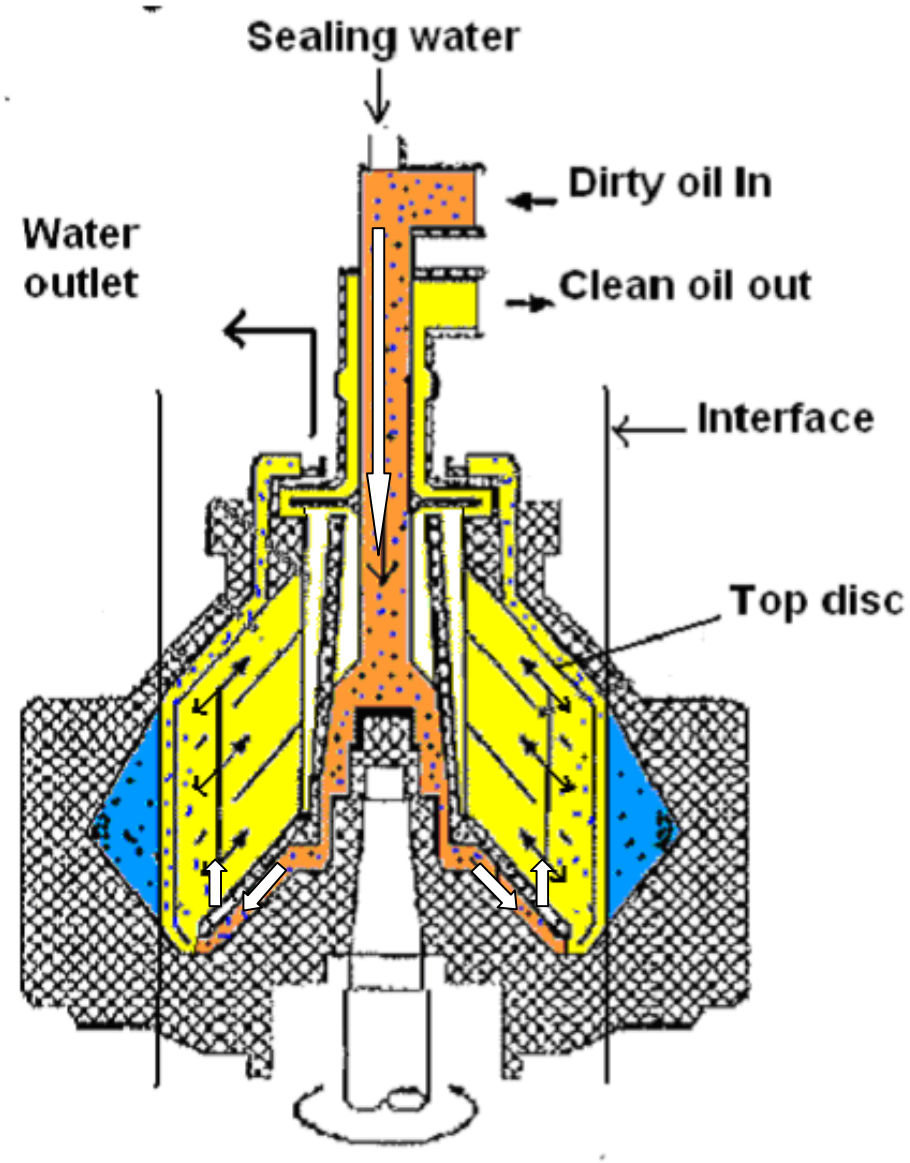


Fig. 1.9

Factors required to maintain the position of Interface:

> Correct gravity disc size
> Clean disc stack
> Maintain following feed conditions:
++ Constant oil properties i.e. Viscosity & Density
++ Constant Flow rate
++ Constant Temperature

Sensitivity of Interface Position:

The Figure 1.10 below shows the effect of change in Temperature on the Interface position for various mineral oils in Marine & Diesel applications.

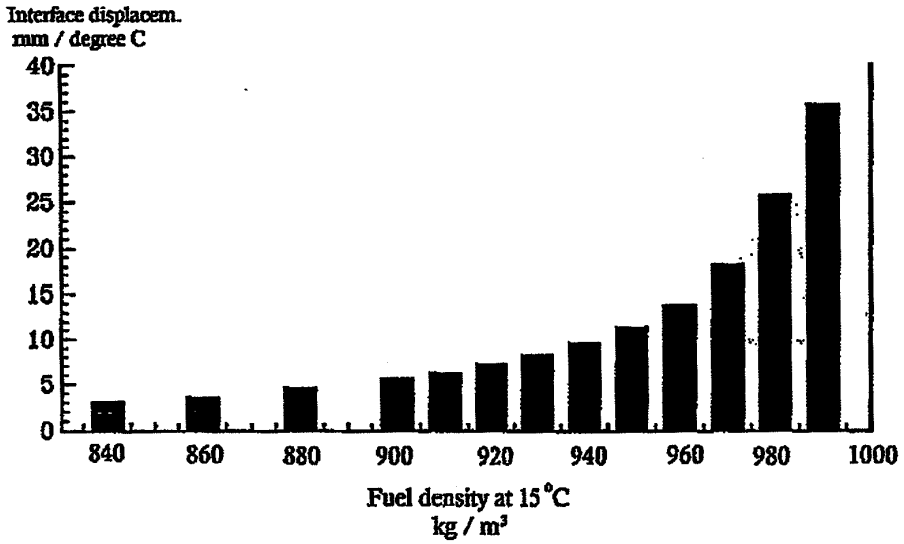


Fig. 1.10

Source: Alfa Laval

1.3 Selection of Gravity Disc:

The selection of gravity disc depends upon the following factors:
1) Specific gravity of feed oil at 15ºC or at any other given temperature
2) Feed rate
3) Feed oil temperature

How to decide Feed rate:

For fuel oil, the feed rate is mainly governed by the daily fuel oil consumption. It is recommended that the separator should operate at about 50-70% of capacity.

If the oil quality is over specification and its properties exceed NYK specifications, it is recommended to operate available purifiers in parallel operation and reduce the feed-oil rate to about 30% for each purifier.

The minimum feed rate is limited by the controllability of constant temperature.
When the feed rate is changed drastically, it is necessary to recheck whether the gravity disc is appropriate and if required, change it, since the feed rate is one of the governing factors in the selection of gravity disc.

For lube oils, the recommended feed rate is the minimum possible feed rate at which separation temperature can be maintained. This minimum feed rate will help in removing the finer impurities. For a continuous separation system, it is better to circulate the full system oil through the separator 5~6 times/24 hrs rather than circulating it 10~15 times/24 hrs with increased feed rate.

The Flow rate should be adjusted if the separation temperature or the size of impurities changes. This is shown below.

Example 1:

If particles of 10µm in the oil can be separated efficiently at the flow rate of 1000 l/hour, then can particles of 5µm in the same oil be separated efficiently at the same flow rate?

- No

Since as per Stokes' law, to get the same separation efficiency
Flow rate α (particle size)²
So in this case, the flow rate = 1000* (5/10) ²= 250 l/hour
So, the Flow rate should be reduced by 75%!!!

Example 2:

Case 1:- Separation temperature =98°C, Viscosity= IFO 380 37.1cSt, Flow rate = 1000 l/hour
Case 2: Separation temperature = 90°C, Viscosity = 49.9cSt, Flow rate =???
As per Stokes' law, to get the same separation efficiency
Flow rate α 1/ Viscosity (η)
So, the flow rate should be = 1000 * 37.1/49.9 = 743 l/hour
So, the flow rate should be reduced by 26%.

Selection of centrifugal separators is normally based on Maximum Recommended Capacity (MRC) tables, provided by separator manufacturer. But separation performance at these capacities is unspecified.

A new method for assessing separation performance has been presented by DNV and this is being evaluated by six other classification societies. The capacity, defined by this method is called Certified Flow Rate (CFR).

Certified Flow Rate is:
> A capacity lower than Max. recommended capacity for all separator suppliers
> An objective and reproducible way to compare fuel separators
> Basis for a new Type Approval (CFR) of separators and for a new Separation Performance standard

Certified Flow rate ensures:
> High reliability of engine plant
> Ample margin against excessive wear of diesel engine

A separation standard is needed for:
> Safe and reliable cleaning of fuel oil
> Control of engine wear
> Historical results on bunkers cannot be used for reference – bunkers are too different
> Transparency – possible to compare separators from different suppliers

How to decide Feed oil temperature:

The oil should be heated to obtain an appropriate reduction in viscosity and specific gravity as this will help in efficient and quick separation of water impurities as explained before.

However, the oil temperature should be maintained less than 100ºC to avoid evaporation of the sealing water and damage to O-rings.

For efficient separation, Optimum viscosity: 24mm2/sec
Maximum heating temperature:
Heavy oil C 98ºC
Lube oil 90ºC

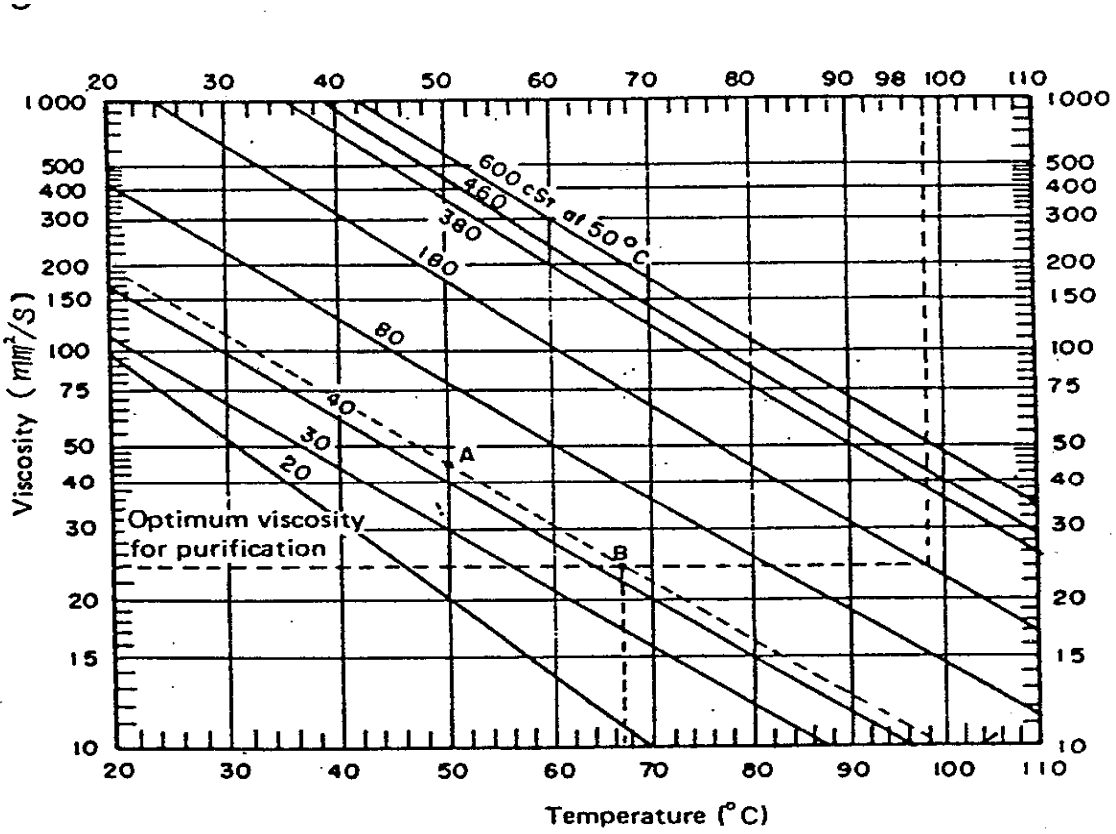
Example: To calculate treating temperature for heavy oil with viscosity of 45mm2/sec (50ºC)

1) Draw a horizontal line from 45 mm2/sec point and a vertical line from 50ºC. These lines will intersect at point “A”.

2) Draw a line through “A” parallel to 40mm2/secline and a horizontal line from 24mm2/sec point. These two lines will intersect at point “B”.

3) Draw a vertical line downward from this point and note the value of temperature. This is the treating temperature for this oil i.e. 67ºC.

Figure 1.11 shows the relationship between various oil temperatures and their viscosity. By referring to this diagram, treating temperature of various oils can be determined.



Temperature vs. Viscosity diagram

Fig. 1.11

Table below shows the treating temperature for each type of oil for Mitsubishi SELFJECTOR type separator.

Oil type		Treating temperature (ºC)
Fuel oil A	14 mm2/sec/40ºC	40
Fuel oil C	180~700mm2/sec/50ºC	98
Lubrication oil	150mm2/sec/40ºC	83~90
	100mm2/sec/40ºC	74~90

Procedure for Gravity disc selection:

The method of using a gravity disc selection chart depends on whether the "specific gravity of treated oil at 15ºC" is known or unknown.
Moreover, there are different types of gravity disc selection chart according to the type of oil and model no. of separator.
The procedure for selecting size of gravity disc by using the chart has been explained below for separator model no. SJ30F.

Example No.1: When specific gravity of oil at 15ºC is known.
Treating condition
Specific gravity of treated oil at 15ºC: 0.905
Treating temperature : 70ºC
Feed rate : 3000 l/hour
Selection method:
1) Select the point on the S.G. axis equivalent to 0.905. Draw a parallel falling curve (1) from this point and a vertical line from 70ºC point on the temperature axis. These two lines will intersect at point "A".
2) Draw a horizontal line (2) from point "A" till it reaches the vertical line through 100ºC point. These two lines will intersect at point "B".
3) Draw a line (3) from point "B" to the point of 3000 l/hour on the feed rate scale on the right hand side. This line will cross the gravity disc scale on a point "C". Read the value corresponding to that point. This value is the inside diameter of the gravity disc i.e. Φ85.

Example No.2: When specific gravity of oil at 15ºC is unknown.
Treating condition
Specific gravity of treated oil at 50ºC: 0.944
Treating temperature : 98ºC
Feed rate : 1250 l/hour

Selection method:
1) Draw a rising curve (4) from a point of 0.944 S.G. and a vertical line from a point of 50ºC. These two lines will intersect at point "D". This is done to convert the S.G. at 50ºC to S.G. at 15ºC.
2) Draw a falling curve (5) from point "D" and a vertical line from a point of 98ºC. These two will intersect at point "E".
3) Draw a horizontal line from point "E" till it reaches the vertical line through 100ºC point. These two lines will intersect at point "F".
4) Draw a line (6) from point "F" to the point of 1250 l/hour on the feed rate scale on the right hand side. This line will cross the gravity disc inside diameter scale on a point "G". Read the value corresponding to that range. This value is the inside diameter of the gravity disc i.e. Φ76.

Figure 1.12 shows a gravity disc selection chart.

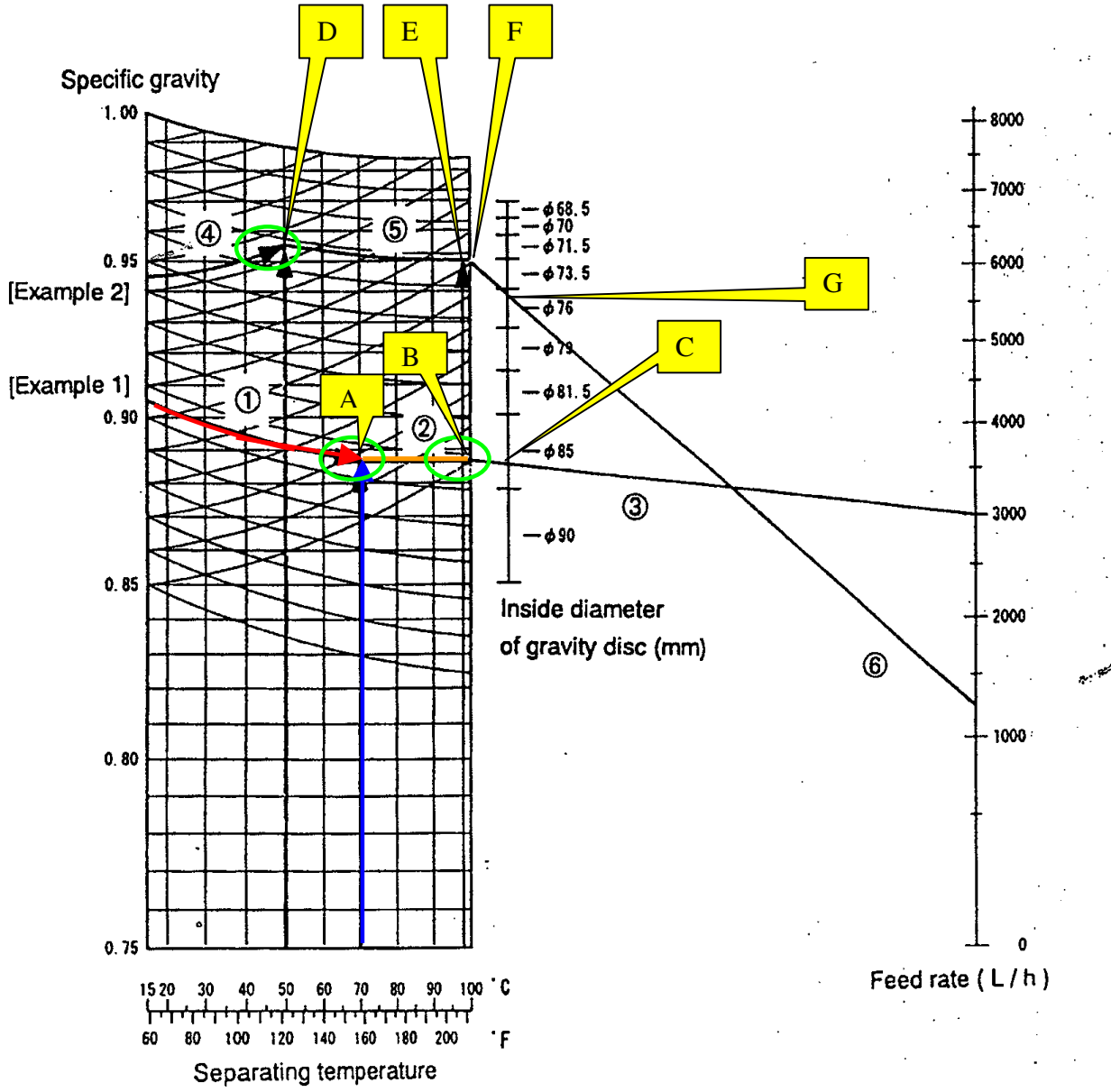


Fig. 1.12

Note: If the calculated size of the gravity disc from the chart is falling close to centre of two ranges, the gravity disc of bigger size should be chosen. This is just to make sure that no water goes to clean oil outlet side.

2. Structure of Separator (SELFJECTOR):

General: The power is transmitted from the motor through the friction clutch to the horizontal shaft and this is further increased in speed and transmitted to the vertical shaft through the spiral gear mounted on the horizontal shaft and pinion on the vertical shaft. The vertical shaft is supported by upper and lower bearings. The bowl mounted on the top of the vertical shaft rotates at the speed of the vertical shaft. To supply feed oil, the feed pump (gear pump) is connected to the horizontal shaft through the safety joint. In some models, the feed pump is a separate gear pump. To deliver clean oil, a light liquid impeller is secured in the Frame cover on the top of the bowl. For SJ10F~SJ30F, water overflows from the bowl and for SL40F~SL100F, water is discharged outside by a heavy liquid impeller similar to that for clean oil.
The figure 2.1 shows structure of the Separator.

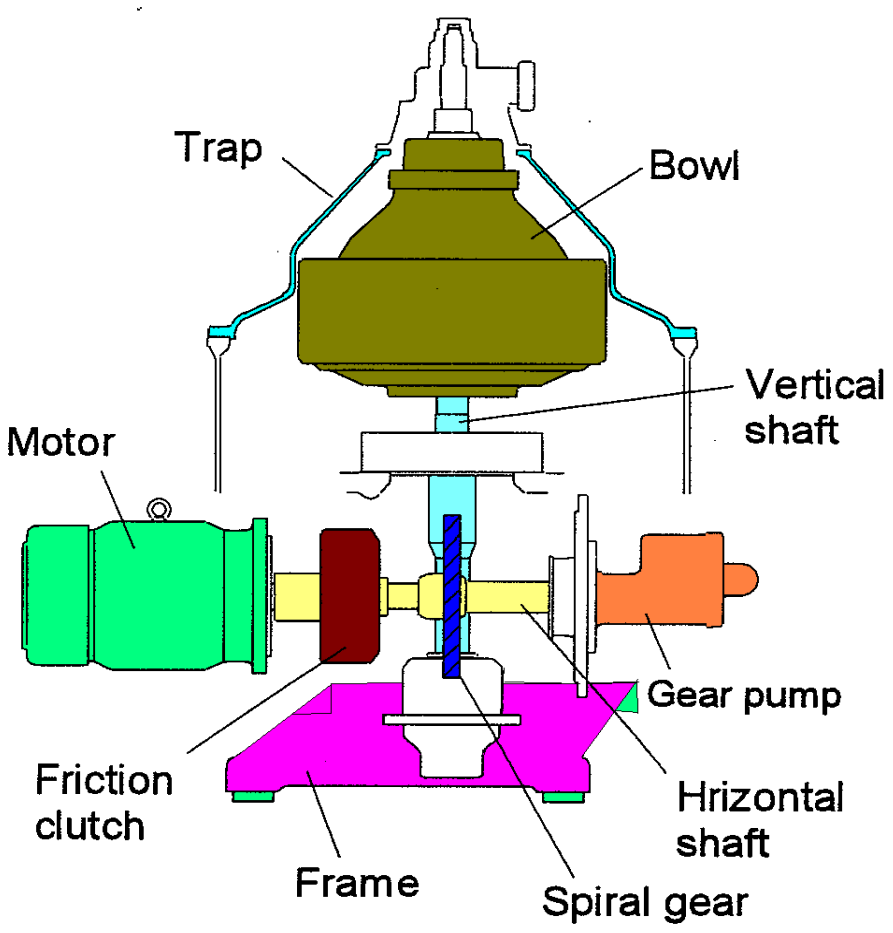


Fig. 2.1 Structure of the Separator

Vertical shaft section:

The vertical shaft is driven by the horizontal shaft via the spiral gear and the vertical shaft rotates the bowl mounted on its top.
The vertical shaft and bowl are supported by upper springs, radially incorporated at 6 points on the upper bearing section, and lower spring in the lower bearing section so that they can stably rotate.
Ball bearing or Roller bearing is used at the upper section for supporting the shaft radially.
Angular bearing or other type bearing is used at the lower section for supporting the shaft axially and counteracting the thrust force.

Figure 2.2 shows arrangement of Vertical shaft section.

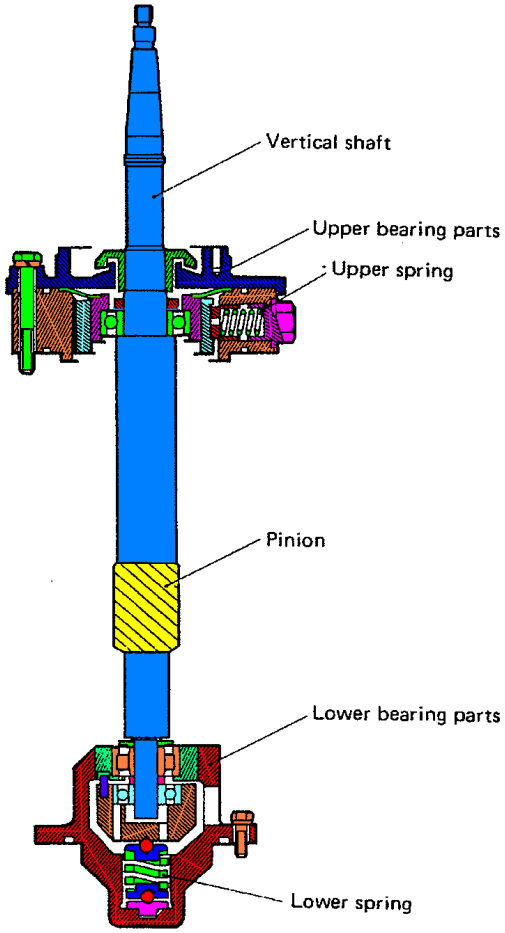


Fig. 2.2 For Model Mitsubishi SJ 20T~60T

Horizontal shaft section:

The horizontal shaft is rotated by the motor via the friction clutch arrangement.
The horizontal shaft is supported by two ball bearings built in the bearing housing (3) and bearing housing (4). The Spiral gear is mounted between them. The bearing housings are provided with oil seals to avoid gear oil leakage.
The horizontal shaft is directly coupled with the gear pump by the safety joint.

Figure 2.3 shows arrangement of Horizontal shaft section.

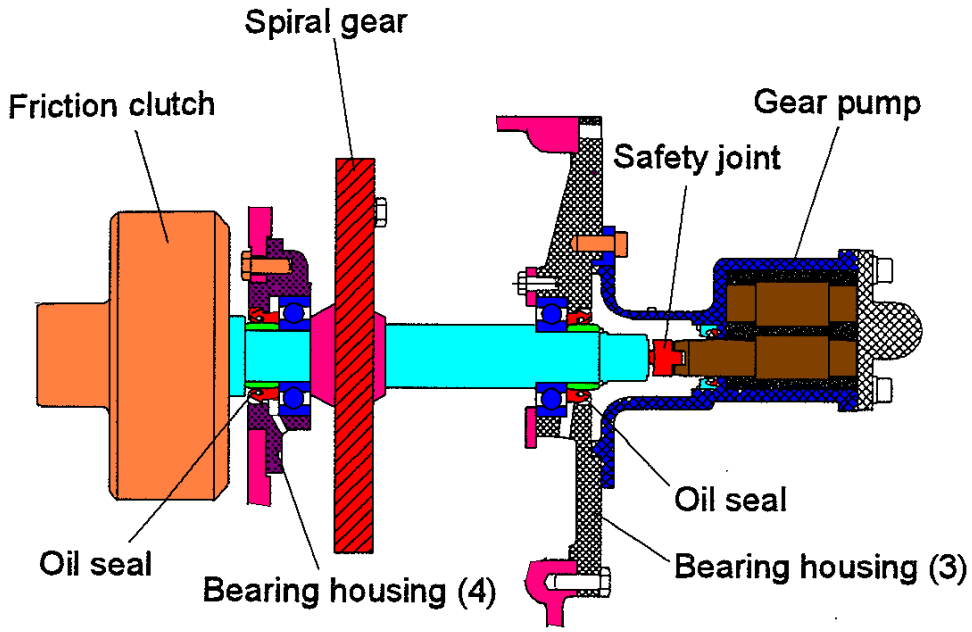


Fig. 2.3

Brake:

A hand brake is fitted to the separator in case it is required to stop the rotation quickly.
The hand brake consists of spring and brake linings.
When operated, the brake linings are pressed against the outer surface of friction pulley by the spring.
For normal stoppage, refrain from braking and allow the separator bowl to come to standstill on its own.

Figure 2.4 shows arrangement of Brake.

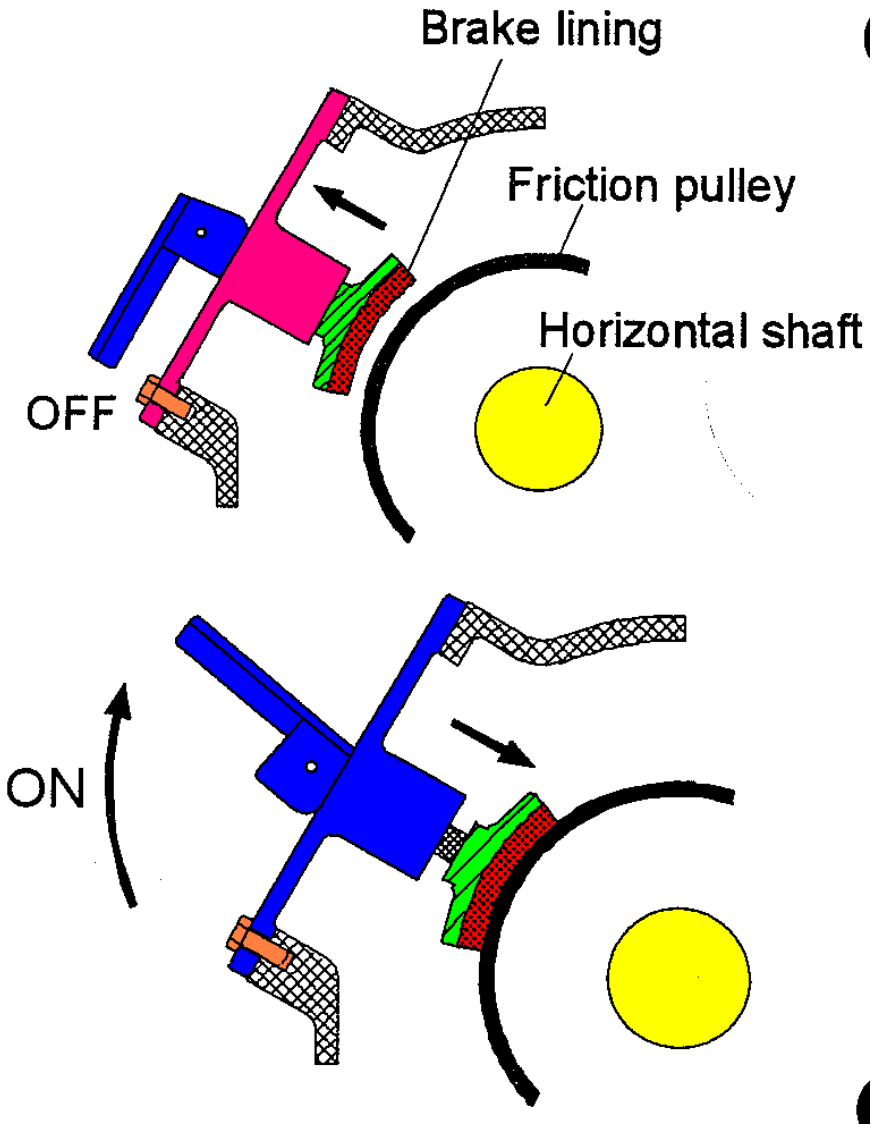


Fig. 2.4

Friction clutch:

A friction clutch is incorporated in the Separator for gradual starting and acceleration and thus prevents the motor overloading during starting.
The friction boss is fitted onto motor shaft and houses the friction blocks. The friction pulley is fitted on the horizontal shaft.
Once the motor is started, it achieves the designed speed instantly. The friction blocks are pressed against the internal surface of the friction pulley due to centrifugal force acting on them. The power is transmitted to the friction pulley and thus to the horizontal shaft as the friction block lining and friction pulley inner surface slip with each other.
The bowl is so designed that it normally attains its rated rotation in about 3 to 7 minutes.

Figure 2.5 shows arrangement of Friction clutch.

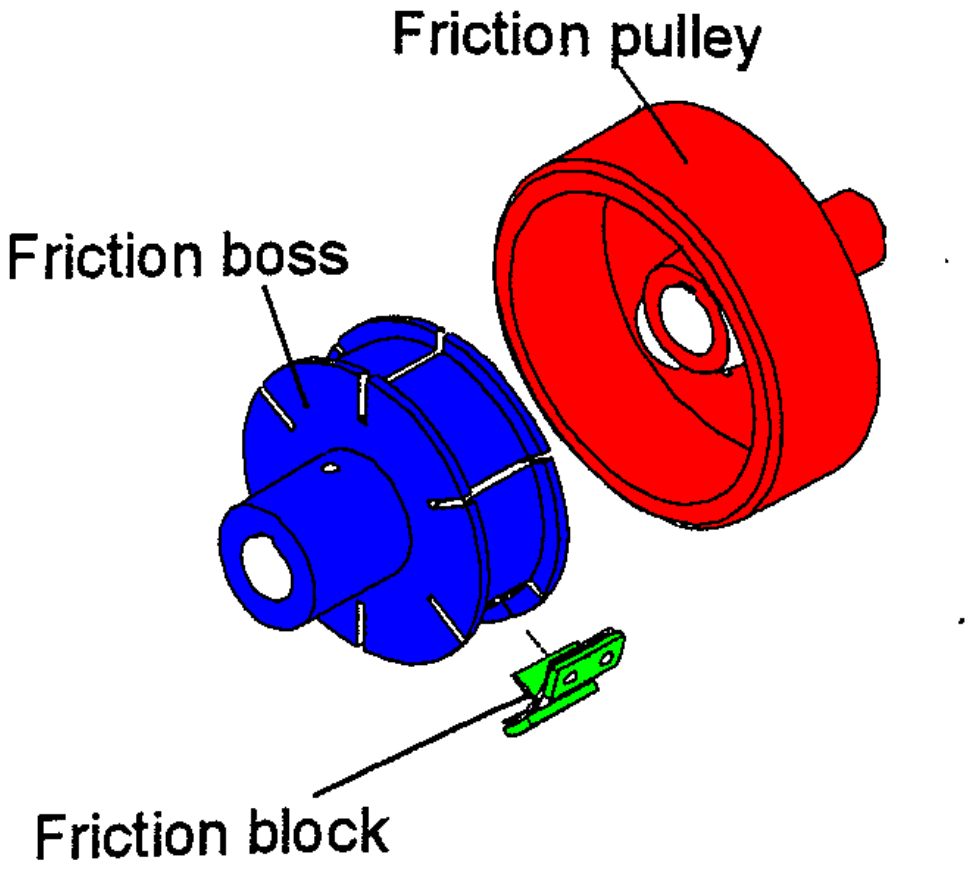


Fig.2.5

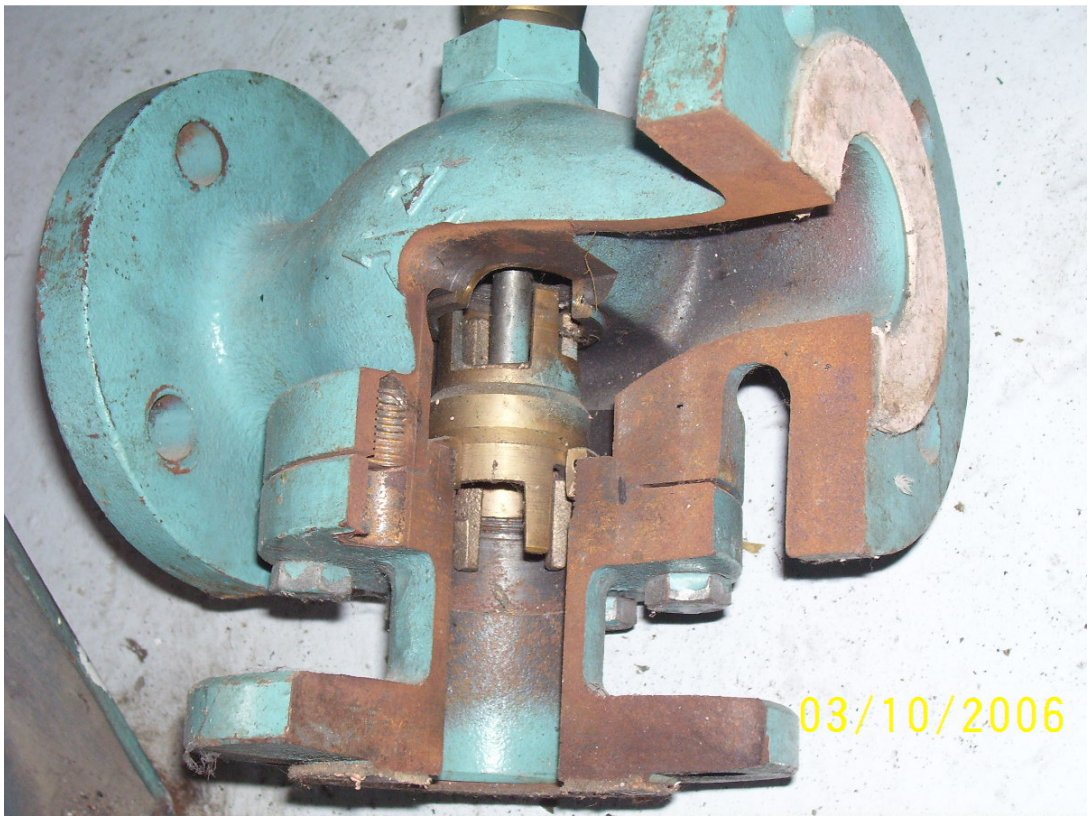
3-way change over valve:

The 3-way change over valve changes from supply to circulation to stop supply oil to purifier, when purifier is sequenced for sludge discharge or stop operation. It is changed from circulation to supply at the beginning of separation process.

In case, the movement of valve is fast during this position changeover, oil will be supplied with a sudden gush into the purifier. This may cause oil to carry away some the sealing water with it to clean oil outlet side. Therefore, its movement during position changeover should be smooth.

The speed of change over can be adjusted by controlling the air flow by the air regulator.

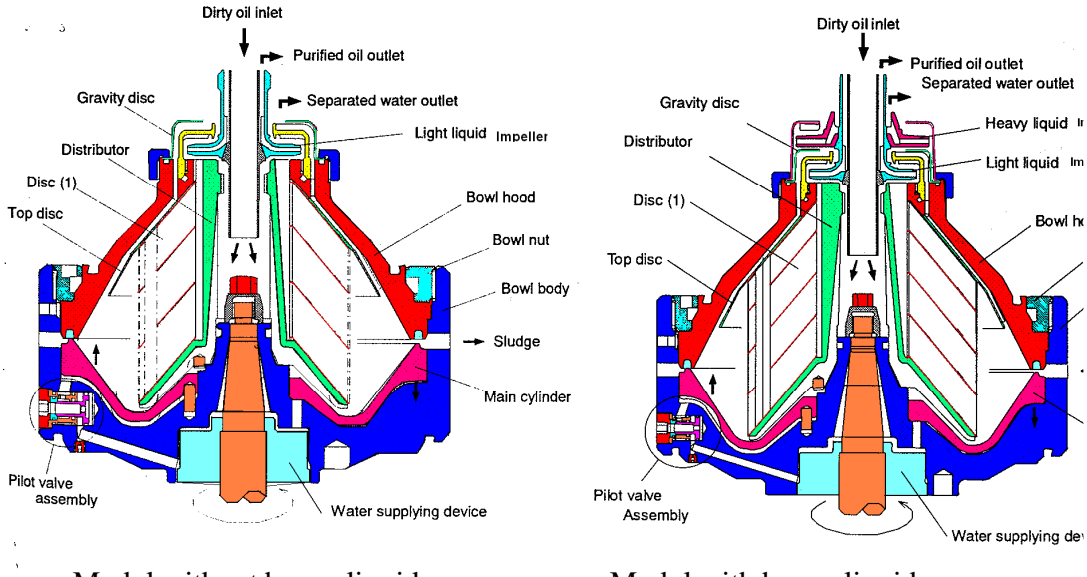
Picture below shows the cut off view of 3-way change-over valve.



Bowl:

The bowl consists of body, hood and nut. The bowl incorporates separation chamber, composed of disc (1) and top disc, and distributor which distributes inlet feed liquid to the separation chamber uniformly.

Figure 2.6 shows the structure of the Bowl.



Model without heavy liquid pump Model with heavy liquid pump

Fig. 2.6

There is a main cylinder, which slides vertically up/down. The upward movement is caused due to water pressure acting below and downward movement is due to its own weight, when there is no water pressure acting from below. The upward movement of the Main cylinder seals the bowl for separation and downward movement is required for sludge discharge, which is separated and accumulated on the inner wall of the bowl during operation.
There are two pilot valves assemblies for controlling the main cylinder up/down movement, thus performing separation and sludge discharge operation.
Inlet feed liquid, through the distributor to the separation chamber, passes through the gap between the discs (1), where solids and water are separated and purified oil is discharged outside by the light liquid impeller.
(For SJ10F~SJ30F) Separated water overflows continually and
(For SJ40F~SJ100F) separated water is continually discharged by the heavy liquid impeller, located above the light liquid impeller.

Discharge Mechanism: (Total Discharge)

1) Separation in progress:

A centrifugal force acting on the pilot valve moves the pilot v/v outwards and thus closes the opening in the valve seat. The water pressure chamber for closing the Main Cylinder is filled with operating water. The operating water pressure pushes up the main cylinder to seal against the main seal ring for commencement of separation process.

Operating water for closing the Main Cylinder is intermittently introduced into the closing water chamber for a given period of time during the separation process. In the water pressure chamber, the centrifugally generated pressure of water, turning with the bowl, is balanced with the supplied water pressure to hold the water surface at certain level. So, just the make up water is supplied into the chamber.

Figure 2.7 shows bowl condition during separation process.

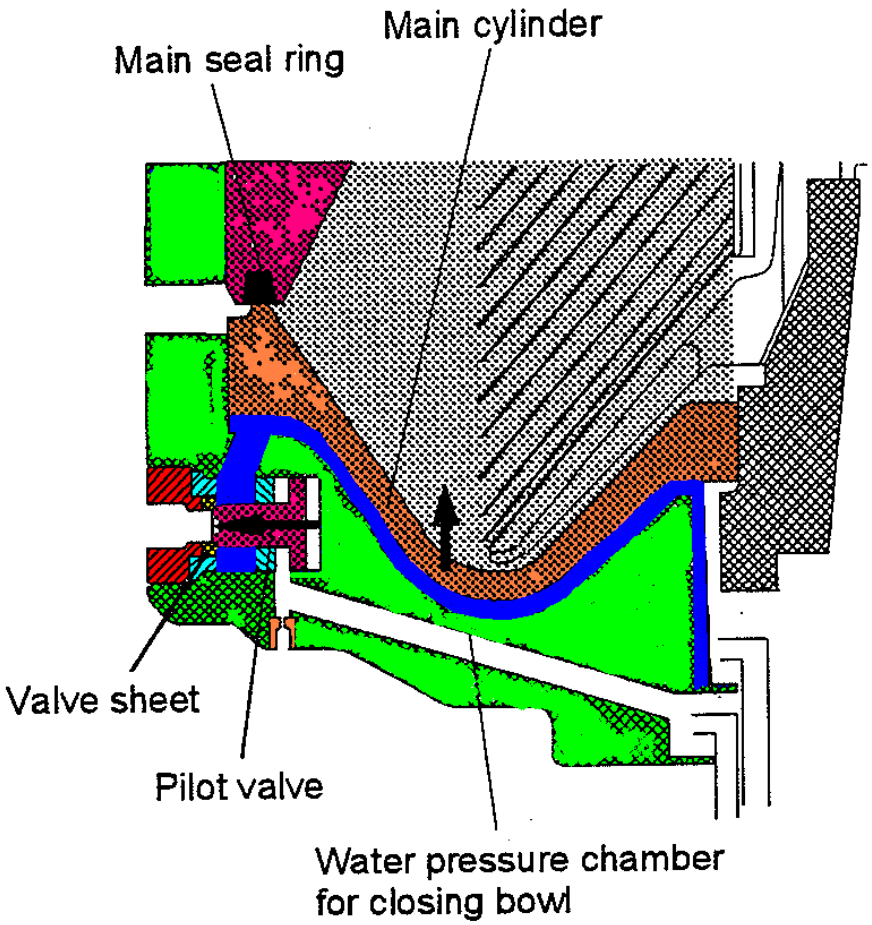


Fig. 2.7

2) Supply of opening water:

The operating water for opening the Main Cylinder is supplied to the opening water chamber for a certain time period. A small part of it drains out from the drain nozzle. Remaining water fills up the opening water pressure chamber and the space behind collar of the plot valve. The water pressure pushes the pilot valve inwards, thereby uncovering the opening in the valve seat. The water in the closing pressure chamber for Main Cylinder starts draining out.
Figure 2.8 shows bowl condition during supply of opening water.

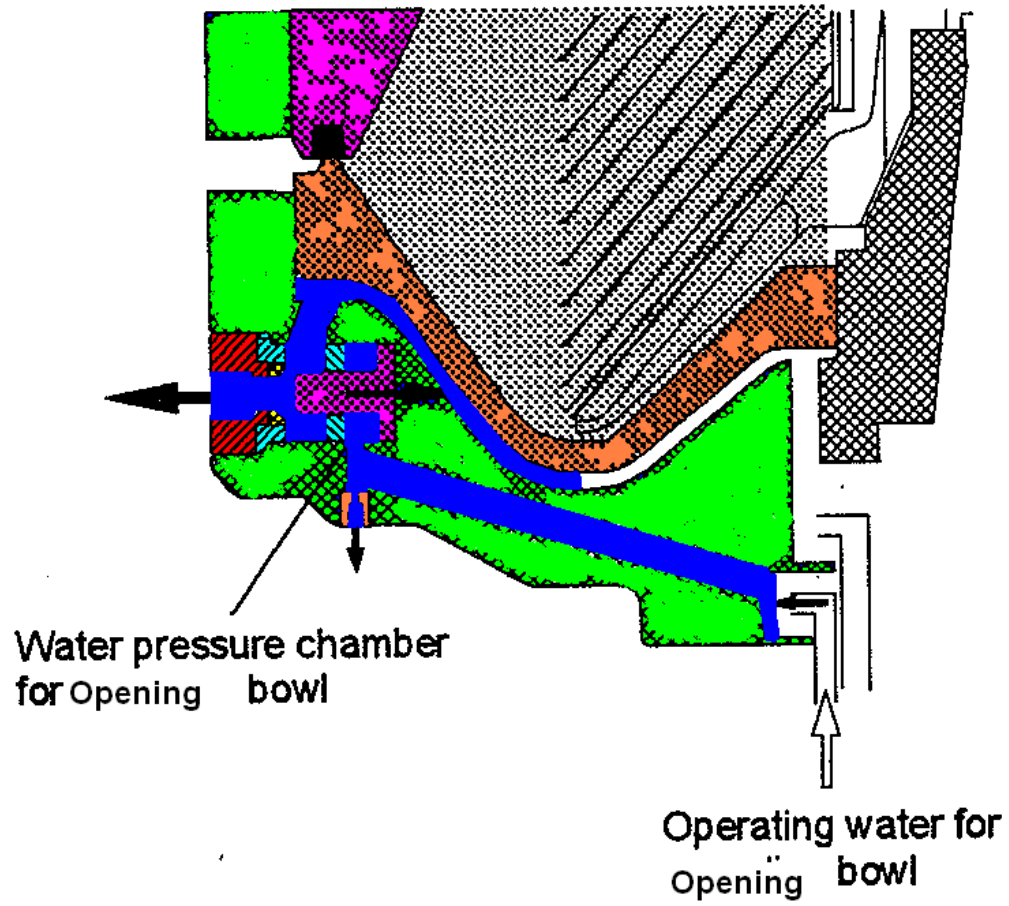


Fig. 2.8

3) Sludge discharge operation:

When the water in the closing pressure chamber has drained so much that the force to push up the main cylinder is not sufficient, the main cylinder comes down due to gravitational force. As the seal between the main seal ring and the main cylinder breaks, the sludge is discharged outside the bowl.
During the sludge discharge period, all water inside the opening water pressure chamber gets drained through the drain nozzle. The centrifugal force pushes the pilot valve outwards to seal against the valve seat.
Figure 2.9 shows bowl condition during sludge discharge operation.

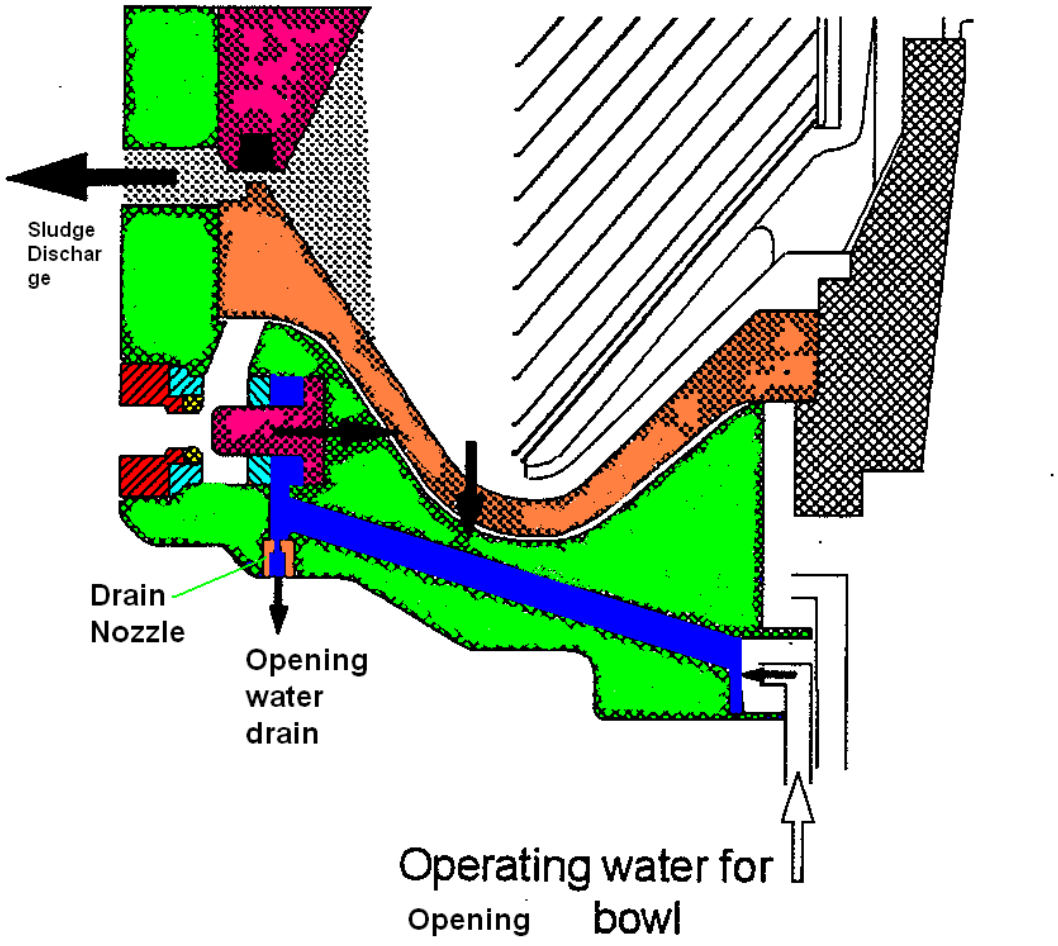


Fig. 2.9

4) Supply of Closing water:

After the sludge discharge period, operating water for closing the Main Cylinder is supplied to the closing water pressure chamber. When the chamber is completely filled up, the main cylinder is pushed up against the main seal ring, thus closing the sludge discharge ports.
Figure 2.10 shows bowl condition during supply of closing water.

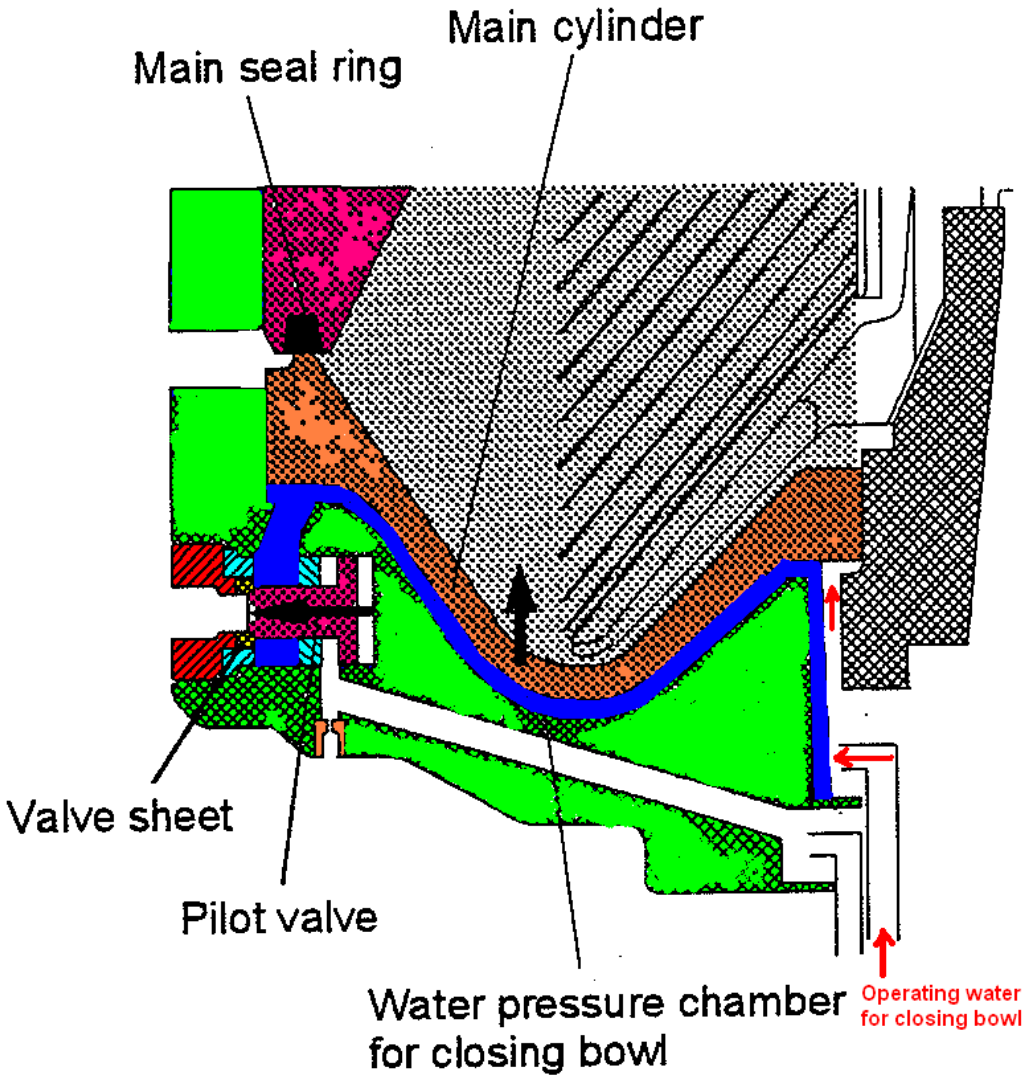


Fig. 2.10

Water supply device:

The water supplying device is located below the bowl to supply operating water for controlling the separation and sludge discharge operation.

Operation of water supply device (Total discharge):

Operating water for opening the Main cylinder is fed from section A, which then enters the water pressure chamber for opening the Main cylinder. This water is supplied for very short period before the sludge discharge operation.

Operating water for closing the Main cylinder is fed from section B, which then enters the water pressure chamber for closing the Main cylinder. This water is supplied after the sludge discharge operation. There are two types of closing water supply system i.e. Tank type and Non tank type. In the system having an operating water tank, the closing water is supplied intermittently at specified regular intervals for a specific period to make for any loss of water from the water pressure chamber.

Figure 2.11 shows arrangement of water supplying device for total discharge type.

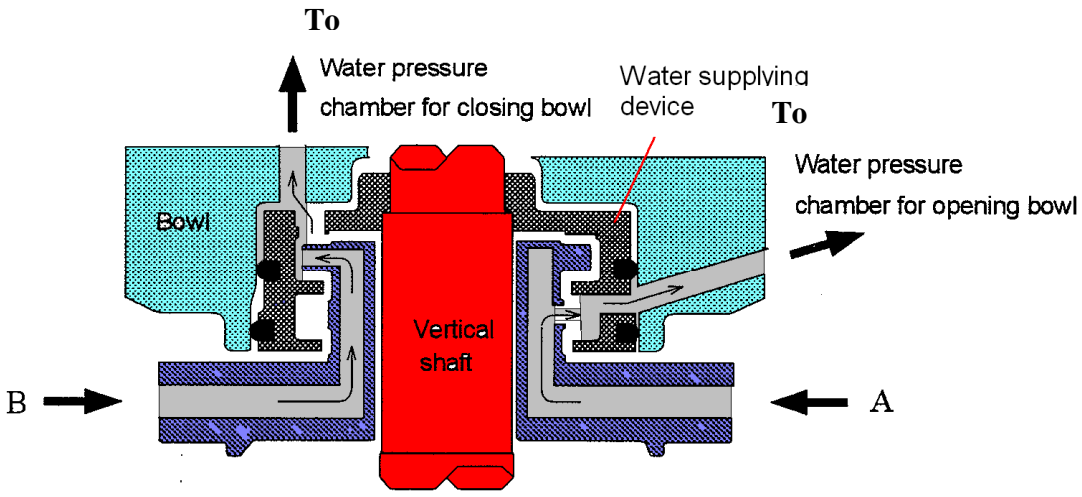


Fig. 2.11

3. Operation:

There are two modes of separation processes, Purifier and Clarifier.
When the Sealing water is involved in the separation process, the separator is called a Purifier.
When the principal contaminant is dirt or sediment, the Separator is used as a Clarifier.

3.1 Purifier operation:

This separation process requires the following features:
1) A heavy liquid outlet for continuously discharging separated water.
2) Sealing water to be supplied before introducing oil so that oil will not flow out through the heavy liquid outlet.
3) Gravity discs of various inside diameters to maintain the oil-and-water interface within a specified range.
4) The specific gravity of oil at 15°C should be less than 0.991.

Contaminated oil enters the top of the revolving bowl through the feed liquid inlet (1). The oil then passes down the inside of the distributor (A), out the bottom, and up into the stack of discs. As the dirty oil flows up through the distribution holes in the discs, the high centrifugal force exerted by the revolving bowl causes the dirt, sludge, and water to move outward. The purified oil is forced inward and upward, discharging from the neck of the top disc and then discharged out by the light liquid impeller. The water forms a seal between the top disc and the bowl top. (The top disc is the dividing line between the water and the oil.) The heavy liquid passes outside the top disc (C) and overflows over the gravity disc out of the separator.

For model SJ40F~SJ100F, heavy liquid is discharged by the heavy liquid impeller.

Figure 3.1 shows arrangement of purifier operation.

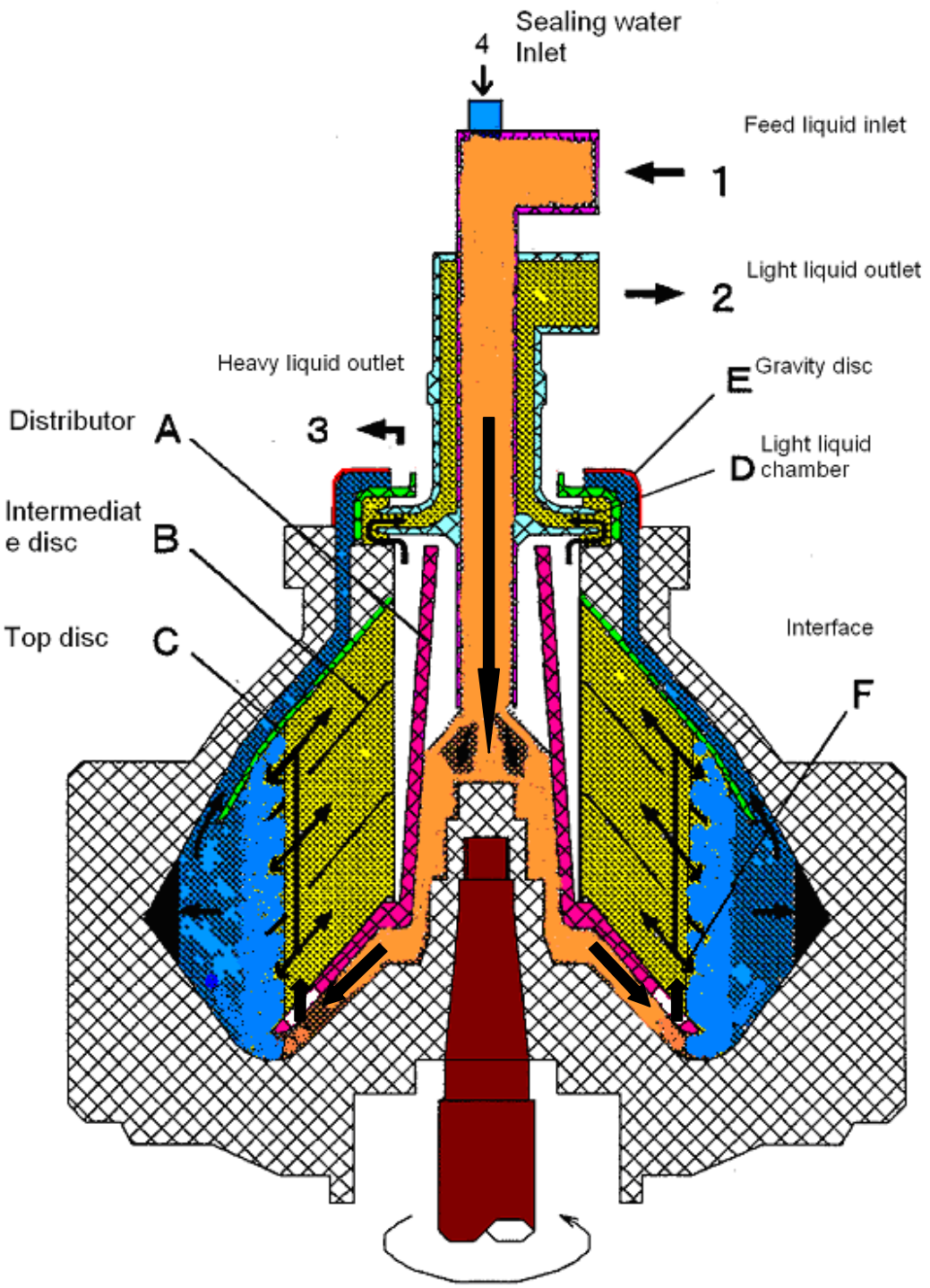

Sealing water Inlet
4
Feed liquid inlet
1
Light liquid outlet
2
Heavy liquid outlet
3
Gravity disc
E
Light liquid chamber
D
Distributor
A
Intermediat e disc
B
Top disc
C
Interface
F

Fig. 3.1

Case 1: Importance of the Sealing water in case of Purifier operation:

If oil is introduced into an empty Bowl, oil will occupy all the space inside the bowl and thus subsequently will flow out from the Water outlet side since there is no sealing water inside the bowl and the inner diameter of the Gravity disc is bigger than the inner diameter of the disc (B) (oil outlet weir H). This has been shown in figures 3.2 & 3.3.

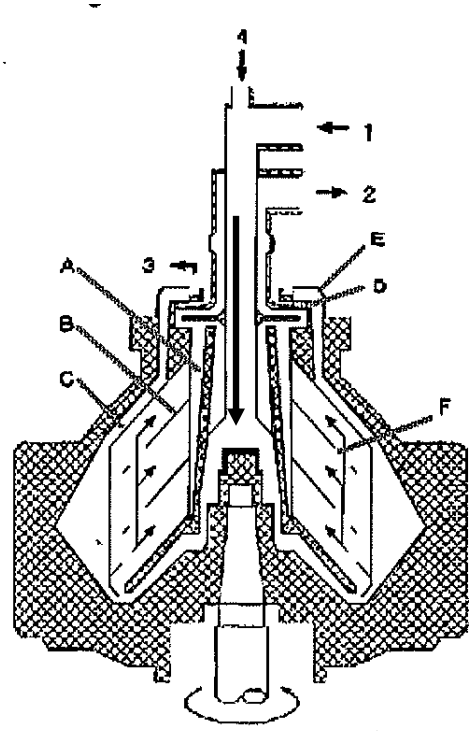


Fig 3.2
Empty Bowl

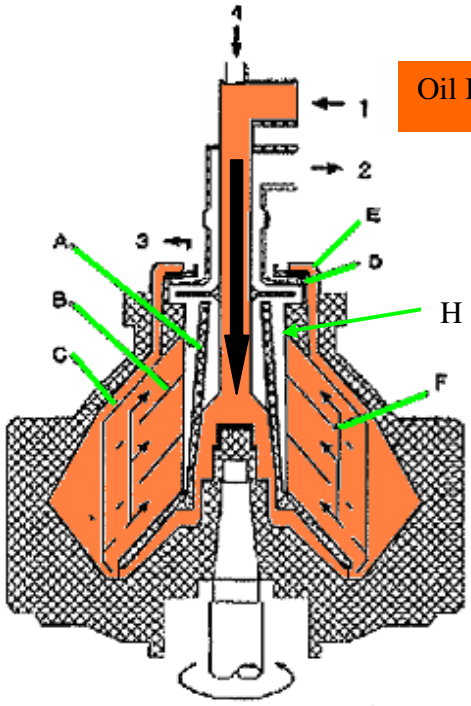


Fig 3.3
Bowl filled up with oil

1- Feed liquid inlet, 2- Clean oil outlet, 3- Water outlet,
4- Sealing water inlet,
A- Distributor,
B- Disc,
C- Top disc,
D- Oil chamber
E- Gravity Disc
F- Interface
H- Oil outlet weir (inner dia of disc)

Case 2: Separation of oil:

In this case the specified amount of water is fed to the bowl at the Sealing water inlet (4), which occupies the space in the bowl between the inner surface of bowl and the interface. Then oil is supplied at oil inlet (1). This oil passes through the distributor (A) downwards and then moves upwards to occupy the space between the bottom and top of the bowl. Initially, this incoming oil pushes sealing water inside the bowl and causes excess water to come out from the water outlet (3). The oil-and-water interface moves closer to the outer edge of disc holes.

As soon as water and solids start separating, they are pushed to outer periphery of bowl and clean oil moves towards the clean oil outlet. The interface positions itself closer to the outré edge of disc holes and the purification process stabilizes.

The sealing water is introduced at a controlled rate into the bowl at regular intervals during the operation. This is done to maintain the sufficient amount of sealing water inside the bowl at all times during the operation, since some amount of sealing water is lost during the operation.

If the sealing water input is too much, water may be carried over with clean oil.

The normal sealing water throughput should be adjusted to 70%~80% of the volume of water inside the bowl, at the moment water starts discharging from the water outlet side.

This phenomenon has been shown in figure 3.4, 3.5, 3.6 & 3.7.

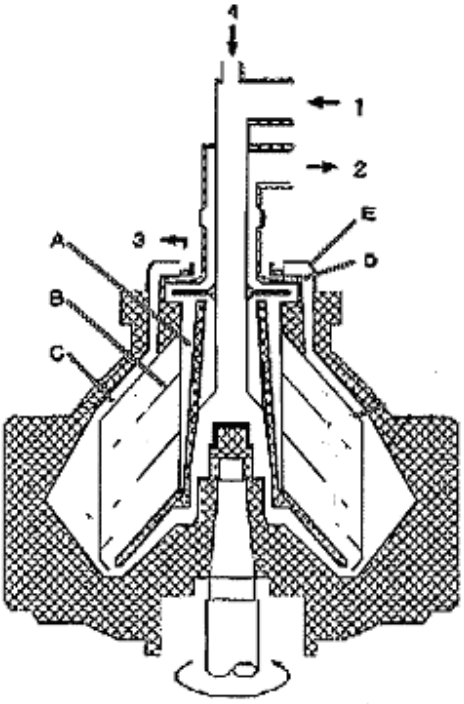


Fig 3.4
Empty Bowl

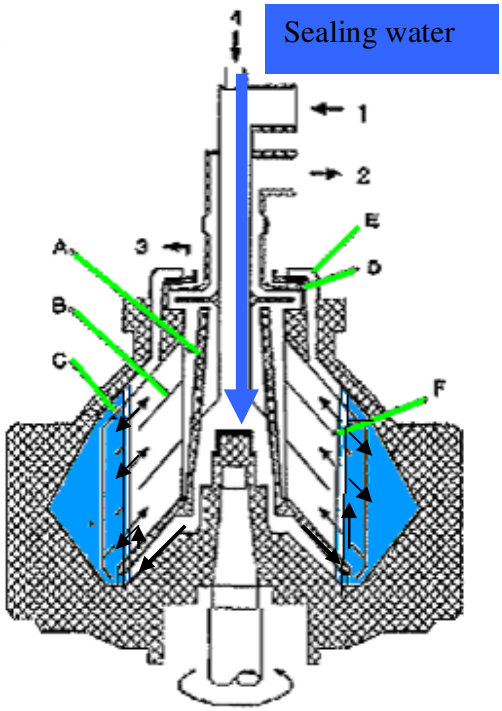


Fig 3.5
Operation Stage after sealing water inlet

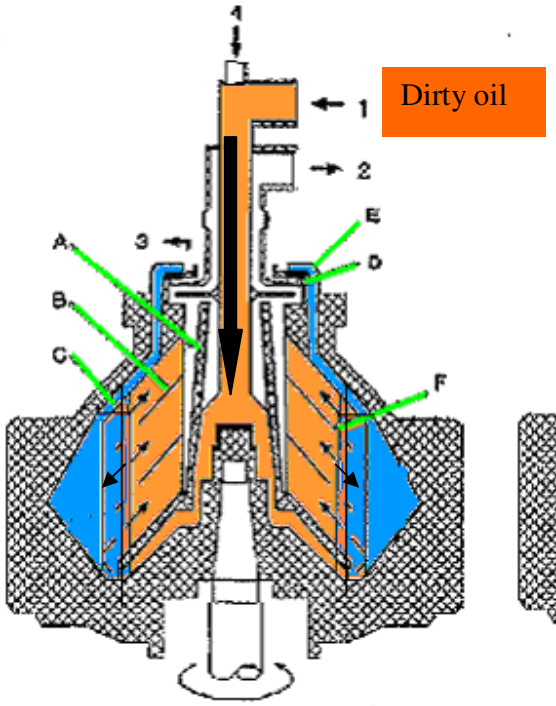


Fig 3.6
Operation stage after oil inlet

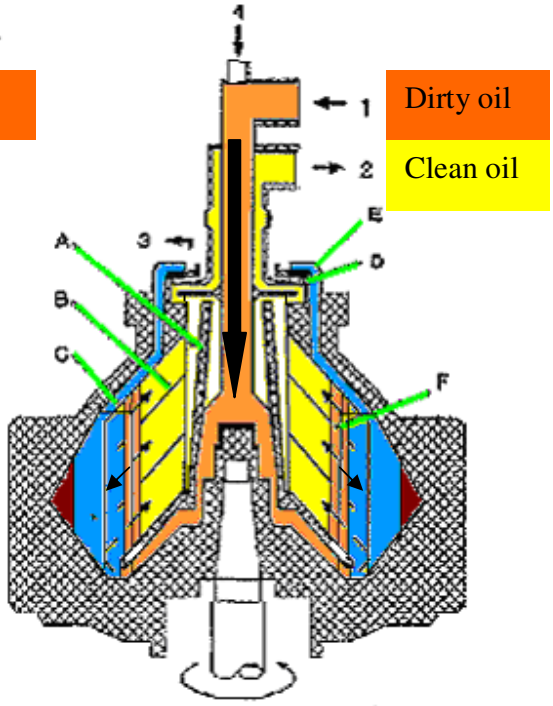


Fig 3.7
Operation Stage after stabilization

3.2 Clarifier operation:

This process incorporates the following features:

1) When the specific gravity of oil at 15ºC is more than 0.991, the separation process is easily affected by temperature, flow rate and other operating condition changes, thereby causing abnormal outflow or poor separation.

2) Since there is no heavy liquid outlet, the separated water can not be discharged continuously.

In some systems (e.g. HIDDENS system), Separator consists of partial discharge clarifier and Water detector. When the water content of the discharged oil has exceeded a certain value, the water detector initiates a signal to discharge separated water in the bowl. This type of separator can handle oil with specific gravity up to 1.01 (at 15ºC).

3) Sealing water is not required.

The operation is similar to purifier. Since there is no sealing water, light liquid passes outside the top disc (C) and reaches the gravity disc (E). But, since the inside diameter of the gravity disc is smaller than the inside diameter of intermediate disc (1), the light liquid does not overflow over the gravity disc.

Figure 3.8 shows arrangement of clarifier operation.

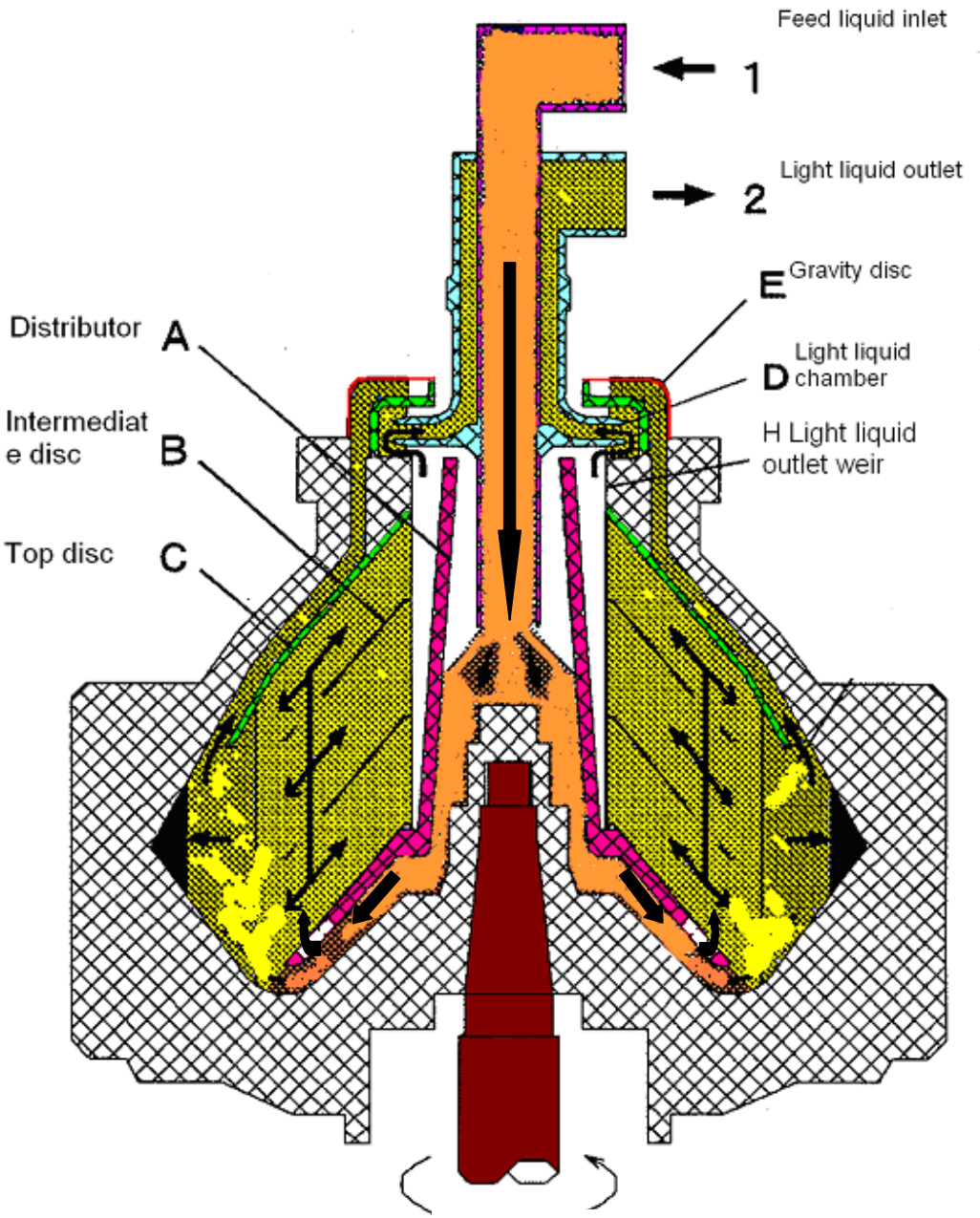

Feed liquid inlet
1
Light liquid outlet
2
E Gravity disc
D Light liquid chamber
H Light liquid outlet weir
Distributor A
Intermediat e disc B
Top disc C

Fig. 3.8

As per the quality of oil, the separators can be used in parallel or series for better separation. Diagrams for SELFJECTOR-F type are shown below:

1) Parallel operation:

The feed rate of each separator is reduced preferably by ½ of the total feed rate. Both separators are used as purifier.

Figure 3.9 shows arrangement for Parallel operation.

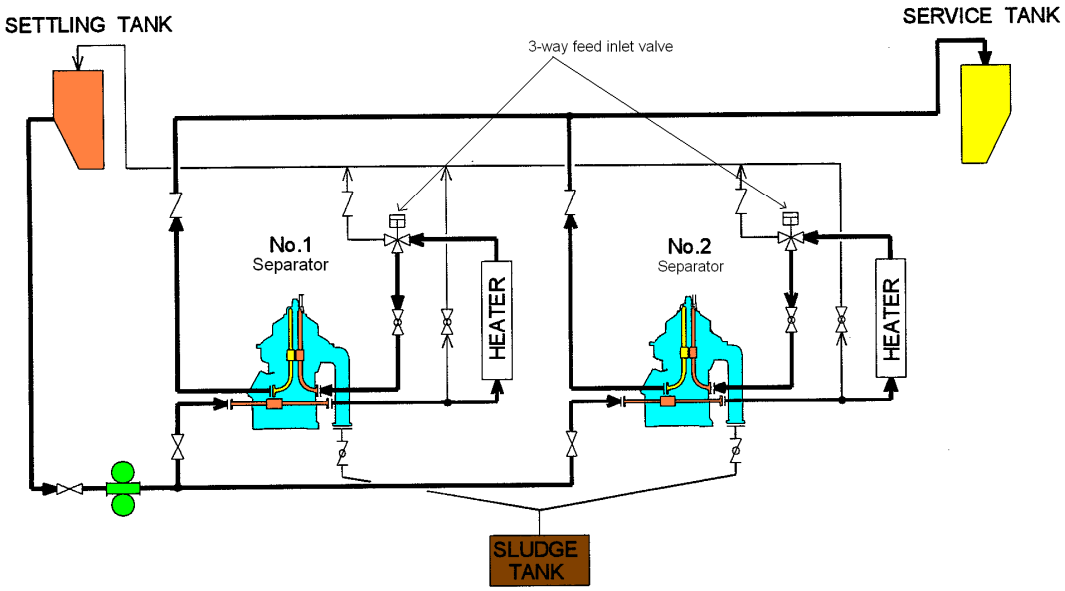


Fig. 3.9

2) Series operation:

Normally No.1 separator runs as purifier and No.2 as clarifier. Feed rate should be as low as practically possible, but it is higher than that of parallel operation.

Figure 3.10 shows arrangement for Series operation.

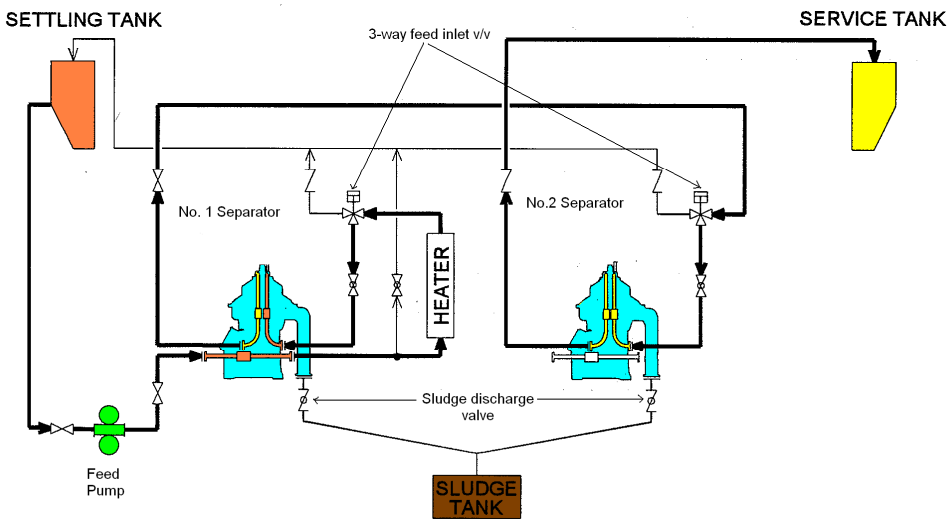


Fig. 3.10

Flow diagram for SJ-F (FSC, FBC) type separator:

Figure 3.11 shows Flow diagram for SJ-F separator.

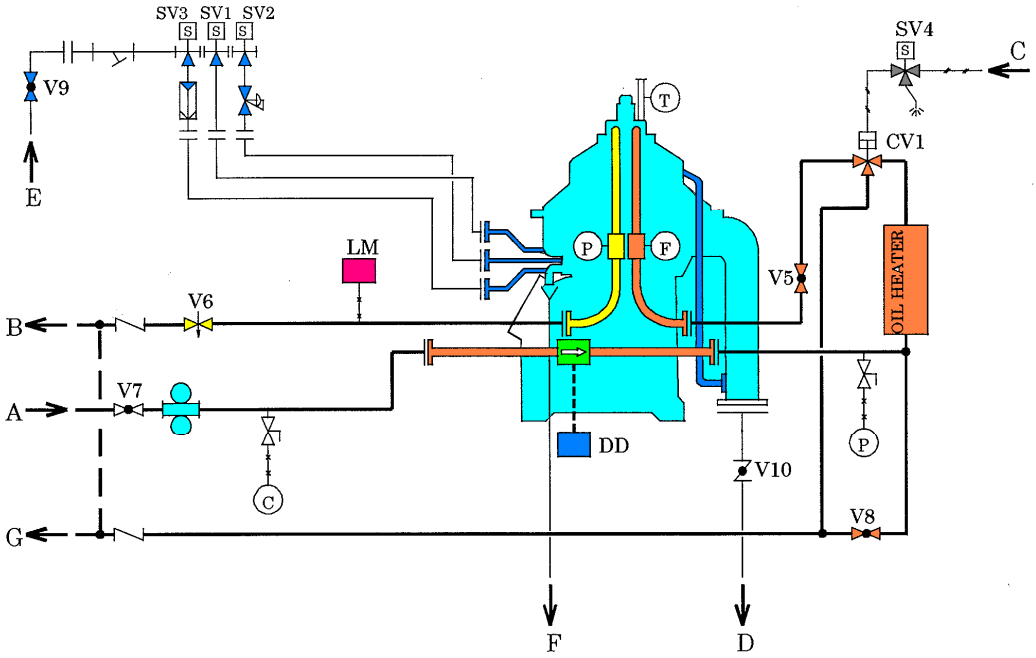


Fig. 3.11

V5	: Flow control valve
V6	: Pressure control valve
V7	: Feed liquid inlet valve
V8	: By-pass valve
V9	: Operating water inlet valve
V10	: Butterfly valve
SV1	: Solenoid valve for water (for opening bowl)
SV2	: Solenoid valve for water (for closing bowl)
SV3	: Solenoid valve for water (for sealing water & replacement water)
SV4	: 3-way solenoid valve (for feed valve)
CV1	: Feed valve
LM	: Leakage Monitor
DD	: Discharge Detector (option)

A : Feed liquid inlet
B : Light liquid outlet
C : Compressed air inlet
D : Sludge & Heavy liquid outlet
E : Water inlet
F : Operating water drain
G : Return

Ⓒ : Compound gauge
Ⓟ : Pressure gauge
Ⓕ : Flow meter
Ⓣ : Thermometer

Figure 3.12 shows a typical separator system.

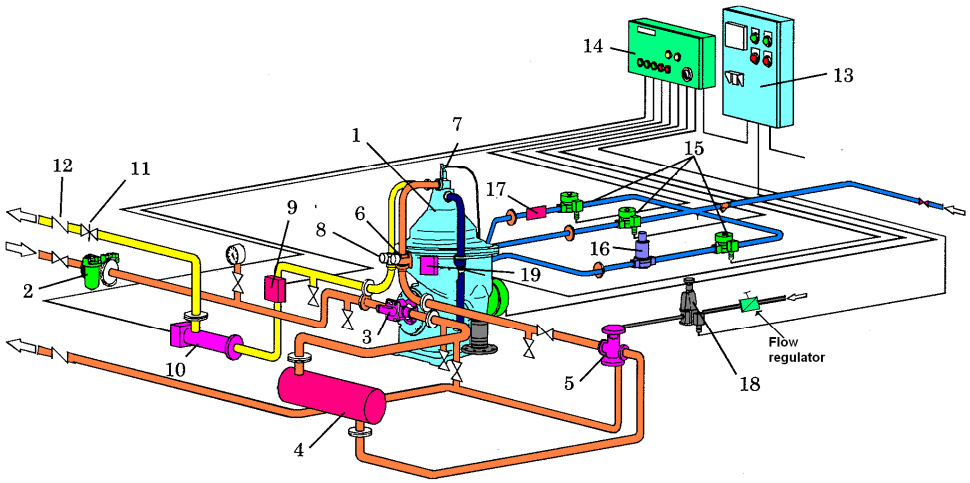


Fig. 3.12 Typical Separator system

1	Separator	11	Pressure control valve
2	Oil strainer	12	Check valve
3	Gear pump	13	Starter
4	Oil heater	14	Control panel
5	3-way cylinder valve	15	Solenoid valve
6	Flow meter	16	Reducing valve
7	Thermometer	17	Constant flow valve
8	Pressure gauge	18	3-way solenoid valve
9	Leakage Monitor(LM)	19	Discharge Detector(DD)
10	Water Detector		

Motor Starting Characteristics:

The motor power is transmitted to the horizontal shaft via the friction blocks to reduce the starting load. After starting, the motor immediately reaches the rated speed and then gradually accelerates the bowl via the friction blocks. During this acceleration process, the rated motor power is exceeded. Therefore, a motor, which can endure this overload, is selected. The motor overload characteristics are given below:

Overload in %	Duration in min
25	30
50	15
75	5
100	1

The relation between motor current and bowl speed (for SJ-F type) is shown in Figure 3.13.

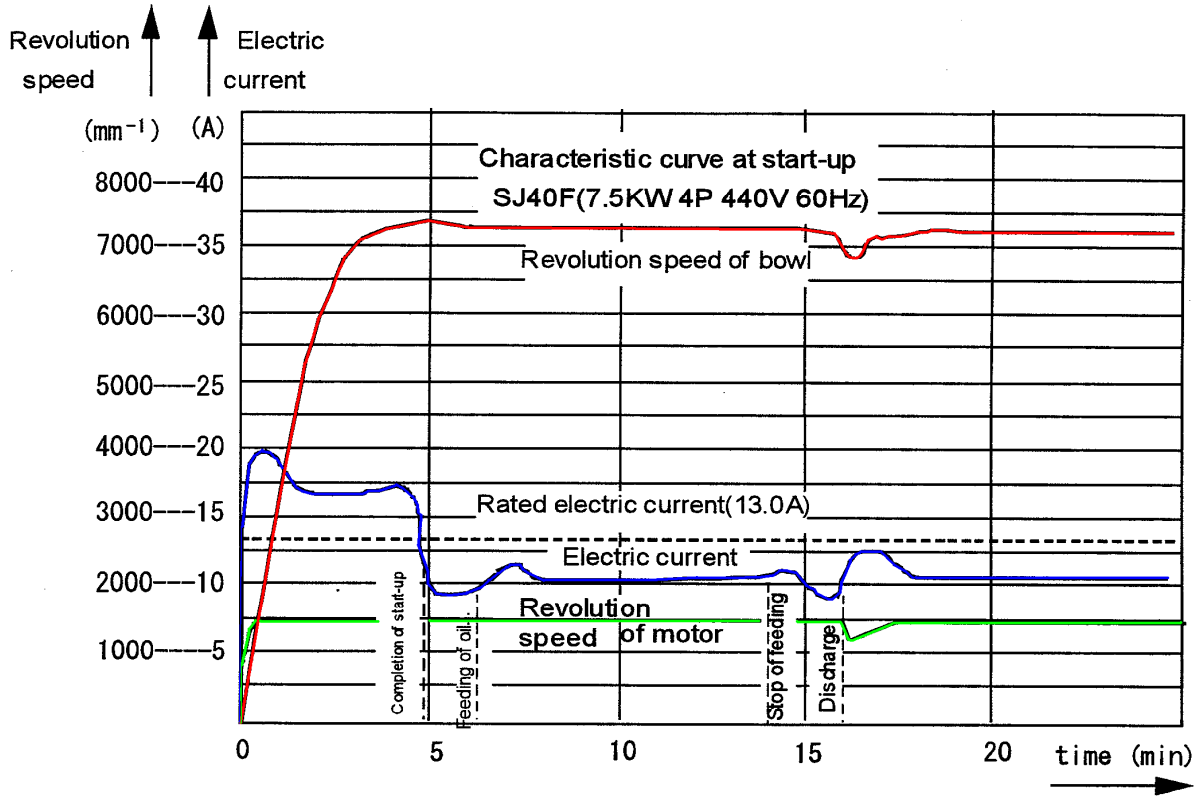


Fig. 3.13

From the above diagram, It is evident that starting current is about twice the normal current and the motor attains its normal speed instantly. The bowl attains its normal speed gradually with the help of friction blocks.
If the normal speed of revolution drops, the treating capacity and separation efficiency of separator will go down.

Checks before Starting:

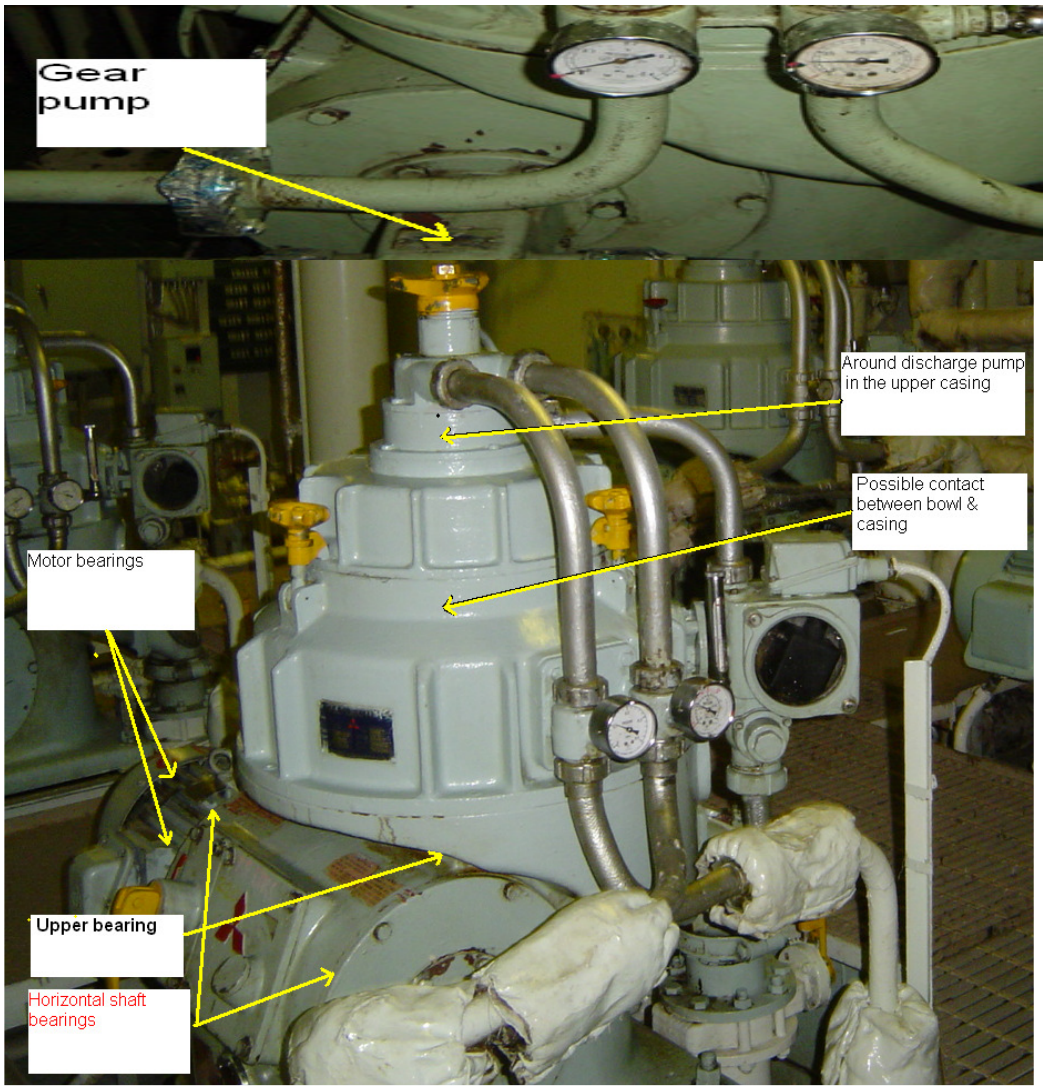
1) Make sure that the separator has been correctly assembled, paying special attention to securing parts (e.g. cap nut for securing bowl to vertical shaft) and all pipe connections have been adequately tightened.
2) Check that the correct size of gravity disc has been fitted.
3) Gear case is filled up to correct level with appropriate lubricant.
4) Line up oil, operating water, sludge, heating steam and control air line properly. Ensure that correct supply pressure for respective mediums is available. Ensure valves V5, V6, V7, V8, V9 & V10 are fully open.
5) Hand brake is disengaged.

3.3 Test Running:

Start the separator and
1) Confirm that the Direction of motor is correct.
2) Confirm that no abnormal sound and vibration are generated.
3) Confirm that the motor current is following the starting characteristics as explained earlier.
Usually the bowl takes a long time to reach the specified speed due to its high weight. Initially, the ammeter indicates a current value more than the rated value and then gradually comes to normal running value as the bowl attains its normal speed. Therefore, a friction clutch and thermal relay cancellation circuit are used during start up.
Usually the rated bowl speed is achieved within 3 to 7 minutes and correspondingly the current value falls within 50% to 70% of its rating. If the bowl has not achieved its rated speed within the specified time, stop the separator and find the cause (friction blocks).
Therefore, it is important to observe the ammeter to identify any abnormality with the separator.
4) Confirm that no abnormal vibrations are observed.

Initially, some vibration may occur, which is normal. But, if the vibrations are severe at the rated speed also, stop the separator and identify the cause.
The following points as indicated in the photos should be checked for any abnormality/vibrations with the help of a pointed metal rod.

Picture below shows check points during starting.



After the motor current has steadied at normal running value, supply the operating water for closing the bowl by manually operating the solenoid valve SV2 for 20~30seconds. If any leakage is observed from the operating water drain line, the water supply equipment is abnormal. Check the condition of parts, o-rings and gasket.

The operating lever for the water supply solenoid valves is to be changed to “O” position for manually opening the valve. During auto operation, the lever should be in “S” position.

If no operating water leakage is observed, supply the sealing water by manual operation of solenoid valve SV3. If too much sealing water is supplied, it will overflow from the heavy liquid outlet pipe.
Figure 3.14 and Picture below show arrangement of water supply solenoid valves.

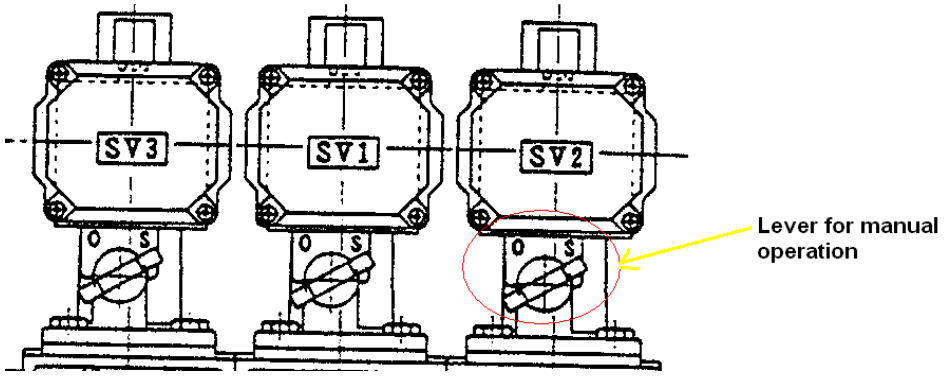
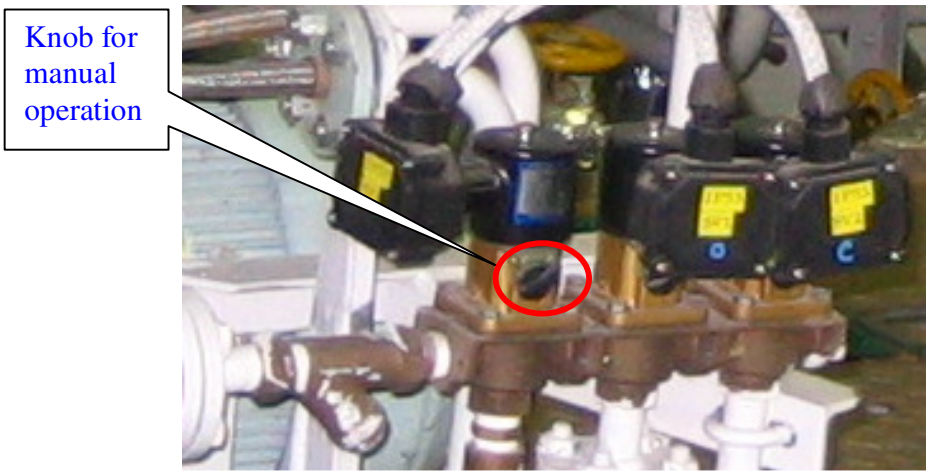
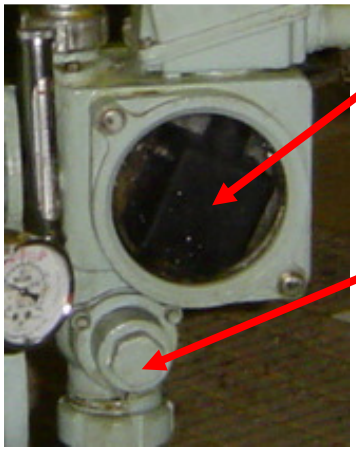


Fig. 3.14



This can be confirmed from the sight on the heavy liquid outlet pipe. Check that there is no water leakage from the sludge discharge pipe. If any leakage is observed, it means that the bowl is not sealing properly. This may be due to defective main seal ring or defective closing mechanism of the main cylinder.



The water flow through the heavy liquid outlet pipe must be so adjusted by adjusting the drain valve that the float switch operates only when there is high viscosity oil flow through the pipe and not during normal water drainage.

If no leakage of sealing water is observed, supply the operating water for opening the bowl by opening solenoid valve SV1. Confirm discharge by the discharge sound and increase in the motor current. Confirm the operation of sludge discharge switch. After confirmation of discharge, stop the opening water supply. Confirm that there is no water discharge from the operating water drain pipe after closing the valve.

If there is continuous discharge of water after closing the valve, it may be due to defective solenoid valve or defective water supply device. Overhaul these parts.

If there is no leakage of operating water for opening the bowl, supply the operating water for closing the bowl by opening the solenoid valve SV2 for 20~30 seconds and carry out earlier mentioned checks.
Confirm that the bowl has closed and the motor current has returned to normal value at no load.
If the motor current does not return to normal value at no load after the supply of closing water, it means that the bowl has not closed completely. This can be further confirmed by observing the leakage of water from the sludge discharge pipe after supplying the sealing water.
If the motor current is steady at normal value, supply the sealing water and confirm that the bowl is properly closed.

Start operation:

If the feed oil temperature is correct, push the start switch and observe that the 3-way feed oil valve operates. Check the speed of its movement. If the speed of change over is fast, there will be a sudden gush of feed oil into the bowl, thereby leading to rapid increase in the motor load and drop in bowl RPM. This rapid ingress of oil may also cause the sealing water to mix with the oil and consequently carry over of water with the oil. Therefore, the changeover speed of the valve from recirculation to supply must be adequately adjusted to provide smooth changeover.

After start of feeding, confirm from the sight glass that the extra sealing water has been discharged from the heavy liquid outlet pipe. If there is no discharge of heavy liquid, it means that the first supply of sealing water was insufficient and the setting time for supply of sealing water needs to be increased. But this should not be for too long, otherwise the water will be carried over to light liquid outlet side.

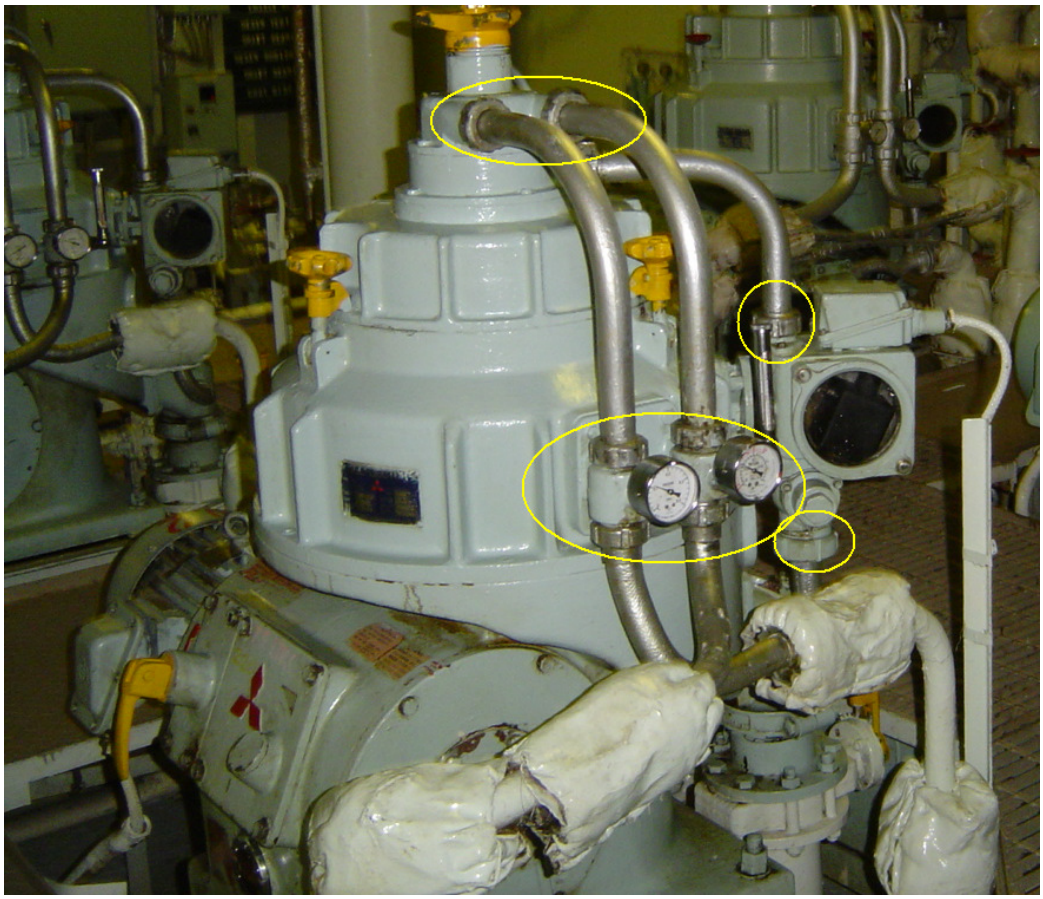
Check the sludge discharge pipe and heavy liquid outlet pipe for any oil leakage. If any leak is observed, it means that either the bowl has not been closed properly or oil-and-water interface position is incorrect.

Check the separator for any abnormal vibrations, oil/water leakages at the pipe connections, etc.

Flow rate should be adjusted to the appropriate value by regulation of valves V5 and V8. If the flow rate is changed from the normal value, it is necessary to check whether the gravity disc size is appropriate and change it, if required.

Confirm that the oil temperature is below 100°C and close to the set point.

Picture below shows check points for leakages during starting.



If the separator is running normal, perform the auto sludge discharge test and check all points as in case of manual operation. Confirm sludge discharge by sound and increase in motor current. Confirm closing of bowl, return of motor current to normal, supply of sealing water. Confirm changeover of 3-way feed valve, discharge of extra sealing water. Confirm there is no leakage or abnormal vibrations. Confirm correct feed rate and treating temperature. Confirm setting of appropriate auto sludge discharge interval.

Stop operation:

Before stopping the separator, discharge sludge by operating the sludge discharge switch. If required, sludge discharge can be performed several times, just to make sure that no sludge remains in the bowl.

If sludge discharge is not carried out before stopping the separator, this sludge may become hard when the bowl becomes cold and if distributed unevenly inside the bowl, will lead to unbalance and abnormal vibration during start.

After performing sludge discharge, stop the separator and confirm correct stop sequence.
Switch off the power supply.
Shut off operating water supply.
While the separator is idling, judge the condition of each ball bearing by listening the generated sound. Check vibration of bowl and its balance.
Confirm that the bowl has come to standstill. This can be checked by inspecting the cooling fan of motor or pump shaft. Close all valves in the respective system.

Inspection points during running:

The following points should be checked during running of the separator.

a) Vibration ／sound／ temperature

Inspect the following points by hearing rod or hand touch or thermometer:
1) Ball bearing point at both ends of motor >> Check bearing condition >> by observing vibrations／ hearing sound
2) Motor body >> check vibration and temperature
3) Ball bearing point of both end of horizontal shaft >> Check bearing condition >> by observing vibrations／ hearing sound
4) Feed pump body >> check vibration and sound
5) Lower part of purifier >> check condition of lower bearing and gear part >> by observing vibrations／ hearing sound
6) Middle part of purifier >> check condition of upper bearing and bowl balance >>by observing vibrations／ hearing sound
7) Upper part of purifier >> check condition of purified oil transfer pump part >>by observing vibrations／ hearing sound
8) Solenoid valve for operation water etc. >> check condition of electric coil >>vibration ／ heat

Figure 3.15 shows check points on separator during running.

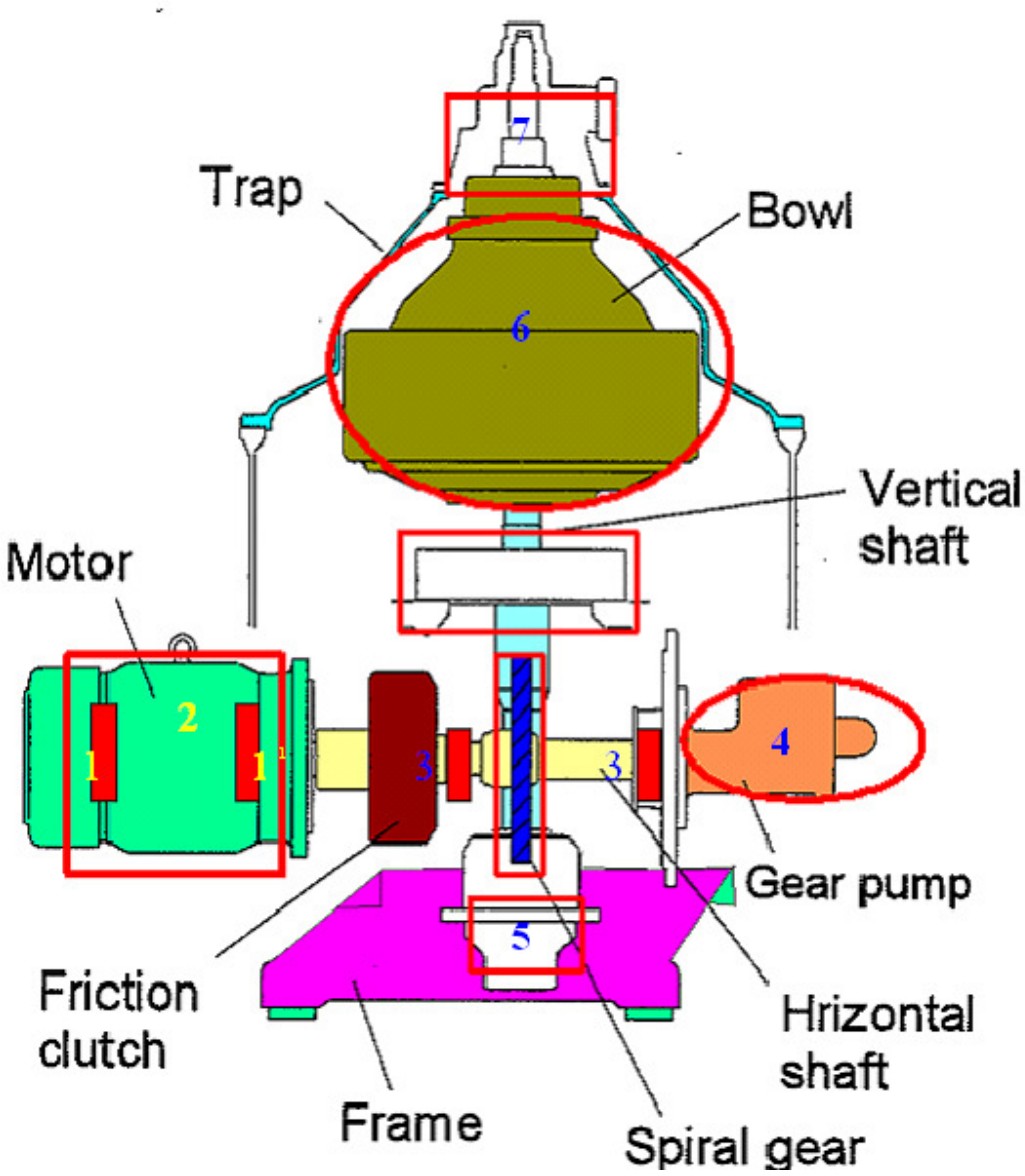
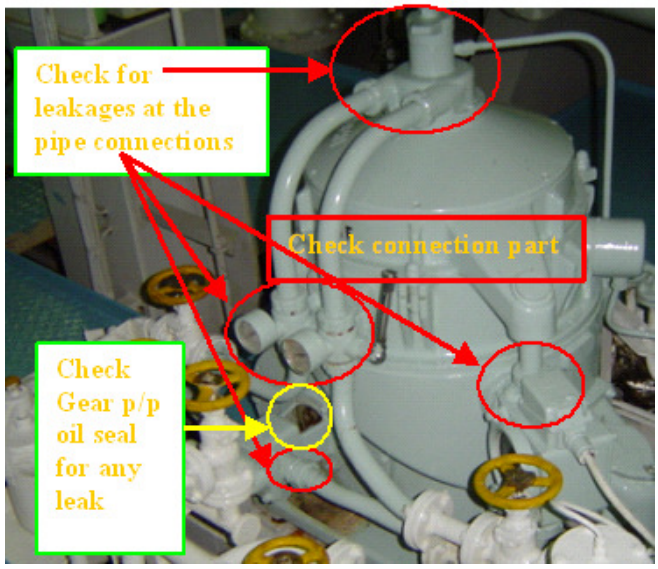


Fig. 3.15

b) Leakage:

Check the following points:
1) Both ends of horizontal shaft (motor side & pump side) >> check near the oil seals at both ends for any leakage of gear oil
2) Feed oil pump >> check near the oil seal for leakage of feed oil
3) Upper cover part of purifier >> check the connection part for leakage or damage of O-ring etc.
4) Each pipe line (light liquid／sludge／heavy liquid) >> check the connection part and pipe line for any leakage
Pictures below show check points for leakages.

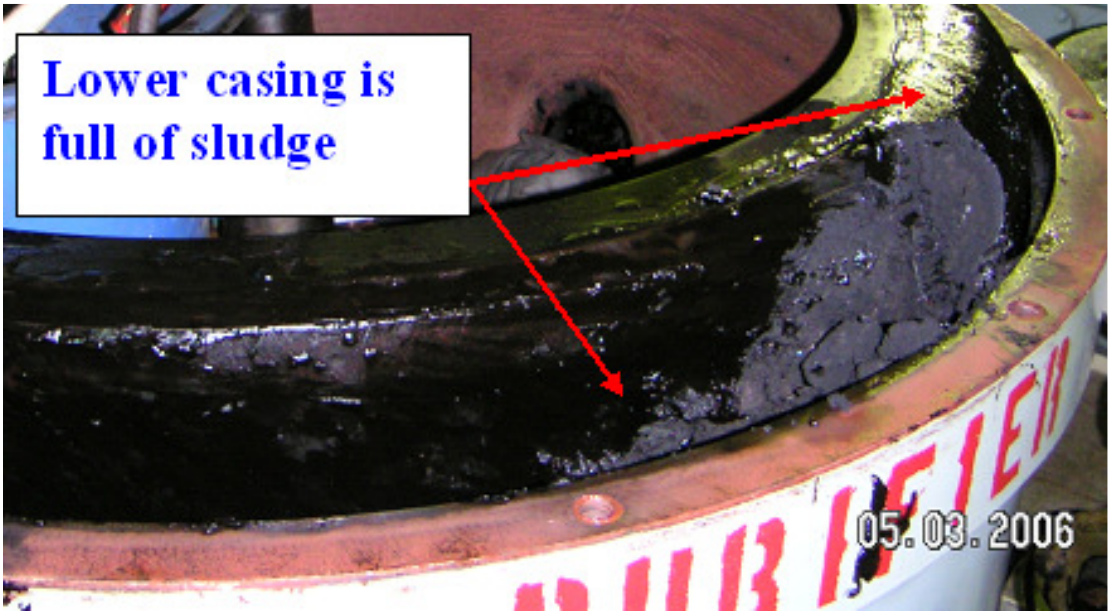


c) Function:

Check the following points:
1) Discharge condition in the operating water drain pipe
If there is continuous drainage of water from the operating water drain pipe during normal separation operation, it means that the water supply device is defective.
The cause may be defective O-ring or leaky water pipe line to device or damaged parts.
Stop the separator and overhaul the water supply device.

2) If after the sludge discharge operation, the sludge discharge is not smooth, it means that there is blockage in the discharge pipe or sludge accumulation in the lower part of the casing.
Stop the separator and clean the inside of the casing and sludge discharge piping.

Picture below shows a condition of lower casing being full of sludge.



3) If during normal operation, water is continuously drained from the heavy liquid discharge pipe, it is possible that the feed oil contains excess water. This may be due to faulty heating equipments (e.g. leaking heating coils in the FO storage and FO settling tank or leaky heater tubes or high water content in the bunker itself or leakage of sealing water into the bowl.

4) If after the sludge discharge operation, there is no drainage of water from the heavy liquid discharge pipe, it means that the sealing water supply is insufficient.
Clean the strainer in the water supply line or adjust the timer for opening the solenoid valve for sealing water.

5) If there is a large quantity of water drainage from the heavy liquid discharge pipe, it may be due to either excess supply of the sealing water or due to fast changeover of the feed valve, causing sudden rush of oil into the valve. This will cause oil to push the water with sudden force, resulting in excess drainage of sealing water. This may also cause water to get carried over to oil side.
Adjust the timer for sealing water quantity.
Adjust the changeover speed of the 3-way feed valve from recirculation to supply by the use of control air pressure regulator.

6) Check the level of the sludge tank daily.
Since the number of sludge discharges per day is fixed, the total increase in the sludge tank level per day should be almost constant.
If the increase in level is more, it means either the oil contains excess water or there is some abnormality with the separator.
If the increase in the level is less, it means that the sludge discharge function is not working correctly.

d) Perform discharge test:

This test gives the following indications:

1) Observe the motor current indicator for any fluctuation. This corresponds to balance of the bowl.
2) Correct setting of sealing water quantity and speed of changeover of 3-way feed valve can be judged.
3) Condition of bowl and outer lower casing can be judged.
4) Condition of water supply device can be judged.

e) Temperature and Feed rate check:

1) Check that the feed oil temperature is correct.
2) Check that the feed rate is correctly adjusted.

Summary of Checks Before & During Operation

Sr. No	Frequency	Checkpoint	Criteria	Value
1	Daily (During rounds)	Check visually for any vibration	No vibrations	
2		Check for vibration / abnormal sound using a telescopic stethoscope/sounding bar	No abnormality	
3		Check visually for leaks	No leaks	
4		Check all connections properly secured	Secured	
5		The purifier comings are oil free.	Clean	
6		The laggings on FO/DO/LO lines are free from any oil stains.	Satisfactory	
7		Feed oil Inlet temperature	FO : 98 deg.C LO : 90 deg.C	
8		Sludge outlet valve for running purifier open & stopped purifier closed	Position confirmed	
9		Optimum gear oil level maintained.	Level to be maintained between L & H	
10		Delivery pressure within in range Note: The P (pressure drop) value in regard to the Leakage Monitor function varies in response to the changing level of actual back pressure. Therefore it needs no adjustment even if liquid side pressure differs from its initial set value unless the deviation exceeds 0.2 MPa (2.0 kgf/cm²).	(Standard value: 0.15 MPa {1.5 kgf/cm²})	
11	Weekly	Vibration to measured using vibration meter Note: To be more specific, if the vibration at the point A as per below figure exceeds 100 μm(peak to peak) at rated speed, stop SELFJECTOR & carry out troubleshooting	Max : 100 μm	

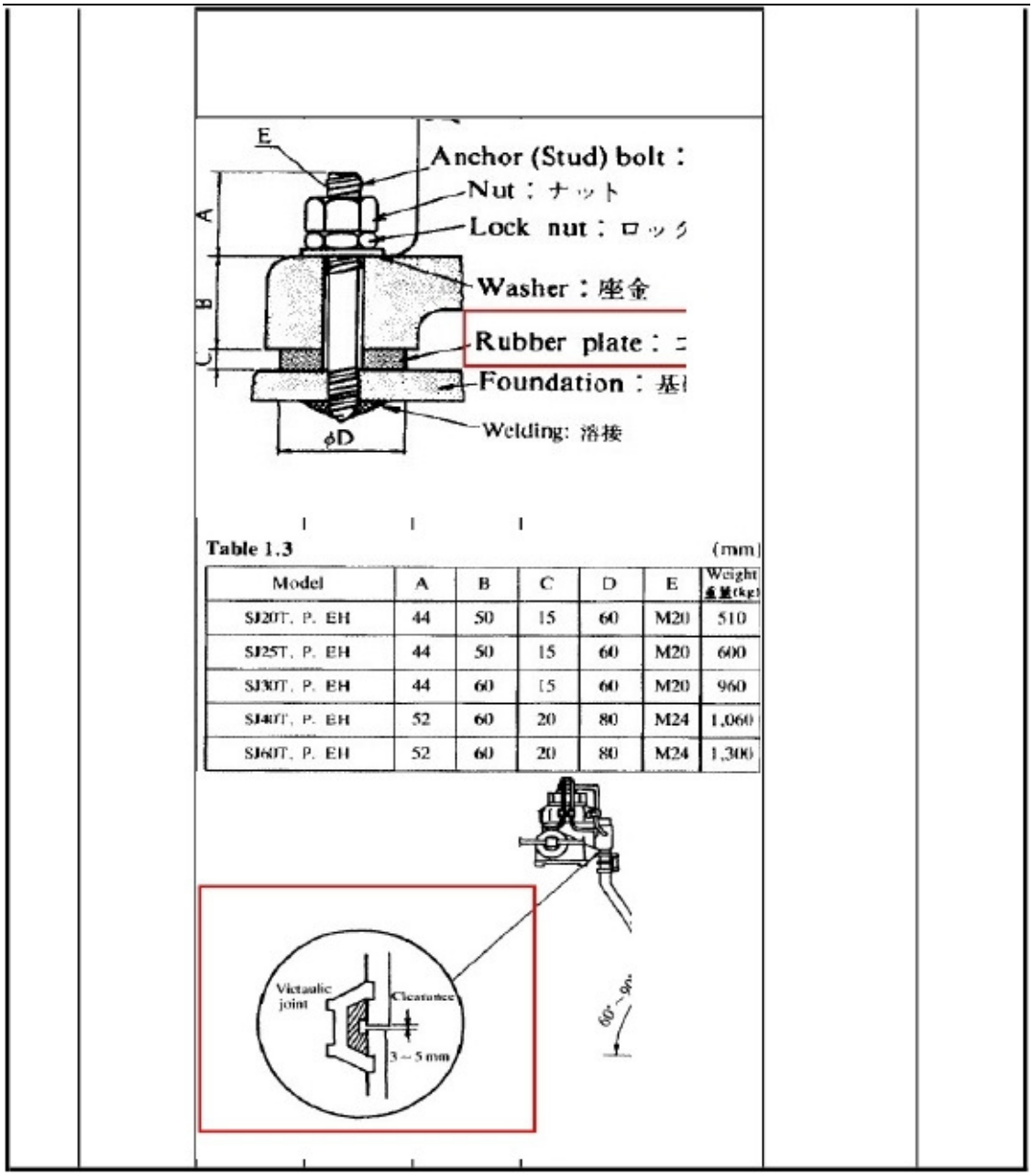


Table 1.3 (mm)

Model	A	B	C	D	E	Weight 重量(kg)
SJ20T, P, EH	44	50	15	60	M20	510
SJ25T, P, EH	44	50	15	60	M20	600
SJ30T, P, EH	44	60	15	60	M20	960
SJ40T, P, EH	52	60	20	80	M24	1,060
SJ60T, P, EH	52	60	20	80	M24	1,300

Use the above form to carry out checks before starting and during operation of the separator.

3.4 Control and Safety Devices:

1) Control device:

A control device is provided for automatic operation of separator. It performs the following processes automatically:
Supply of operating water for closing the main cylinder
Supply of sealing water
Supply of feed liquid in case of purifier operation
Supply of replacement water
Supply of operating water for opening the main cylinder
If an abnormality occurs with the auto separation process, it will stop the supply of feed liquid, initiate the sludge discharge and stop the motor automatically.
The automatic operation has been explained below for FBC-2 type control used with Mitsubishi SJ30F series separators.
The automatic control panel has the Timers and Relays, which are suitably marked for easy location. The setting time and purpose of Timers are given below.
This set time for sealing water and the replacement water is applicable, when the supply water flow is about 12L/min.
Sludge discharge interval setting is based on the general quality of oil. It is to be changed if the oil specification differs from normal.

The table below shows the typical set time for typical lubricating oil purifier. Adjust the time as per the requirement for other types.

Timer	Purpose	Setting time
20-IT	Creates an interval of operation of each solenoid valve in the sludge discharge process	15 sec
20 RT	Sets the supply time for replacement water	10 sec
20DT	Sets the supply time for opening water	2 sec
20 ST	Sets the supply time for sealing water	9 sec
120 QT	Sets the feeding time for untreated liquid (FO C oil (380cSt @ 50℃)	1~2 h
220 QT	Sets the feeding time for untreated liquid (LO cross head type)	2~4 h
20 CT	Sets the supply time for closing water during feeding	10 sec
66 T	Sets the supply interval for closing water during feeding	10 min

2) Sequence of operation:

a) Switch on the power supply for the automatic control panel and motor starter panel.
b) Start the motor from starter panel.
c) Confirm that the bowl has reached the normal speed by checking the motor current on the ammeter and then push "Auto start" switch on the auto control panel.
The timer "20 IT" for interval is excited. The solenoid v/v SV2 is activated and the water for closing the bowl is supplied. The main cylinder is closed.
d) When the set time for timer 20-IT is over—
+Timer 20 RT for setting the supply time of replacement water is excited.
+The solenoid valve SV3 is activated to supply replacement water to the bowl.
e) When the set time of 20 RT is over -----
+ The solenoid valve SV3 is deactivated to stop the supply of replacement water.
+ The timer 20 DT for setting the supply time for opening water is excited.
+ The solenoid valve SV1 is activated to supply opening water to the bowl, thereby opening the bowl to discharge the replacement water.
f) When the set time of 20 DT is over --------
+ The solenoid SV1 is deactivated to stop the supply of opening water and the bowl is closed as the closing water is being continuously supplied.
+ The timer 20-IT is excited.
g) When the set time of 20-IT is over -----
+ The timer 20 ST for setting the supply time of the sealing water is excited.
+ The solenoid valve SV3 is activated to supply sealing water to the bowl.
h) When the set time of 20 ST is over ------
+ The solenoid valve SV3 is deactivated to stop the supply of sealing water.
+ The timer 20 IT is excited.
i) When the set time of 20-IT is over -----
+ The timer 120 QT for setting the feeding time is excited.
+ The solenoid valve SV4 is activated to operate the 3-way feed valve to supply the dirty oil into the bowl.
+ The solenoid valve SV2 is opened intermittently to supply the closing water to the bowl during the feeding process.
+ The timer 20CT for setting the supply of closing water is excited and opens the solenoid valve SV2. Once the set time of timer 20 CT is over, SV2 is closed and the timer 66T for setting the supply interval of water for intermittent closing of bowl is excited. Once the timer 66T is over, solenoid valve SV2 opens and the timer 20 CT is excited. This process is continued during the feeding operation.
+ The Feeding signal goes to the leakage monitor.
j) When the set time of timer 120 QT is over -----
+ The solenoid valve SV4 is deactivated to change over the 3-way valve CV1 to recirculation, thus terminating the supply of oil to the bowl.
+ The Feeding signal to the leakage monitor goes off.
+ The timer 20-IT is excited at the same time.

+ The solenoid valve SV2 is activated to supply closing water to the bowl.
+ The "Discharge Process" signal is supplied to the Discharge detector, if provided.
k) When the set time of timer 20-IT is over -----
+ The solenoid valve SV3 is activated to supply the replacement water to the bowl.
+ The timer 20 RT for setting the supply time of replacement water is excited at the same time.
l) When the set time of timer20 RT is over -----
+ The solenoid valve SV3 is deactivated to stop supplying the replacement water.
+ The timer 20 DT for setting the supply time of opening water is excited.
+ The solenoid valve SV1 is activated to supply the water to open the bowl. The bowl opens and sludge is discharged.
m) When the set time of timer 20 DT is over ----
+ The solenoid valve SV1 is deactivated to stop the supply of opening water. The bowl is closed as the closing water is being supplied continuously.
+ The timer 20-IT is excited.
n) When the set time of timer 20-IT is over -----
+ The timer 20ST for setting the supply time of sealing water is excited.
+ The solenoid valve SV3 is activated to supply the sealing water to the bowl.
+ The output of the "Discharge process" signal to the discharge detector is stopped, if provided.
o) When the set time of timer 20ST is over ----
+ The solenoid valve SV3 is deactivated to stop the supply of sealing water.
+ The timer 20-IT is excited at the same time.
p) When the set time of timer 20-IT is over -----
+ The timer 120 QT for setting the feeding time is excited.
+ The solenoid valve SV4 is activated to operate the 3-way feed valve to supply the dirty oil into the bowl.
+ The solenoid valve SV2 is opened intermittently to supply the closing water to the bowl during the feeding process.
+ The timer 20CT for setting the supply of closing water is excited and opens the solenoid valve SV2. Once the set time of timer 20 CT is over, SV2 is closed and the timer 66T for setting the supply interval of water for intermittent closing of bowl is excited. Once the timer 66T is over, solenoid valve SV2 opens and the timer 20 CT is excited. This process is continued during the feeding operation.
+ The Feeding signal goes to the leakage monitor.
q) Sludge discharge test can be performed any time during the feeding operation, by pressing the auto discharge switch on the control panel. The sequence of operation of timers and solenoid valves are same as in case of timed discharge. After the discharge process, the automatic operation continues. The timer 120 QT resets to initial condition.

Figure 3.16 shows the Timing chart.

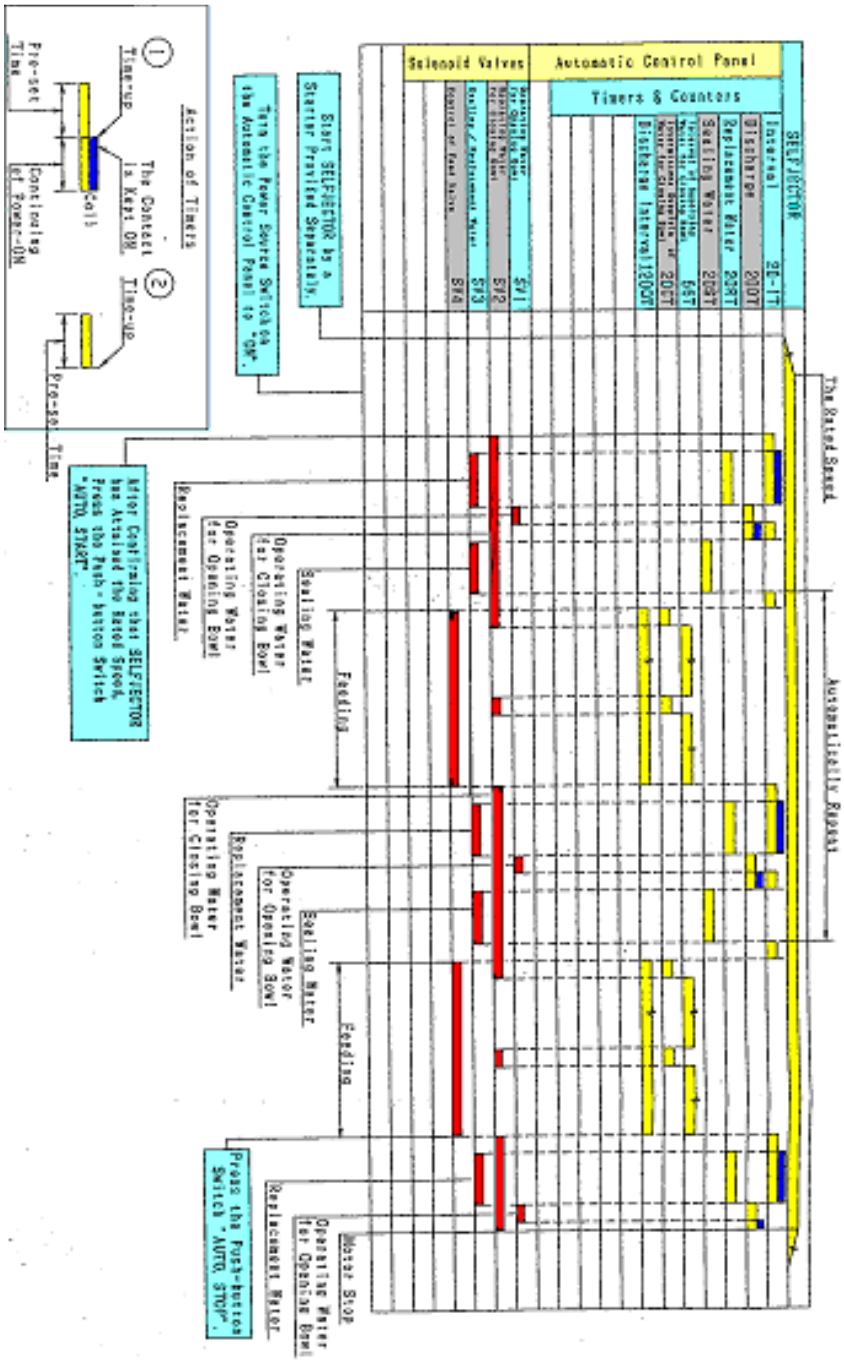


Fig. 3.16 Timing chart "Auto operation" FBC-2 type

r) The separator can be stopped by pressing the auto stop switch on the control panel. Once the stop switch is pressed----
+ The timer 120QT is deactivated.
+ The solenoid valve SV4 is deactivated to operate the 3-way valve to recirculation position, thereby terminating the oil supply to the bowl.
+ The Feeding signal to the leakage monitor goes off.
+ The timer 20-IT is excited at the same time.
+ The solenoid valve SV2 is activated to supply closing water to the bowl.
+ The "Discharge Process" signal is supplied to the Discharge detector, if provided.
s) When the set time of timer 20-IT is over ----
+The timer 20RT for setting the supply time of replacement water is excited.
+ The solenoid valve SV3 is activated to supply the replacement water to the bowl.
t) When the set time of timer 20 RT is over ----
+ The solenoid valve SV3 is deactivated to stop the replacement water supply.
+ The timer 20 DT for setting the supply time of opening water is excited.
+ The solenoid valve SV1 is activated to supply the water to open the bowl. The bowl opens and sludge is discharged.
u) When the set time of timer 20 DT is over ---
+ The solenoid valve SV1 is deactivated to stop the supply of opening water.
+ The magnetic contactor of motor is turned off and the motor stops.
+ The solenoid valve SV2 is deactivated to stop the supply of closing water.
v) If the separator is stopped by using the Emergency stop, the separator stops without discharging sludge. In that case, the separator bowl should be cleaned before starting to avoid unbalance due to remaining sludge in the bowl.

Figure 3.17 shows general layout for separator.

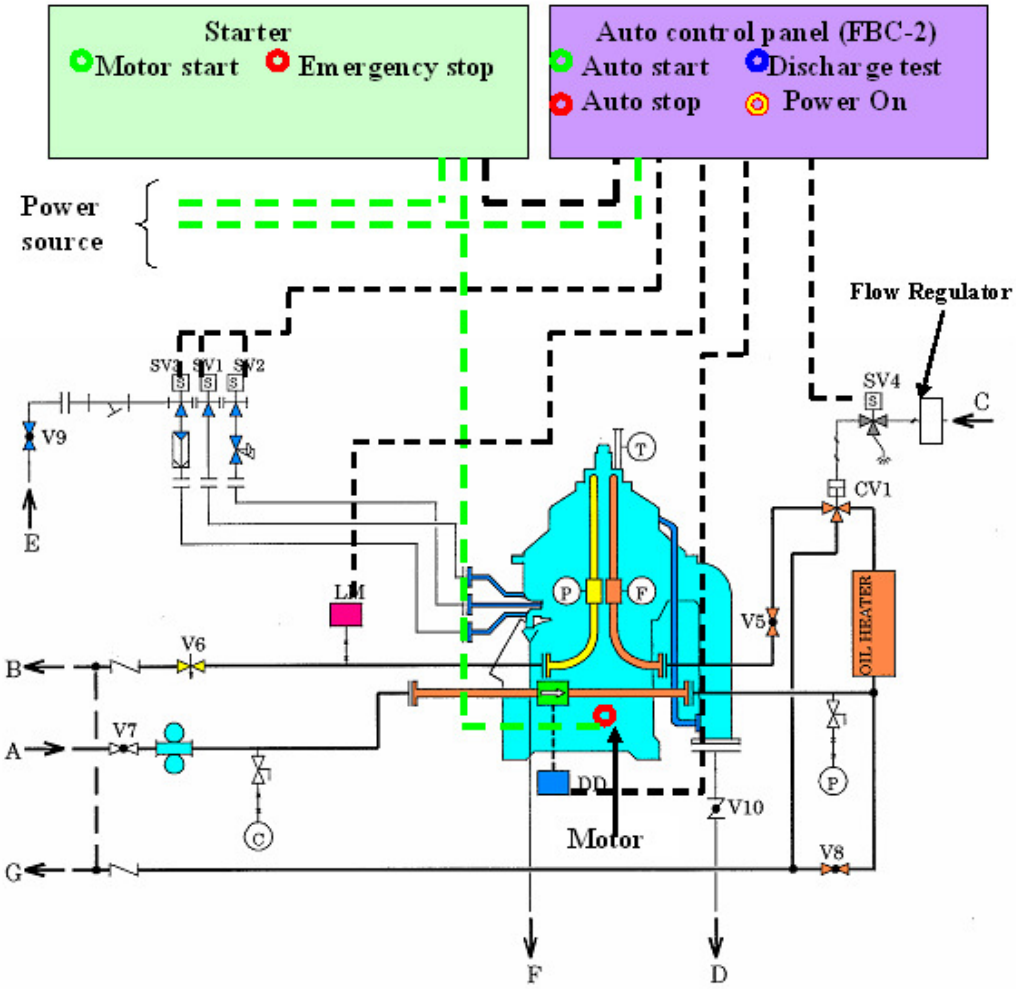
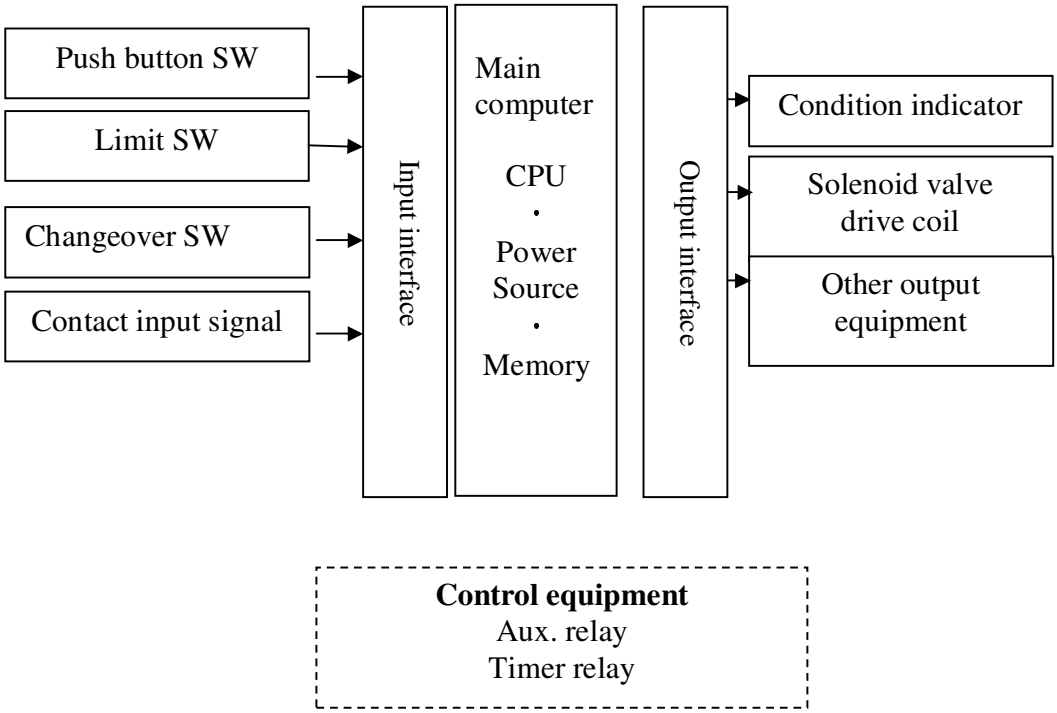


Fig. 3.17

3) Programmable Controller:

The Programmable controller consists of Input interface, main computer & Output interface.



There are two types, one type combines the three parts and the other type is modularized.

Input interface

Input Interface side receives the information that is necessary for control, an START signal, an STOP signal, a heavy solution outflow signal, a sludge discharge signal, an OCR signal.
The ON / OFF signal can be confirmed by the status of the LED. On the other hand, a signal is sent to the main computer via a converter when an analog signal is necessary.

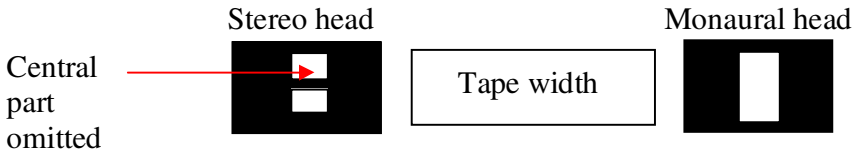
Main computer

The main computer has three parts:

A Source i.e. Power supply (converts AC power into low voltage direct current)
A CPU part (a central processing unit),
A Memory (stores, programs and controls CPU).

To save the programme in the RAM, It is equipped with a back up power supply (a battery or a condenser) for preservation.
In case of loss of power supply for long time, there is a chance that the programme may get erased. The programme has to be installed again using an external input device.

Loading and reading of a program
A programme saved on an external memory device can be transferred to CPU of the sequencer.



Caution: The Mitsubishi Kakoki uses a cassette tape as an external memory. The original program is stored on a cassette tape by monaural recording. This tape is supplied to the ship.
When reloading the program into the sequencer, use a monaural cassette recorder. If the tape is played back in stereo, the main computer can not read the program, since the central part of the tape can not be read by the stereo head. Therefore, it becomes reading of an incomplete program.

Output Interface
The output interface sends the computed results of the input signal and the control program. The status (ON/OFF) of the output signal can be checked by the LED.

Troubleshooting:
When controls are not working correctly, the cause can be detected in the following way:

STEP (1): Confirm the condition of Input i.e. check the condition of each input device (Push buttons, limit switch, etc.) to the sequencer input interface.
a) Generate a dummy signal by jump wiring or operate each input device manually.
b) Confirm the input condition from the corresponding LED status.
c) If the input signal is received, the problem lies somewhere else.
d) If the input signal is not received, the problem lies in the machinery wiring, look for defect.

STEP (2): Confirm the condition of main computer
a) Confirm that the controls are being performed as per the control time-flow chart shown in the instruction manual.

b) If normal control processing is being performed, check whether the output LEDs related to processing turn ON/OFF
c) Confirm setting points e.g. timers
d) If there is no apparent abnormality, the problem lies somewhere else.
e) If abnormality is detected in the output signal, the main computer may be defective. Try reinstalling the program. If abnormality is still present, the main computer is defective and should be repaired / replaced.

STEP (3): Confirm the condition of the output interface
a) Confirm the condition of output device corresponding to the status of the output signal LED. Both should be in same position.
b) If the output device is not in an operable condition, while the corresponding LED lights, the concerned output device or wiring is defective.

While troubleshooting, divide the automation control in three parts i.e. Input interface, main computer and Output interface. Check actual status of input and output devices corresponding to the LED position. If there is no abnormality with input and output connections, the problem lies with the main computer.

Safety devices: The separator is normally equipped with monitoring equipments for detecting
>> the abnormal leakage of oil from the separated water outlet or from the sludge outlet. Leakage monitor or Heavy liquid leak detector is provided to monitor this.
>> the abnormal sludge discharge condition. Discharge detector or Sludge discharge switch is provided to monitor this.
>> the abnormal increase of water content in the clean oil outlet. Water detector is provided for this.
Additional safety devices may be fitted depending upon the Make/Type of the separator.

Various types of these safety devices are used depending upon the separator model.

Heavy liquid leak detector:

The heavy liquid leak detector is composed of a mechanical part and an electrical part that converts mechanical readings to electrical signals.
If the oil-and-water interface moves outwards due to any abnormality, the purified oil leaks to the heavy liquid discharge line.
The leak detector detects this abnormal condition and a Float lifts up. This causes a micro-switch to make contact and thus activate an alarm.

The discharge-flow quantity is controlled by the adjustment or throttle screw located outside of the float chamber to detect abnormal flow.
Adjustment is performed by opening or closing the discharge port by turning the adjustment screw.
When the discharge port is properly adjusted, any heavy liquid (either seal water or separated water, both of low viscosity) drains smoothly.

But if, the purified oil (high viscosity) flows in the chamber, it cannot drain smoothly, it is accumulated in the chamber and the float is pushed upward and alarm is raised.

General check points:

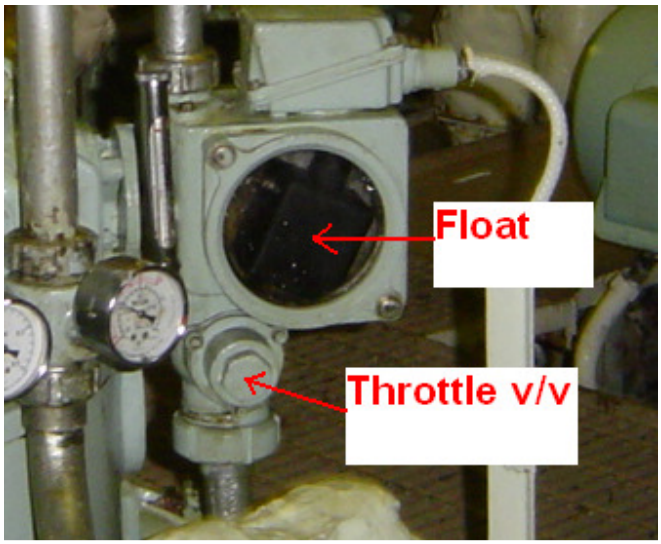
1) Check the movement of the float.
Ensure that it can be easily lifted by hand.

2) Check the condition of the micro switch.
Check the micro switch operation by lifting the float.

3) Check the float condition.
Check for corrosion and any other damage.

4) Remove the cover of micro switch and check the condition around the penetration part of the casing.
Carry out an overhaul if there is any leakage.

Picture below shows arrangement for Leak detector.



Picture below shows location of one type of Leak detector and Sludge discharge switch on the separator.

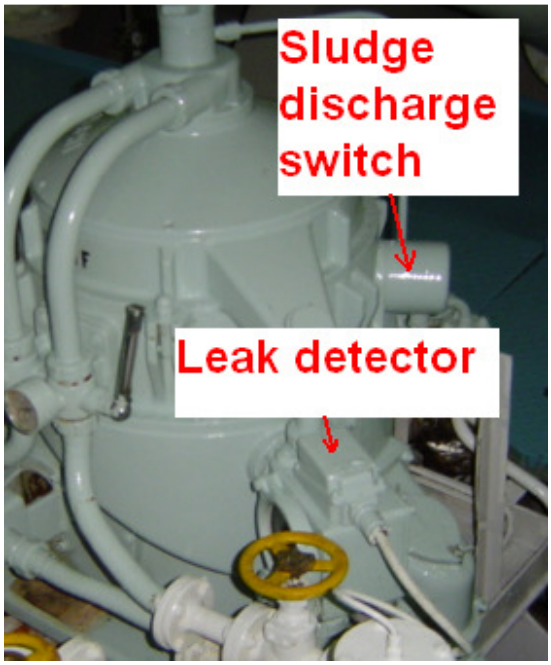


Figure 3.18 shows cut off view of Leakage detector.

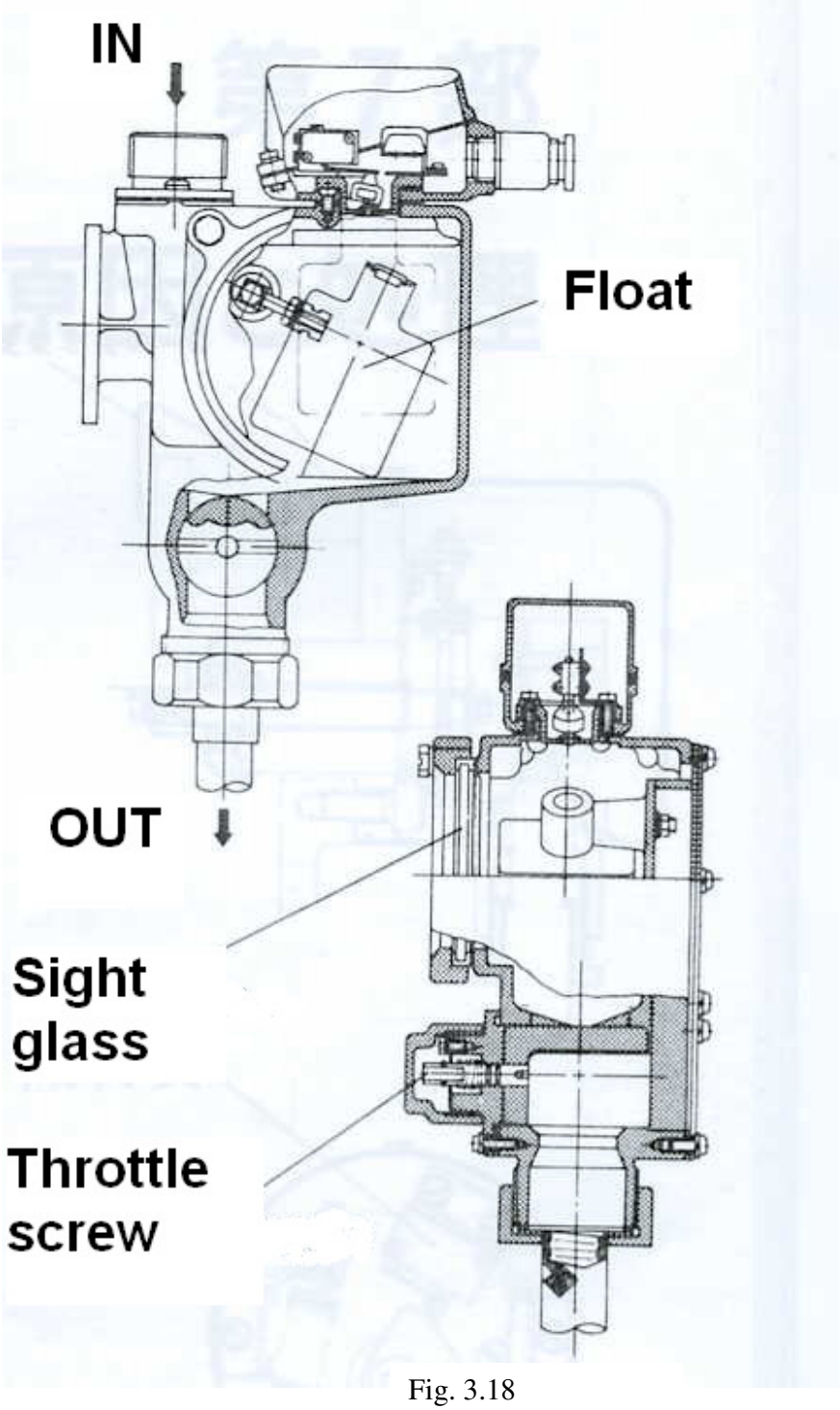


Fig. 3.18

Sludge Discharge switch:

This detector is composed of a mechanical part and an electrical part. The mechanical part (a sludge discharge condition sensing lever) is moved by the sludge discharged from the bowl. The lever's movement turns a shaft with a cam that pushes a micro switch. The micro switch then generates an electrical signal.

When sludge discharge is detected other than during the normal sludge-discharging process e.g. the main cylinder fails to close properly, etc., the safety device activates and shuts down the purifier, while generating an alarm at the same time.

General Check points:

1) Check the condition of the lever and its movement. Confirm the working condition of Micro switch by turning ON or OFF the light of LED on the Control panel.
Check for corrosion and any other damage.

2) Check the attachment points of the lever's parts.
Check for the presence of any cracks.

3) Check the condition where the shaft penetrates the casing.
Inside corrosion often occurs because of a damaged and leaking oil seal.

4) Check the condition of the electric parts (micro switch, wires, connections, etc.).
Check for corrosion and loosening of the each connection.

5) Check the condition of the mechanical parts (cam, spring, ball bearings).
Check for corrosion and movement.

Figure 3.19 shows general arrangement of Sludge discharge switch.

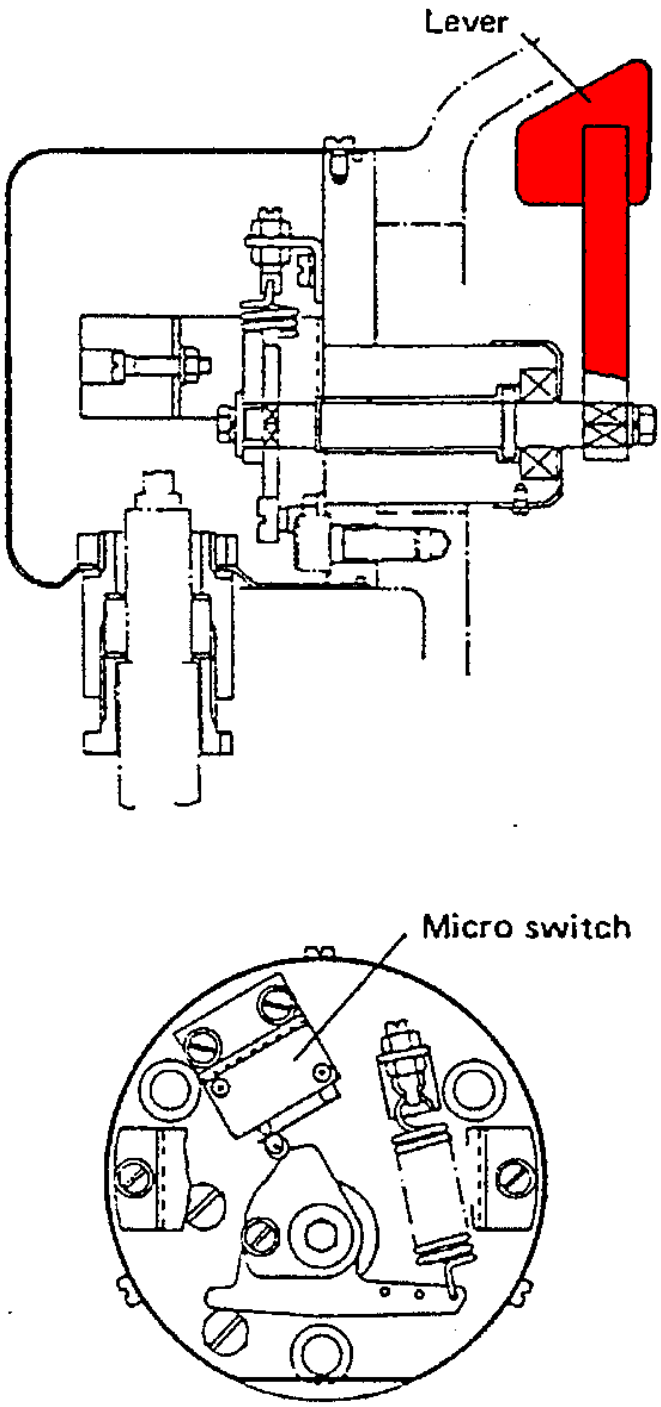


Fig. 3.19

4.0 Maintenance Works:

Precautions before Maintenance: Make sure that

1) Separator is at standstill. This can be ensured by checking the motor fan or the LED of Discharge detector (Continuously lit when stopped) or Gear pump shaft.

2) Power supply to starter is OFF and placard stating “Do not switch ON, Maintenance in progress” is displayed.

3) Isolate the separator by closing valves for Oil, Water, Steam, Sludge outlet, etc.

4) Take extra precautions if opening a separator soon after stopping as it might be still hot.

Precautions during Maintenance: Make sure that

1) All the screws are opened in correct direction as described in the Instruction manual. (Screws are threaded Clockwise for SELFJECTOR)

2) The bowl parts are neither heated by open flame nor welded.

3) The bowl parts are not interchanged as it may lead to imbalance.

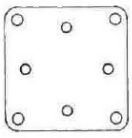
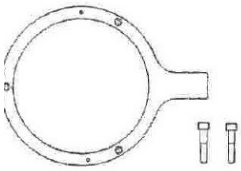
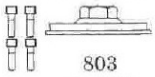
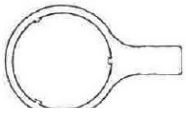
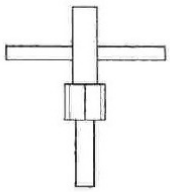
4) The Bowl nut, Disc nut, cap nut of vertical shaft, Set bolt of Frame cover and Lock nut (hexagon) of Inlet pipe are tightened sufficiently.

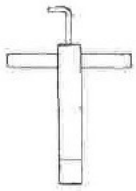
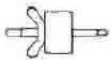
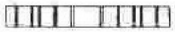
5) The Tally marks of the Bowl parts are properly aligned.

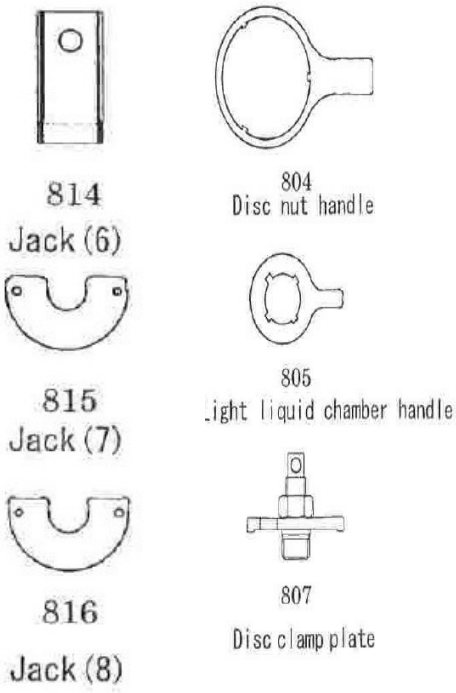
6) The each part surface is properly inspected for any corrosion or erosion.

Note: Refer the Instruction manuals for Maintenance procedure of particular Make/Type of Separator during overhaul.

Summary of Checks before Overhaul

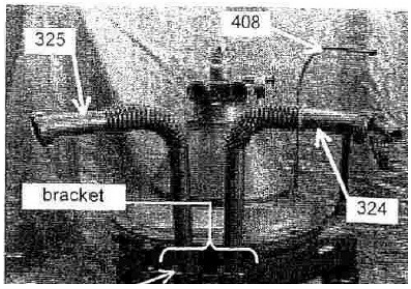
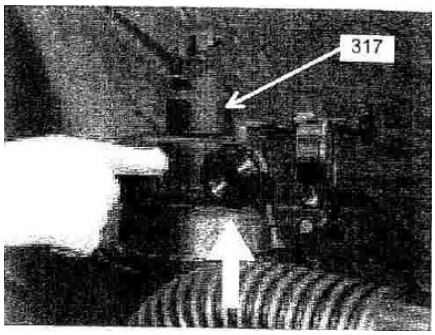
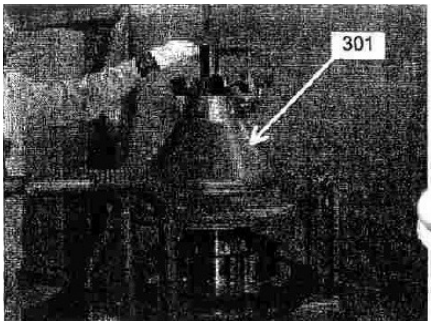
Sr. No	Frequency	Checkpoint	Criteria	Value
1	Prior Overhaul	Bowl has come to a complete stop (verify by visually checking the safety joint of gear pump / checking the rotation of friction clutch)	Stopped	
2		Brake to be engaged	Engaged /	
3		Motor breaker to be switched off	On / Off	
4		Inlet / outlet valves closed	Close / Open	
5		Caution : All screws in the selfjector are threaded Clockwise 	Confirm understanding	
6		Confirm all special tools in good condition  801 Dismantling stand  802 Bowl nut handle  803 Jack (1)   821 Jack (4)  822 Jack (9) (SJ50G～SJ150G)  823 handle (1)	Satisfactory / Unsatisfactory	

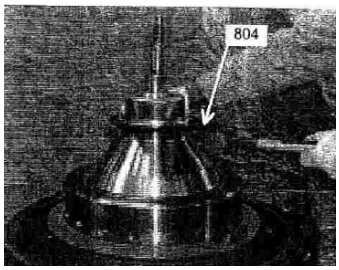
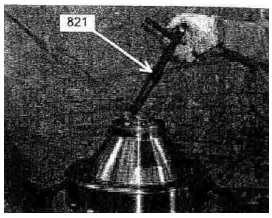
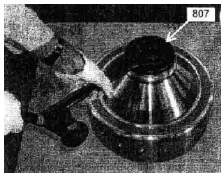
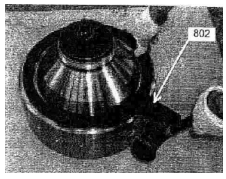
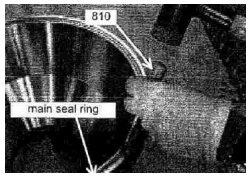
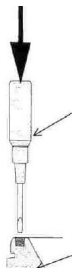
Sr. No	Frequency	Checkpoint	Criteria	Value
	Prior Overhaul	Confirm all special tools in good condition  808 Cap nut spanner  809 Jack (3)  810 Main sealing cutter  811 bolt × 2  812 Protective plate  813 Jack (5)  817 Jack (10)  818 Hook spanner  819 Push bolt_ 820 Hexagon socket heat bolt x 2	Satisfactory / Unsatisfactory	

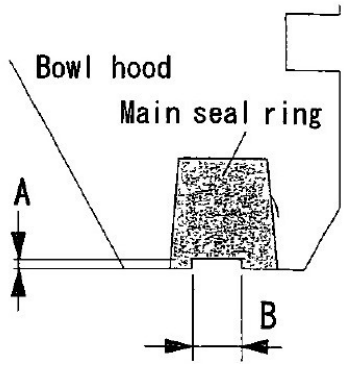
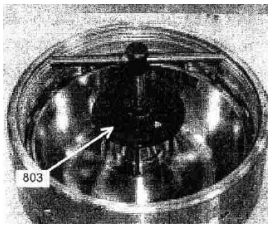
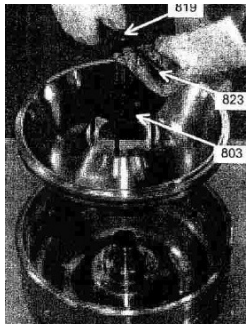
Sr. No	Frequency	Checkpoint	Criteria	Value
	Prior Overhaul	Confirm all special tools in good condition  814 Jack (6) 804 Disc nut handle 815 Jack (7) 805 Light liquid chamber handle 816 Jack (8) 807 Disc clamp plate	Satisfactory / Unsatisfactory	

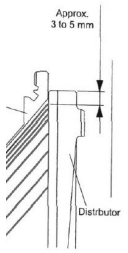
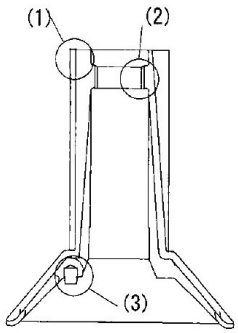
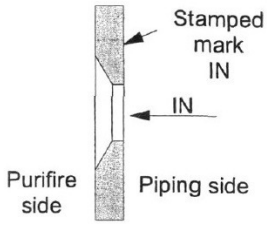
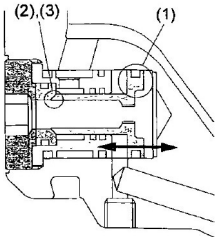
Use the above form to carry out checks before commencing overhaul of the separator.

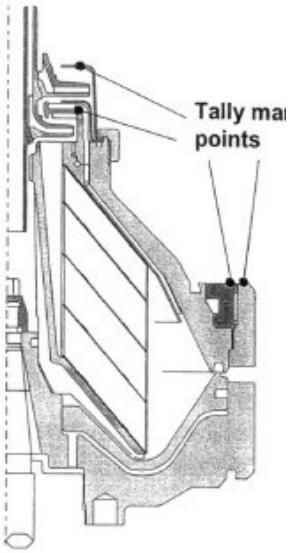
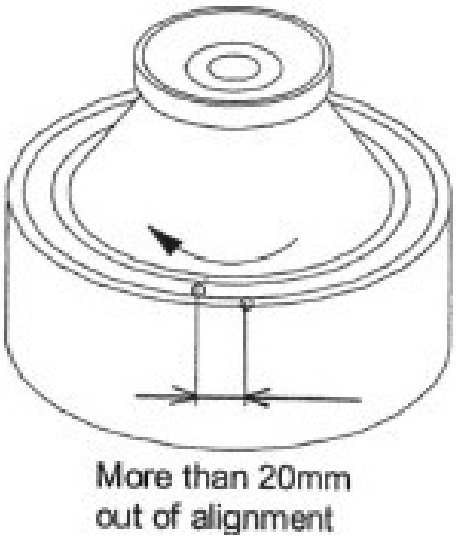
Summary of Checks during Overhaul of Bowl

Sr. No	Frequency	Checkpoint	Criteria	Value
1	Bowl Overhauling	When commencing bowl overhaul, preferred method would be to commence soon after stopping the purifier when the purifier is still hot (It will prevent sludge from solidifying & lock nut/sliding parts to get siezed/stuck)	Hot/ Cold	
2		When connecting pipes are disconnected from the Upper hood, union nuts at the bottom of the connecting pipes to be loosened appropriately such that the pipes can be turned side ways. (Same will keep the pipes clear while lifting bowl & prevent damage) 	Clear / Not Clear	
3		Take due care of the orifice (not to loose/damage) 	Satisfactory	
4		When lifting upper hood, secure the sling in tool such that same will not slip 	Secured	

Sr. No	Frequency	Checkpoint	Criteria	Value
5	Bowl Overhauling	Lock nut for heavy liquid chamber / gravity disc opens counter clockwise. Confirm understanding. 	Confirmed	
6		When removing bowl assembly from casing, ensure same jacked up using correct tool. If the bowl is not jacked up, there is strong possibility that bowl is tightly fitted with vertical shaft & while lifting the shaft shall also be elevated causing damage.  	Confirmed	
7		Do not attempt to open the lock nut without proper use of disc clamp plate. Ensure that the disc clamp plate is properly installed (the disc stack compression can be viewed from the sighting hole) and secured by means of a spanner prior attempting to open lock nut.  	Verified	
8		When lifting the bowl hood, care to be taken to avoid damage to sealing surface of main seal ring. In case sealing surface is damaged, main seal ring should be replaced. When removing main seal ring, due care should be taken to avoid damage to groove as this will lead to liquid leakage. 	Position confirmed. 	

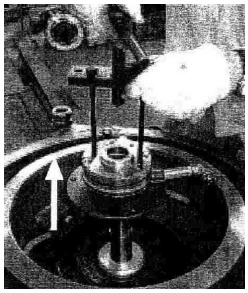
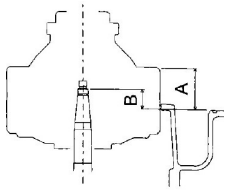
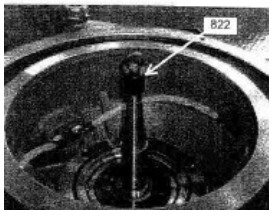
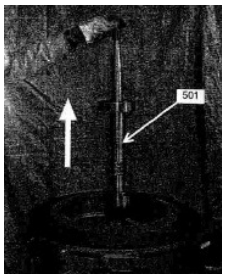
Sr. No	Frequency	Checkpoint	Criteria	Value
9	Bowl Overhauling	Additionally, if the depth of the groove of main seal ring is more than 0.5 mm or the width of the groove is more than 60% of its total width, main seal ring should be renewed.  	A:0.5 mm B:60%	
10		When removing the main cylinder (sliding bowl), jack to be used in a manner to exert pull in an equilibrium. Even a slight inclination will lead to cylinder getting stuck. In case the cylinder is stuck, light taps from a mallet to be used instead of forceful jacking. One effective means is to fill the main cylinder with ice for 3~5 minutes prior using the jacking tool.   	Even extraction	
11		Post dismantling, all parts to be thoroughly cleaned of sludge. All parts to be inspected for deformation/defect & renewed accordingly. All threaded parts to be suitable coated with Molycote.	Satisfactory	
12		Inspect condition of all o-rings and gaskets. Same to be renewed if required.	Renewed	

Sr. No	Frequency	Checkpoint	Criteria	Value
13	Bowl Overhauling	Discs to be checked thoroughly for cracks/scratches etc. Ensure required quantity of discs is assembled. The disc stack tends to have some looseness due to seating phenomenon. In case distance between top disc and distributor is more than 3~5 mm, discs to be added accordingly. Inadequate number of discs shall lead to heavy vibration.	Range:3~5 mm 	
14		When inspecting the distributor, if the keyway is found to be deformed / damaged, same to be replaced with a new one. 	Keyway(1) satisfactory	
15		When fitting the orifice, ensure that the stamp mark is on the outside (piping side) 	Confirmed	
16		Pilot valve to be dismantled during each overhauling - All o-rings to be renewed - Sliding surfaces to be well lubricated and ensure free movement by hand - Valve sheet to be closely inspected & in case pitting more than 0.3 mm, same to be renewed 	Range:0.3 mm for valve sheet	

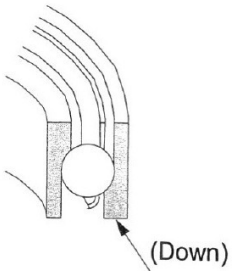
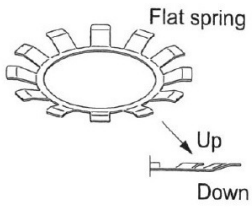
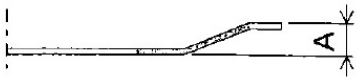
Sr. No	Frequency	Checkpoint	Criteria	Value
17	Bowl Overhauling	When assembling, due care must be given to tally marks. For lock nut, the limit is 20 mm.  	Limit : 20 mm	

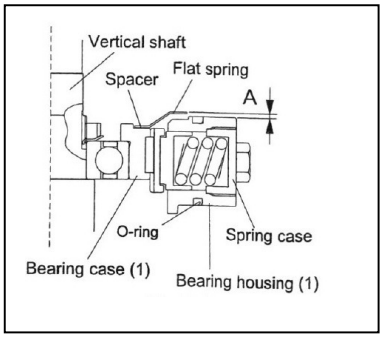
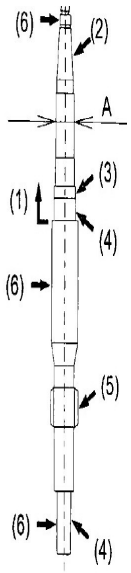
Use the above form to carry out checks before commencing overhaul of bowl of the separator.

Summary of Checks during Overhaul of Vertical Shaft

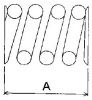
Sr. No	Frequency	Checkpoint	Criteria	Value
1	When overhauling Vertical Shaft	Prior removing vertical shaft, ensure following - Water supply shut and water supply assembly disconnected & removed - Vertical shaft height measured for reference   (mm)	Water supply assembly removed Height recorded	
2		Before removal of vertical shaft ensure that spiral gear of horizontal shaft is removed from gear boss	Disengaged	
3		Also disconnect and remove the bearing cover, bearing cap with o-ring, flat spring, spacer and bearing housing prior removal of the shaft	Satisfactory	
4		When vertical shaft is lifted using the tool, same will come out with the bottom bearing with cover attached. Due care to be taken while extraction & parts to be properly stowed on wooden plank to prevent damage  	Secured	

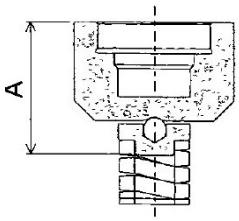
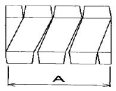
Model No	SJ10G/GH	SJ20G/GH SJ30G/GH	SJ50G/GH SJ60G/GH	SJ70G/GH	SJ100G/GH SJ120G/GH	SJ150G/GH
Dimension A	68±1.0	70±1.0	99±1.0	104±1.0	133.5±1.0	146.5±1.0
Dimension B	28.5±1.0	28.5±1.0	63±1.0	63±1.0	69±1.0	69±1.0

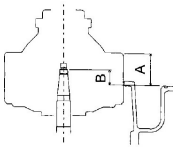
Sr. No	Frequency	Checkpoint	Criteria	Value
5	When overhauling Vertical Shaft	If vertical shaft bearing is removed, then it must be replaced even if it is not due for renewal.	Confirmed	
6		When renewing the bearings, ensure same is of correct type. Bearing to be heated in oil at 80~90 degree C for 20 min for smooth installation. After installation, ensure that bearing is turning smooth & inner race is stationary.	Confirmed	
7		When installing the bearing, ensure that bearing number is on bottom side  	Verified	
8		When installing the flat spring, ensure correct direction. Additionally check the spring height and if less than the limit, same to be renewed.   Model No. / SJ10G/GH ~SJ30G/GH / SJ50G/GH ~SJ70G/GH / SJ100G/GH ~SJ150G/GH Dimension A: 4.5 / 6.5 / 7.5 (mm)	Position confirmed	

Sr. No	Frequency	Checkpoint	Criteria	Value
9		Before installation of flat spring, spacer needs to be installed. Two spacers are normally provided 0.5 mm & 1.0 mm. Spacers to be used as per below diagram.  	Range: 0.5 to 1.0 mm	
10	When overhauling Vertical Shaft	**4.3 Vertical shaft system** **4.3.1 Vertical shaft** (1) Carefully check the portion above the upper bearing fitting portion, as there is a high likelihood of corrosion. If the dimension A shown in **Fig. 4-9** is more than 1mm smaller in diameter than the value shown in **Table 4-1**, replace the vertical shaft with a new one. **Table 4-1** (mm) (2) If there are partial scratches in the bowl bush fitting portion, make repairs with set files or an emery cloth (#320). If there is a ring-like continuous groove flaw, replace the vertical shaft with a new one. (3) If there is a localized flaw like a pounding in the threaded portion, make repairs to smooth it out, using set files, emery cloth (#320), etc. **(4) In regard to the secular wear of the bearing fitting portion, if the inner race of the bearing slips, replace the vertical shaft with a new one.** (5) If the pinion tooth surface is rough and is lightly worn, make repairs with set files, emery cloth (#320), oil stone, etc. (6) Measure the runout of the shaft center in three places, the straight portion at the end of the shaft, the middle portion of the shaft, and bearing fitting portion, with the upper and lower bearing fitting portions supported by the measuring jigs. The runout should be limited to 5/100mm maximum. If the runout is larger than that, replace the vertical shaft with a new one.  Fig. 4-9	Satisfactory	

Model No	SJ10G/GH ~SJ30G/GH	SJ50G/GH ~SJ70G/GH	SJ100G/GH ~SJ150G/GH
Dimension A	34	44	59

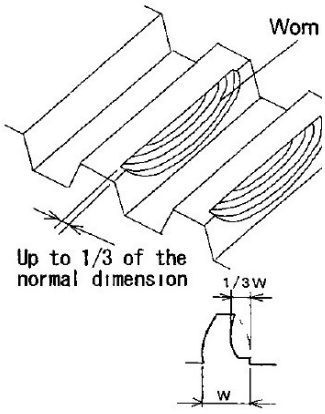
<table>
<tr><th>Sr. No</th><th>Frequency</th><th>Checkpoint</th><th>Criteria</th><th>Value</th></tr>
<tr><td>11</td><td rowspan="4">When overhauling Vertical Shaft</td><td>Inspect upper springs for cracks and damages. Verify free length and if even one spring is more than 1 mm shorter than required, renew full set.
 

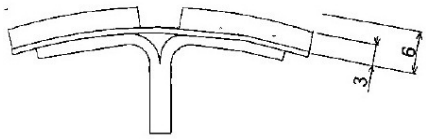
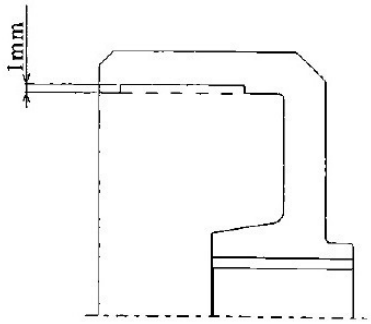
<table><tr><td>Model No</td><td>SJ10G/GH ~SJ30G/GH</td><td>SJ50G/GH ~SJ70G/GH</td><td>SJ100G/GH ~SJ150G/GH</td></tr><tr><td>Dimension A</td><td>34</td><td>44</td><td>46</td></tr></table>(mm)</td><td>Verified</td><td></td></tr>
<tr><td>12</td><td>If the dimension A shown in Fig. 4-11 with the lower spring retainer, steel ball and bearing case (2) put together is more than 1mm smaller than the value shown in Table 4-3, re-check all of these parts, and replace a defective part with a new one. (Refer to Fig. 4-11, Table 4-3)
Table 4-3
<table><tr><td>Model No.</td><td>SJ10G/GH ~SJ30G/GH</td><td>SJ50G/GH ~SJ70G/GH</td><td>SJ100G/GH ~SJ150G/GH</td></tr><tr><td>Dimension A</td><td>63 5</td><td>73.5</td><td>80 5</td></tr></table>(mm)
 
</td><td>Verified</td><td></td></tr>
<tr><td>13</td><td>Check the free length of lower spring and if more than 1 mm smaller than prescribed length same to be renewed.
 

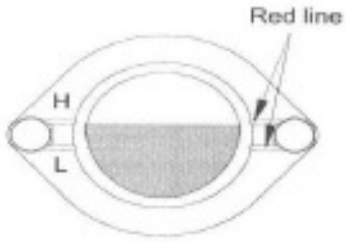
<table><tr><td>Model No.</td><td>SJ10G/GH ~SJ30G/GH</td><td>SJ50G/GH ~SJ70G/GH</td><td>SJ100G/GH ~SJ150G/GH</td></tr><tr><td>Dimension A</td><td>32 5</td><td>55.5</td><td>60.5</td></tr></table>(mm)</td><td>Verified</td><td></td></tr>
<tr><td>14</td><td>Upon completion of vertical shaft, verify height and same to be compared to reading taken before dismantling.
 

<table><tr><td>Model No</td><td>SJ10G/GH</td><td>SJ20G/GH SJ30G/GH</td><td>SJ50G/GH SJ60G/GH</td><td>SJ70G/GH</td><td>SJ100G/GH SJ120G/GH</td><td>SJ150G/GH</td></tr><tr><td>Dimension A</td><td>68±1.0</td><td>70±1 0</td><td>99±1 0</td><td>104±1 0</td><td>133 5±1 0</td><td>146 5±1 0</td></tr><tr><td>Dimension B</td><td>28 5±1 0</td><td>28 5±1 0</td><td>63±1 0</td><td>63±1.0</td><td>69±1 0</td><td>69±1.0</td></tr></table>(mm)</td><td>Satisfactory</td><td></td></tr>
</table>

Summary of Checks during Overhaul of Horizontal Shaft

Sr. No	Frequency	Checkpoint	Criteria	Value
1	When overhauling Horizontal Shaft	Confirm motor starter breaker off and fuse removed.	Confirmed	
2		When draining LO from drain plug, verify condition of oil and if any metal particles/dust is present	Confirmed	
3		When dismounting the motor, place chain block right over the eye bolt to facilitate easy removal and prevent damage	Confirmed	
4		If attached gear pump is provided, same to be disconnected and removed prior removal of horizontal shaft	Confirmed	
5		If bearings are removed, they must not be reused again even if due for renewal	Confirmed	
6		When renewing the bearings, ensure same is of correct type. Bearing to be heated in oil at 80~90 degree C for 20 min for smooth installation. After installation, ensure that bearing is turning smooth & inner race is stationary.	Confirmed	
7		Upon dismantling of horizontal shaft, verify condition of spiral gear for following - if pitting / splintering noted, same indicates deterioration of gear case oil and oil needs to be renewed - If the tooth thickness has reduced to 1/3 of its original thickness and has uneven contact spiral gear needs to be renewed 	Verified	

<table>
<tr><th>Sr. No</th><th>Frequency</th><th>Checkpoint</th><th>Criteria</th><th>Value</th></tr>
<tr><td>8</td><td rowspan="3">When overhauling Horizontal Shaft</td><td>4.4.2 Horizontal shaft
(1) If there is a localized flaw like a pounding on the threaded portion, make repairs to smooth it out, using set files, emery cloth (#320), etc.
(2) In regard to the secular wear of the bearing fitting portion, if the inner race slips, replace the horizontal shaft with a new one.
(3) If the key-way is wider because of wear, replace the horizontal shaft with a new one.</td><td>Checked / Confirmed</td><td></td></tr>
<tr><td>9</td><td>If the diameter of the oil seal & collar worn out more than 0.5 mm + the specified dimension, collar must be renewed
<table><tr><th></th><th>SJ10G/GH ~SJ30G/GH</th><th>SJ50G/GH ~SJ70G/GH</th><th>SJ100G/GH ~SJ150G/GH</th></tr><tr><td>Motor side (1)</td><td>45</td><td>50</td><td>55</td></tr><tr><td>Gear pump side (2)</td><td>45</td><td>50</td><td>55</td></tr></table>(mm)</td><td>Range :
0.5 ~ 1.0 mm</td><td></td></tr>
<tr><td>10</td><td>Verify the condition of the friction pads, if the thickness has reduced to less than 50% renew the friction pads (originally 6 mm, limit 3 mm)
  </td><td>Limit :
3 mm</td><td></td></tr>
<tr><td>11</td><td>Verify inner surface of the friction surface of friction pulley, if worn more than 1 mm (ref below diagram) friction pulley needs to be renewed
  </td><td>Limit :
4 mm</td><td></td></tr>
</table>

Sr. No	Frequency	Checkpoint	Criteria	Value
12	When overhauling Horizontal Shaft	When filling up lub oil, ensure optimum level 	Level to be maintained between L and H	
13		Upon assembling & installing the horizontal shaft in place, ensure free movement by hand.	Verified	

Use the above forms to carry out checks before starting overhaul of vertical & horizontal shafts of the separator.

5. Case Studies, Company's instructions, Maker's service information:

5.1 Case Studies:

Case 1:

Name of Equipment: No. 1 HFO Purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Type: SJ6000
Date of Failure: 21/12/2005
Place of failure: At sea
Reference: Failure report NAD/007/05

Description of event:

AT 1230 hrs on 21/12/2005, No.1 HFO Purifier abnormal alarm sounded. When crew went to check the purifier, heavy vibrations were observed. The purifier was stopped immediately.
During the investigation, it was observed that the Friction clutch assembly was totally damaged. No.2 purifier was prepared for operation after changing the gravity disc and put in use.
On 31/12/2005, the Clutch assembly and Horizontal shaft for No.1 Purifier were renewed and Purifier was put in operation. The purifier was kept under observation and was found to be running satisfactorily.

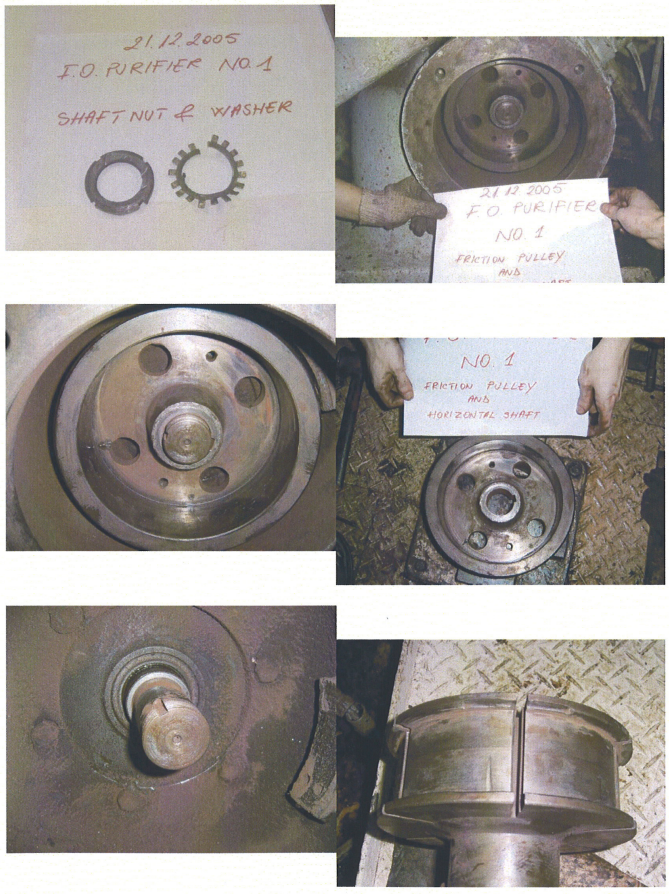
Direct cause of Failure: Shearing of key for Friction pulley on Horizontal shaft.

Probable reason for direct cause: Worn out horizontal shaft.

Counter measures: To adhere to Maker's Instruction manual regarding inspection of parts during each overhaul and take immediate corrective measures i.e. repair or renew parts, if any abnormality is noticed.

The picture below shows damaged parts.

Extent of damage:



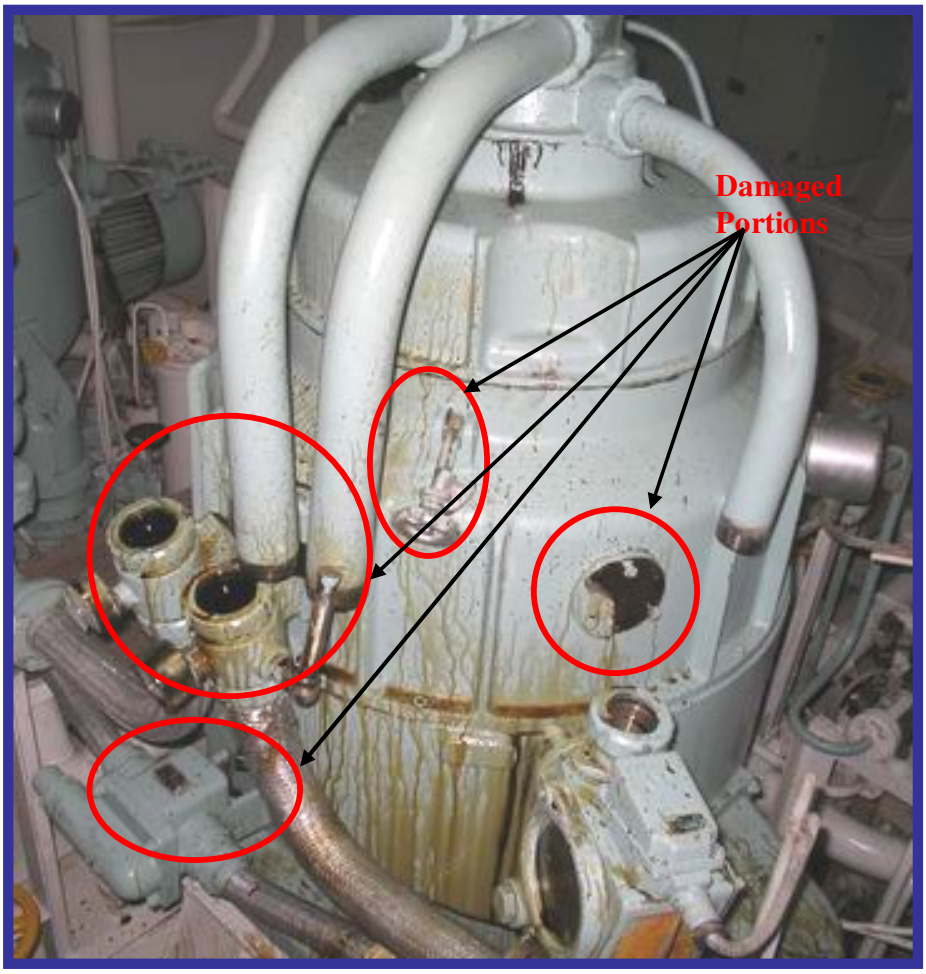
Date: Report No: Status: Final

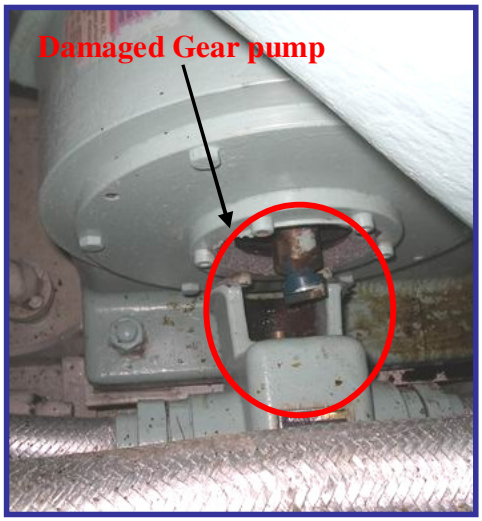
Case 2:

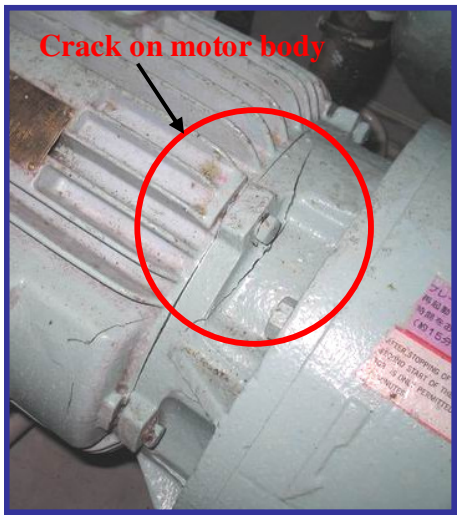
Name of Equipment: L.O. Purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Date of Failure: 17/12/2004

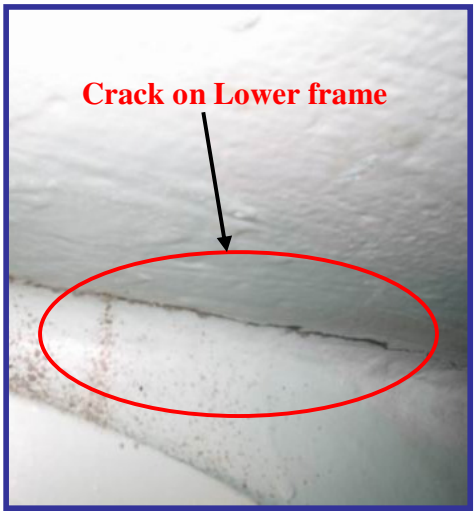
Description of event:

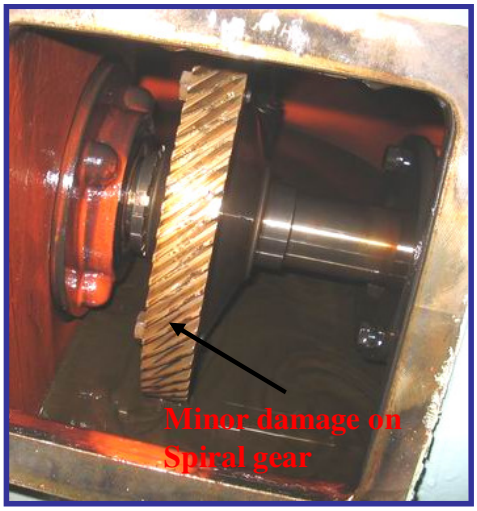
On 17/12/2004, an alarm was sounded indicating trouble with No.2 L.O. purifier. Once the crew reached near purifier, they noticed that the purifier was heavily damaged (as shown in the following pictures).

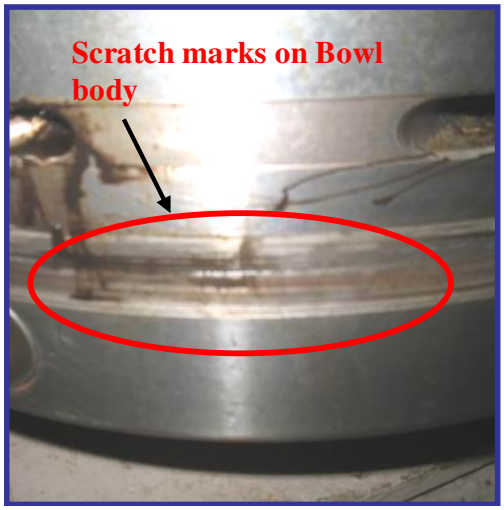


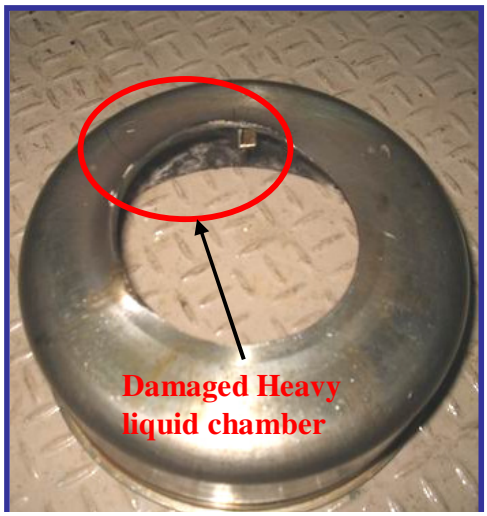

Damaged Gear pump


Crack on motor body


Crack on Lower frame


Minor damage on
Spiral gear


Scratch marks on Bowl
body


Damaged Heavy
liquid chamber

Status of previous overhaul:

Total working hrs.: 40187
Running hrs of Bowl assembly since last overhaul: 704
Running hrs of vertical shaft since last overhaul: 704
Running hrs of Horizontal shaft since last overhaul: 8829
Running hrs of Gear case oil since last change: 704

It is evident from the overhaul records that the purifier was recently overhauled except the horizontal shaft.

Cause of failure:

After investigation, it was assumed that the following sequence must have led to this failure.
1) Improper sludge discharge
2) Improper sludge discharge led to uneven accumulation of sludge inside the bowl.
3) This uneven accumulation of sludge led to unbalanced bowl and subsequently heavy vibrations of purifier.
4) The heavy vibrations caused this damage to the purifier.

Counter measures: To perform manual sludge discharge regularly as per company's instructions and confirm proper sludge discharge operation.

Case 3:

Name of Equipment: HFO Purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Date of Failure: 26/01/2005

Description of event:

On 26/01/2005, the HFO purifier was stopped as crew noticed heavy vibrations at the motor end. After removing the motor, it was noticed that all Friction blocks on lower fitting side and Friction boss in way of Friction blocks were found damaged. Vessel did not have spare Friction blocks and Friction boss for replacement. The purifier was made operational by using the Friction blocks and Friction boss from another purifier, which was being used as Clarifier.
During the investigation, it was noticed that the Friction blocks and Friction boss for the said purifier were frequently replaced in the past, but this was not reported to the company.
After checking the previous maintenance records, the followings were noted:
1) On December 2003, the Friction boss, Pulley and Friction blocks were renewed and Requisition for same raised.
2) Afterwards, these parts were again replaced, but no requisition was raised. Moreover, no reason for replacement of these parts was mentioned.
After checking the previous maintenance records for replacement of individual parts, it was noticed that
1) Friction blocks, Boss and Pulley were renewed on 12th Dec 2003 and 24th October 2004.
2) Friction blocks and Boss were renewed on 16th Apr 2004 and 23rd Aug 2004
3) Friction blocks were renewed on 20th July 2004.
4) Vertical shaft bearings and Gear were changed in October 2004. But Horizontal shaft was not overhauled.

It is evident from the above data that the mentioned parts were repeatedly renewed by the crew but the reason for their damage was not investigated. Moreover, the company was also not informed of the recurring problem.

Counter measures: To investigate and correct the cause of each trouble before putting the equipment back into operation. Renewal of parts should not be considered as a solution to any problem. If problem can not be identified, the company must be informed for further assistance.

Case 4:

Name of Equipment: ME L.O. purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Type: SJ20T
Date of Failure: 04/01/2005
Place of failure: At sea
Reference: Failure report GAS/007/2005

Description of event:

On 04/01/2005, L.O. Sludge tank high level alarm activated. During investigation, it was found that the L.O. purifier bowl was not closing properly, leading to oil leakage (oil loss about 500 ltrs.).
The purifier was stopped and dismantled. During the overhaul, it was noticed that the Operating water nozzle had suffered damage.
The purifier was put in operation after renewing the damaged part.

Direct cause of Failure: Operating water nozzle failure.

Probable reason for direct cause: Ageing of part.

Counter measures: To adhere to Maker's Instruction manual regarding inspection of parts during each overhaul and take immediate corrective measures i.e. repair or renew parts, if any abnormality is noticed. Sludge tank should be regularly sounded to notice any abnormal increase in its level, which may provide early indication of any problem with the separator.

Case 5:

Name of Equipment: ME L.O. purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Type: SJ15T
Date of Failure: 24/08/2005
Place of failure: At sea
Reference: Failure report KAM/016/2005

Description of event:

On 24/08/2005, L.O. purifier stopped after activating "Abnormal alarm". Purifier was opened up and Horizontal and Vertical shaft were removed.
On inspection, the following parts were found damaged.
Spiral gear teeth badly worn out
Damaged collar for Bearing cover
Worn out Spring case
Damaged ball bearings
Damaged Flat spring

The purifier was put in use after renewing the parts.

Direct cause of Failure: Imbalance of bowl due to sludge accumulation on one side.

Probable reason for direct cause: Blockage of ports during discharge operation.

Counter measures: To perform manual sludge discharge regularly as per company's instructions and confirm proper sludge discharge operation.

To adhere to Maker's Instruction manual regarding inspection of parts during each overhaul and take immediate corrective measures i.e. repair or renew parts, if any abnormality is noticed.

Case 6:

Name of Equipment: HFO Purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Type: SJ 60 EH
Date of Failure: 21/11/2005
Place of failure: At sea
Reference: Failure report CAS/009/05

Description of event:

On 21/11/2005, during routine rounds, some abnormal sound was observed coming from the purifier. The purifier was immediately stopped. During dismantling of purifier, the upper bearing was found fully damaged.

The purifier was put in use after replacing the Bearings for both Vertical and Horizontal shaft.

Direct cause of failure: Material failure of Upper bearing.

Probable reason for direct cause: Overdue maintenance

Countermeasure: To adhere to Maker's Instruction manual regarding maintenance intervals and inspection of parts during each overhaul and take immediate corrective measures i.e. repair or renew parts, if any abnormality is noticed.
Also strictly follow the Company's PMS e.g. TM-MASTER.

Case 7:

Name of Equipment: HFO Purifier
Maker: Mitsubishi Kakoki Kaisha, Ltd.
Type: SJ 60 EH
Date of Failure: 03/10/2005
Place of failure: At sea
Reference: Failure report CAS/010/05

Description of event:

On 03/10/2005, "F.O. Leak" alarm activated and the purifier stopped. The purifier was dismantled for inspection. It was observed that the Upper bearing was fully damaged and the Water supply device had made contact with the lower part of the Bowl.

The purifier was put in use after replacing the Water supply device and Bearings for Vertical shaft.

Direct cause of failure: Incorrect assembly of the vertical shaft.

Countermeasure: To adhere to Maker's Instruction manual regarding maintenance intervals and inspection of parts during each overhaul and take immediate corrective measures i.e. repair or renew parts, if any abnormality is noticed.

Summary for Counter measures:

1) To perform Manual Sludge discharge twice a day and confirm proper sludge discharge each time. The proper sludge discharge can be judged by hearing the sound, by checking the increase of motor amperage, by checking the sequence of operation of operating water supply solenoid valves, etc.
2) Confirm that the increase in the tank level is constant. Abnormal increase in the tank level is not the only concerned, since the less increase in the tank level will also indicate some abnormality with the sludge discharge operation.
3) To pay attention to balancing because it eventually leads to Friction Boss and Friction blocks damage. The mechanical energy, given by the motor, is transferred to the bowl by means of the Friction Boss and Friction Blocks. These parts also tend to absorb excessive loads from the bowl assembly such as vibrations in order to prevent direct damage to the motor. So, if there is any abnormality in the operation of the purifier such as imbalance, it will lead to damage of the Friction blocks and Friction boss.
Balancing of Purifier is carried out by the Maker before its installation on board. Since the parts rotate at very high speed, its proper balance is of utmost importance. Any imbalance during its operation may lead to serious damage to parts.
To avoid balancing problem, take care of the followings:
++ Do not drop the bowl
++ Do not use excessive force when overhauling
++ Do not expose to naked flame
++ Do not interchange bowl parts with other purifier.
4) If an increase in the frequency of renewal of Friction blocks, Friction boss and Friction pulley is noticed, investigate the cause. If unable to pin point the cause, report to company for technical support.
5) To pay attention to the spare parts during overhaul and do not interchange parts from different sets of purifiers.
Individual purifiers are set to operate by using their own parts. Care should be observed not to cause of mixing of parts of different purifiers during overhaul. If a rotating part like Main cylinder or bowl body gets damaged and needs replacement. The complete bowl must be re balanced before putting into use.
More care should be observed regarding interchanging of parts, if there is a complete set of bowl on standby.
6) To pay attention to motor amperage during purifier operation.
A difference between the actual ampere from that of normal ampere indicates that there is some kind of abnormality with the purifier. The ampere may be too high or too low or fluctuating. All conditions indicate that there is some abnormality with purifier operation.
7) To confirm the proper sequence of purifier operation from the Timing chart during starting, sludge discharging and stopping.
8) To adhere to Maker's Instruction manual regarding maintenance intervals and inspection of parts during each overhaul and take immediate corrective measures i.e. repair or renew parts, if any abnormality is noticed.

5.2 Company instructions:

Safety and Technical information letter: ST/049/02
Dated: 24/10/2002
Subject: Fuel Oil Purifier Breakdown

[Description]:

GIST:

- Recently we had a problem on one of our fleet managed vessels wherein the fuel oil purifier suffered extensive damage and was beyond repair.
- The vessel was equipped with only one fuel oil purifier and hence a complete new purifier had to be installed.
- This has caused undue hardship both to the vessels crew as well as the owner who had to incur large damage repair costs.

INCIDENT:

- The fuel oil purifier was to be stopped for routine cleaning and inspection. Whilst the auto stopping mechanism was in progress the purifier top cover was blown off and other parts were broken into pieces.

INVESTIGATION:

- The bowl was opened up for further investigation and it was observed that there was a large amount of dry sludge stuck to the sides of the bowl.
- This uneven accumulation of sludge inside the bowl caused the bowl to become unbalanced and this resulted in abnormal rotation of the bowl.
- The purifier had been recently overhauled approx 14 days ago.

CAUSE:

- Maker's service engineer boarded the vessel for investigation and repair. The technician checked the purifier control panel and found that the **timer** for desludge period was defective.
- According to the technician the purifier was damaged as the desludging cycle was not carried out for a long period of time.
- In this case the interval for auto desludging of the purifier was set at 1.5 hour and had been last tested satisfactorily when the purifier had been overhauled 14 days before.

PREVIOUS HISTORY:

- This type of problem involving the timer had been observed to occur 2 years ago and as a countermeasure the manufacturer of the purifier **"Mitsubishi Kakoki"** had issued a Service Report to all ship-owners including the previous managers of the above vessel, to install a new type of electric type timer instead of the old type of timer.

• Unfortunately it seems that the vessel did not renew the timer due to reasons unidentified, and hence the old type timer was still present on board which consequently led to the failure of the purifier.

COUNTERMEASURES:

• In view of the above we request all vessels to be more observant with regard to the desludging mechanism of the purifier.

• It would be imprudent to assume that the auto desludge mechanism is working perfectly.

• To prevent engineers from being lulled into a false sense of complacency **we advise that all running purifiers on board be desludged manually at least twice a day, once in the morning and once in the evening prior going into UMS mode, to confirm that the desludging mechanism is working perfectly.**

SUPPLEMENTARY:

• This also brings to the forefront, the need for vessels to take adequate and timely action on receipt of technical newsletters and other advice from the makers of equipment on board our vessels.

• On receipt of service information if no action is taken by the company or the vessel, any damage occurring to the said equipment due to non compliance of maker's recommendations will result in very serious consequences.

Please be guided accordingly and ensure compliance of the above

5.3 Maker's Service Information for Mitsubishi SELFJECTOR:

4/6

MITSUBISHI KAKOKI KAISHA, LTD.
After Service Section
Machinery Sales Department
2-1, Okawa-cho, Kawasaki-ku, Kawasaki, Japan 210-8560
Phone : +81-44-333-5364 Facsimile : +81-44-355-4579

INFORMATION
OF
MITSUBISHI SELF-JECTOR

No. SM 0054

Change of Thread of Vertical shaft and Cap nut.

Please refer to attached sheet.

A. Noguchi
Manager, After Service Section
Machinery sales Department

MITSUBISHI KAKOKI KAISHA, LTD.
After Service Section
Machinery Sales Department
2-1, Okawa-cho, Kawasaki-ku, Kawasaki, Japan 210-8560
Phone : +81-44-333-5364 Facsimile : +81-44-355-4579

Service Information

No. SM0054

Change of Thread of Vertical shaft and Cap nut

1. Applicable Machine : SJ 40 T/P/EH & SJ 60 T/P/EH
2. Content of Change : Both of the thread pitch has been changed from 5 mm to 3 mm.
(The cap nut of SJ80F is common to SJ40 & SJ60.)

(1) The Shape of thread

	Before Change	After Change
SJ 40	TM25P5	TM28P3
SJ 60	TM25P5	TM28P3

(2) New parts number

	Vertical shaft	Cap nut
SJ 40 T/P/EH		
The contacting part of vertical shaft with bowl body is taper shape only.		
50 HZ	133251001	458704001
60 HZ	133122001	-Ditto-
The contacting part of vertical shaft with bowl body is taper shape with straight.		
50 HZ	133213001	-Ditto-
60 HZ	133095001	-Ditto-
SJ 60 T/P/EH		
The contacting part of vertical shaft with bowl body is taper shape only.		
50 HZ	133252001	450528001
60 HZ	133123001	-Ditto-
The contacting part of vertical shaft with bowl body is taper shape with straight.		
50 HZ	133214001	-Ditto-
60 HZ	133096001	-Ditto-

2. Reason of Change :
The cap nut is securely fastened to vertical shaft by change of thread pitch.
3. Time of Modification : September, 2003.
4. Interchangeability :
There is no interchangeability.
If the modified vertical shaft is delivered, the cap nut & Jack(9)-Lifting tool for vertical shaft will be delivered with the shaft.

3/6

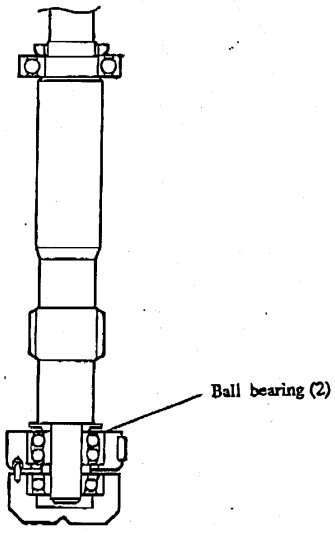
REQUEST FOR PARTIAL REVISION OF INSTRUCTION MANUAL

Recently the vertical shaft bearings have been subjected to a standard change to effect partial modification.
Owing to this change, therefore, the Instruction Manual has been revisted as follows :

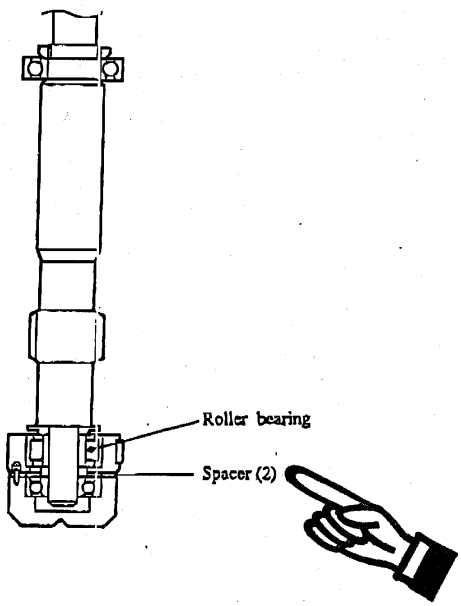
[Change parts]

The lower bearing has been changed from the ball bearing (2) to a roller bearing. When replacing the bearing, be sure to assemble the parts in proper order according to the following parts drawing. (See next page)

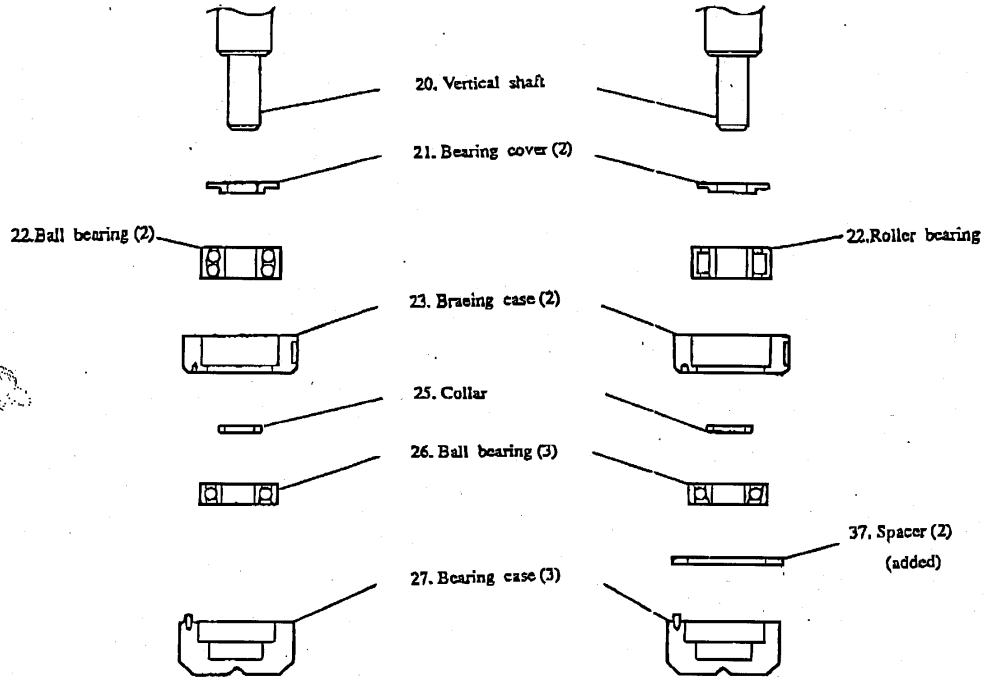
Conventional model (described in the Instruction Manual)



After modification



4/6



Appplicable pages of the Instruction Manual

Manual No. IJ－8904－EG 6－18、6－19ページ

〃 IJ－8904－LG 5－20、5－21ページ

Old and New Parts No.List

No	Parts name \ Model		SJ20T,P,EH	SJ25T,P,EH	SJ30T,P,EH	SJ40T,P,EH	SJ60T,P,EH
18	Ball bearing	新	I16208J4	I16209J4	I16210J4	I16212J4	I16213J4
		旧	I16208J1	I16209J1	I16210J1	I16212J1	I16213J1
22	Roller bearing	新	I42305J1	I42305J1	I42306J1	I42307J1	I42308J1
	Bearing	旧	I32305J1	I32305J1	I32306J1	I32307J1	I32308J1
37	Spacer (2)	新	432904001	432904001	432905C01	432906001	432122001
		旧	—	—	—	—	—

Parts Ordering Instructions

When ordering parts, please specify the parts name(new), PARTS No. and quantity by reference to the above Oild and New Parts No.List.

5/6

PARTS LIST

SEE DWG. NO. 254454C (SJ40T/P/EH II)

SYMBOL	PARTS NAME	MATERIAL	WORK/SET	PARTS NO.	
V1	Vertical shaft (50Hz)	Nickel chromium steel	1	157547001	
	Vertical shaft (60Hz)	Nickel chromium steel	1	157548001	←
V2	Ball bearing (1)	Bearing steel	1	116212J4	←
V3	Upper spring	Piano wire	6	411984001	
V4	Bearing housing (1)	Carbon steel	1	248360001	
V5	Bearing housing (2)	Cast iron	1	266908001	
V6	Roller bearing	Bearing steel	1	142307J1	←
V7	Ball bearing (3)	Bearing steel	1	127307J1	←
V8	Lower spring	Spring steel	1	409646001	
V9	Locknut	Structural steel	1	J2012C0	
V10	Lock washer	Structural steel	1	J3012C0	
V11	'O' ring	NBR	1	A20210A	
V12	'O' ring	NBR	1	A20185A	
V13	Bearing cover (1)	Cast iron	1	248361001	
V14	Bearing cap	Aluminium alloy casting	1	409448000	
V15	'O' ring	NBR	1	A10053A	
V16	Bearing sleeve	Carbon steel	1	368171001	
V17	Bearing case (1)	Carbon steel	1	368170001	
V18	Key	Carbon steel	1	C106025A2	
V19	Spring case	Carbon steel	6	409447001	
V20	Spring retainer (1)	Stainless steel	6	409661001	
V21	Flat spring	Carbon tool steel	1	368526001	
V22	'O' ring	NBR	1	A10145A	
V23	Spacer	Copper-alloy	1 set	※1	
V24	Retainer	Carbon steel	1	421650001	
V25	Bearing case (2)	Carbon steel	1	368169001	
V26	Key	Carbon steel	1	C106025A2	
V27	Bearing case (3)	Carbon steel	1	368168001	
V28	Spring pin	Piano wire	2	B3006016A	
V29	Spring seat	Carbon steel	2	449557001	
V30	Steel ball	Bearing steel	2	J1020J0	
V31	Bearing cover (2)	Carbon steel	1	409446001	
V32	Collar	Carbon steel	1	409445001	
V33	Spacer (2)	Copper-alloy	1	432906001	

※1 : Refer to accessories list of Spacer

MITSUBISHI KAKOKI KAISHA, LTD. L30061D

6/6

PARTS LIST

SEE DWG. NO. 254454C
(SJ40T/P/EHⅡ)

★ PARTIAL

SYMBOL	PARTS NAME	MATERIAL	WORK/SET	PARTS NO.
B51	Operating water disc	Bronze casting	1	248144001
B52	Socket cap screw	Stainless steel	3	F3008015B
B54	Socket cap screw	Stainless steel	3	F3006020B
B55	Packing	Fiber	1	408249001
B57	Bolt	Stainless steel	6	F1004006B
B58	Tongued washer	Stainless steel	6	H5004B2
B59	Chamber cover	Bronze casting	1	367879001
B60	Socket set screw	Chromium molybdenum steel	1	E400608G6
B61	'O' ring	NBR	1	408247001
B62	'O' ring	NBR	1	408248001
B64	Operating water chamber	Bronze casting	1	369079001
B65	Operating water nozzle	Bronze casting	1	369085001

★ TOTAL

SYMBOL	PARTS NAME	MATERIAL	WORK/SET	PARTS NO.
B51	Operating water disc	Bronze casting	1	248144001
B52	Socket cap screw	Stainless steel	3	F3008015B
B53	Operating water nozzle	Bronze casting	1	367881001
B54	Socket cap screw	Stainless steel	3	F3006020B
B55	Packing	Fiber	1	408249001
B56	Operating water chamber	Bronze casting	1	367880001
B57	Bolt	Stainless steel	6	F1004006B
B58	Tongued washer	Stainless steel	6	H5004B2
B59	Chamber cover	Bronze casting	1	367879001
B60	Socket set screw	Chromium molybdenum steel	1	E400608G6
B61	'O' ring	NBR	1	408247001
B62	'O' ring	NBR	1	408248001

230, 335, 423, 511, 602

MITSUBISHI KAKOKI KAISHA, LTD.

L30062C