KEMEL AIR SEAL

Type KEMEL AX

INSTRUCTION MANUAL

This manual is produced based on a typical lubrication diagram for stern tube system installed with Type KEMEL AX seals. For correct understanding and operation of the ship's system, read this booklet together with seal drawing and the piping diagram available in the finished plan.
Besides this booklet, read Instruction Manual for KEMEL COMPACT SEAL Type KEMEL CX, DX & AX included in the finished plan.

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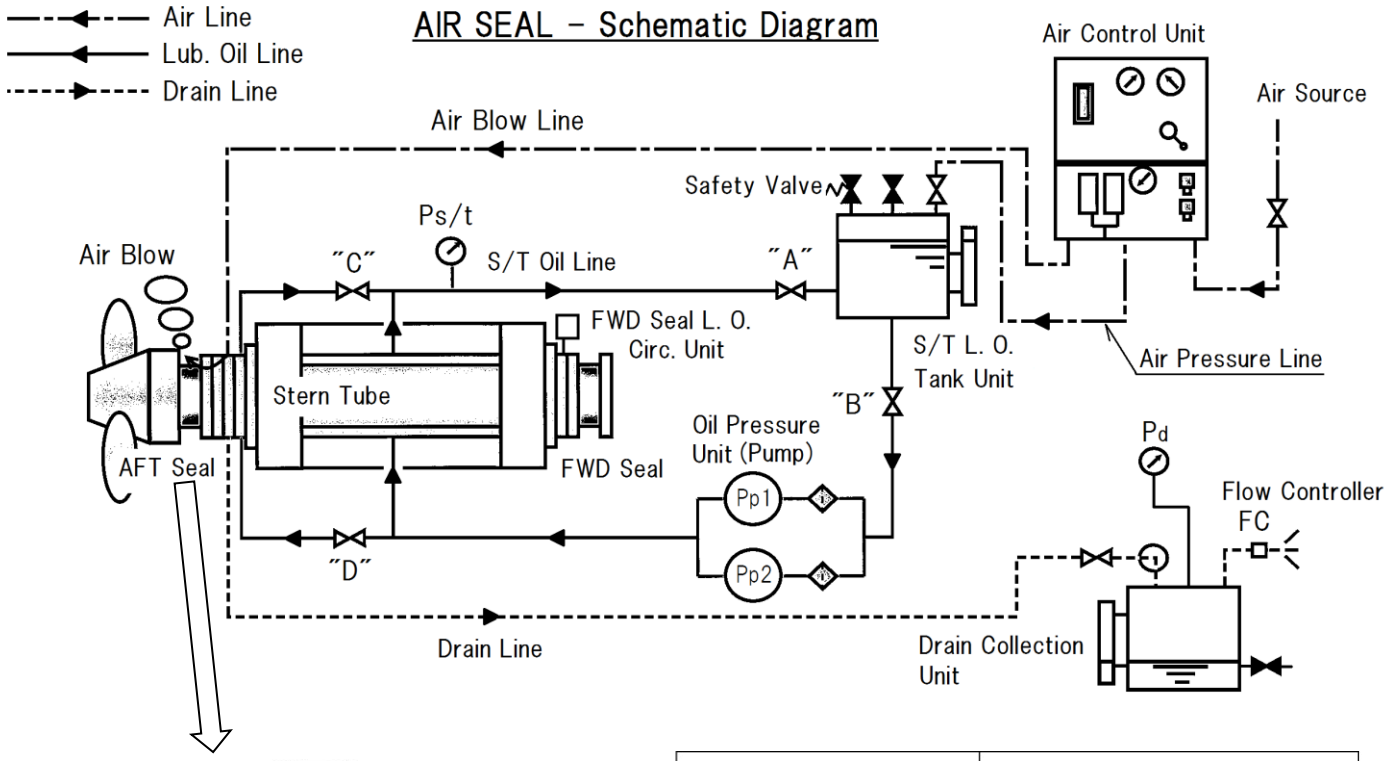
http://www.kemel.com

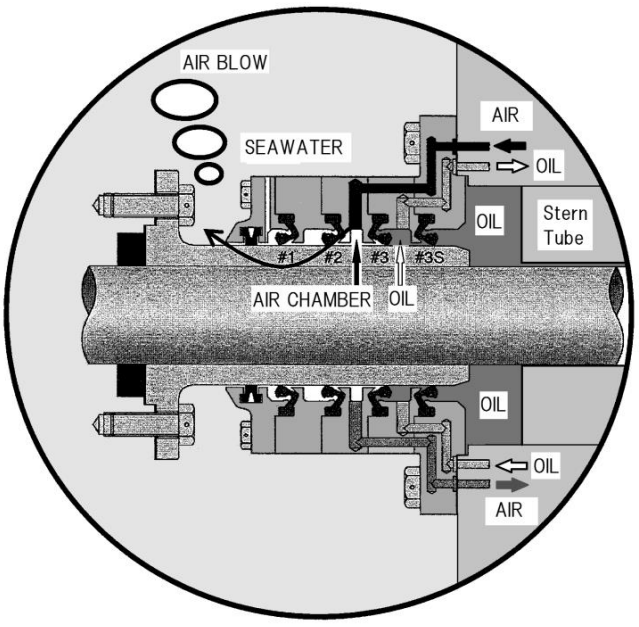
Contents

1. Outline

1.1 Construction

Air Seal keeps seawater out by blowing air into sea through an air chamber **(Air Chamber)** provided at the space between the #2 & 3 seal rings in AFT seal, and it keeps oil tight by controlling stern tube oil pressure to follow change of ship's draft. Segregation of seawater and stern tube oil by **Air Chamber** minimize the risk of seawater contamination. Besides, a drain line provided at the bottom of **Air Chamber** collects and recovers leaking oil and water in engine room in case of leakage. At the same time, the system automatically optimizes the oil pressure based on draft pressure detected at **Air Chamber** and remarkably reduces the pressure load given on AFT seal at all draft levels. The construction of Type DX seal with a stand-by spare seal ring is employed on AFT seal, which enables switching-over to the spare at any time by simple valve operation. FWD seal has a same construction as existing models. The schematic diagram and the components for the system are shown in the sketch below.



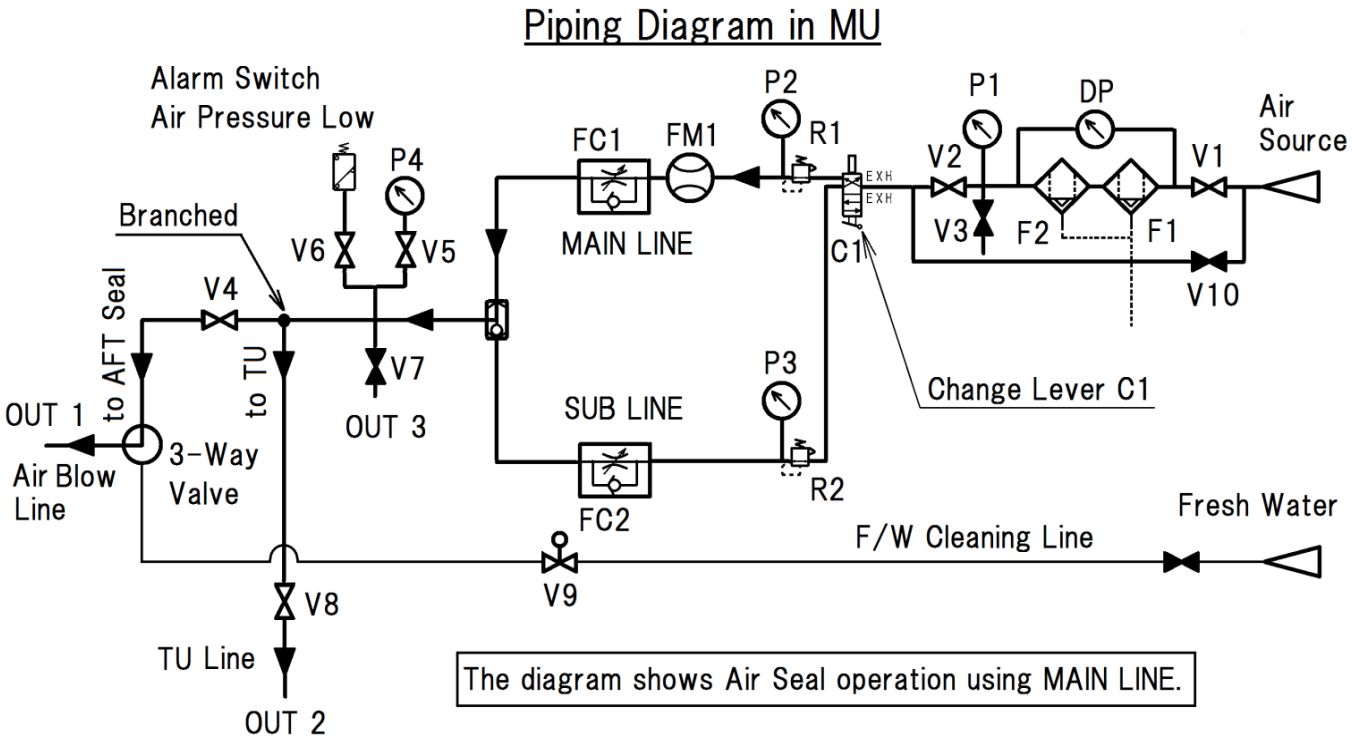


Component	Function
Air Control Unit (MU)	Supply air to AFT seal Regulate supply air pressure Regulate air flow Pressurize S/T L. O. Tank Clean air pipe by fresh water
S/T L. O. Tank Unit (TU)	Supply oil to Pump Pressurize stern tube
Oil Pressure Unit (OU)	Circulate stern tube oil - Pump
Drain Collection Unit (CU)	Recover leaking oil/water Recover cleaning fresh water
FWD seal L. O. Circulation Unit	Circulate FWD seal L. O.

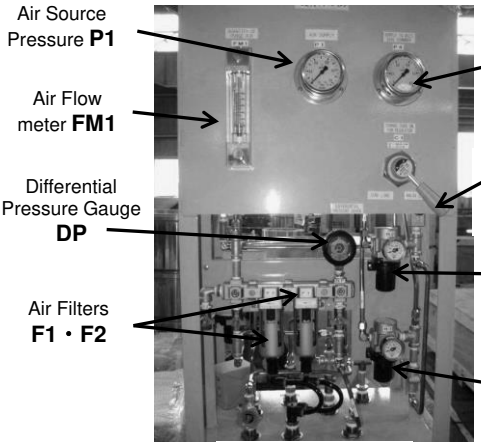
1.2 Air Control Unit (MU)

Air Control Unit (MU) regulates supplied compressed air at the pressure***)** set by **Air Regulator (R1)** and at the flow rate***)** set by **Air Flow Controller (FC1)** after passing **Air Filters (F1 & F2)**. Then the regulated air lead to **Air Chamber** in AFT seal is blown into sea, called **Air Blow Line** which has a branch line to **S/T L. O. Tank Unit** (**TU)**, called **TU Line,** to pressurize it. **MU** has a spare **Air Regulator (R2)** and a spare **Air Flow Controller (FC2)** on **SUB** LINE for switching over from **R1** & **FC1** on **MAIN** LINE by **C1** Lever. Also **MU** has **Fresh Water Line** for periodical cleaning of air purging pipe and has an **Alarm Switch** for Air Pressure Low. **Air Regulators R1** and **R2** have pressure gauges **P2** and **P3** for setting air pressure. Dirtiness of **Air Filters (F1 & F2)** is examined by visual and Differential Pressure Gauge (DP). The gauge **P1** indicates air source pressure and the gauge **P4** indicates **Air Blow Line** pressure.

***)** Set values of **Air Regulators** and **Air Flow Controllers** are shown in "Finished Plan – Piping Diagram Fig. 1".

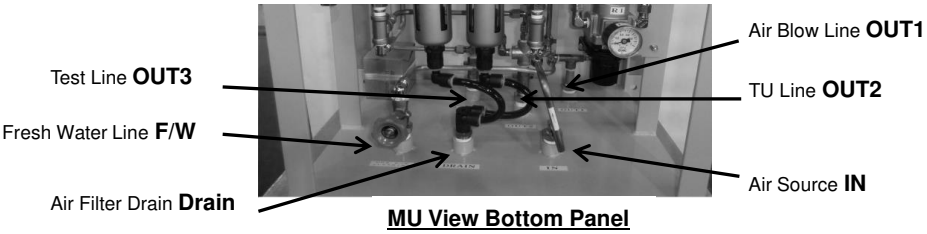


MU Side View Left



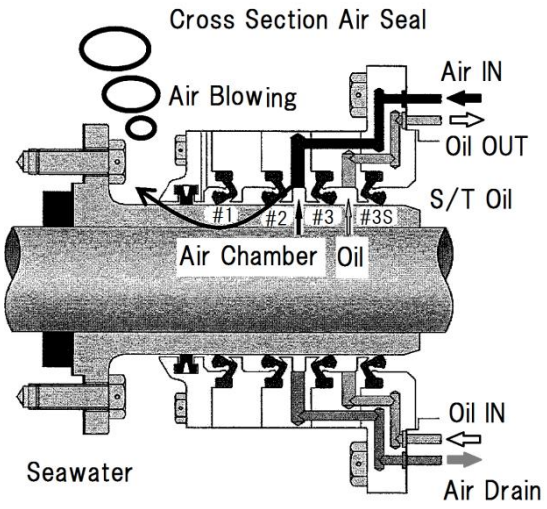
MU Front View

MU Side View Right



MU View Bottom Panel

1.3 AFT Seal



Air supplied from **MU** to **AFT Seal** blows out underwater through **Air Chamber** with the pressure set by **Air Regulator**. The effects of air blow are explained below;

1) When the pressure in **Air Chamber** slightly exceeds the **tension forces from the #1 & #2 seal rings + seawater pressure from the draft**, the air lifts up the #1 & #2 seal lips and starts blowing into sea through **the gap, formed by the lift, with the constant flow rate** set by **Air Flow Controller**.

2) The gap by constant air blow makes **Air Chamber** being kept opened in-water all the time.

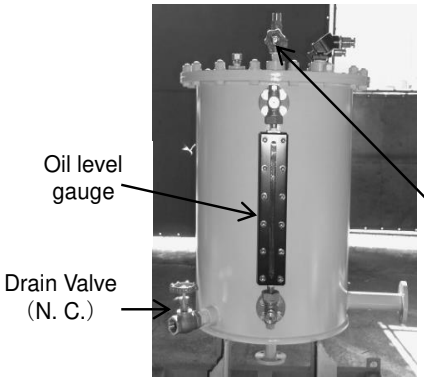
3) By this, **Air Chamber** pressure (**= Air Blow Line pressure P4**) is equalized to the level of **tension forces from the #1 & #2 seal rings + seawater pressure from the draft** or slightly above.

Because of the opening underwater, **Air Chamber** pressure does not go higher up to the pressure set by **Air Regulator**, and also continual air blowing prevents seawater penetration into **Air Chamber**. **Air Flow Controller** keeps constant flow and maintains the gaps under all draft level of the ship. Therefore the pressure in **Air Chamber** follows water pressure from draft change with no time-delay. In addition, air from **MU** partly returning to **Drain Collection Unit (CU)** with slight ventilation in E/R generates low speed air flow to remove leaking oil or water from **Air Chamber**, through a drain hole provided at the bottom lead into **CU**.

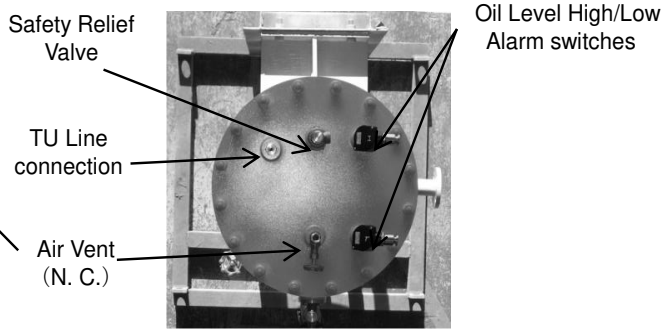
The #3 & #3S seal rings can be switched over by valve operation in E/R. (Valve “C” & “D” shown in the piping diagram P. 6.) Open these valves for the #3 in use and close them for the #3S in use.

1.4 S/T L. O. Tank Unit (TU)

TU is an air-tight oil tank having **100 - 200L** capacity and is installed to give **oil head pressure** in stern tube with **2 - 2.5M** of the oil height above shaft centerline. In addition, **TU** is connected with an air pipe comes out from **Air Blow Line** to transmit the pressure in **Air Chamber**. By the arrangement, stern tube is pressurized at the level of **oil head pressure + Air Chamber Pressure** which is loaded onto the #3 seal ring supported at the same time by **Air Chamber Pressure** from seawater side while air blows out as described in Article 1.3. Because of **Air Chamber Pressure** at the front face and the back of the #3 seal ring, it counteracts each other cancelling the force. As a result, the actual load remains on the #3 seal ring is **oil head pressure** of **TU** constant at all draft. Same effect is available on the #3S seal ring when it is in use. **TU** is provided with **Safety Relief Valve** to avoid excessive pressure, and **Alarm Switches** for Oil Level High & Low. **TU** is also connected with **Oil Pressure Unit** (Oil pumps) to circulate stern tube oil.



TU Front View



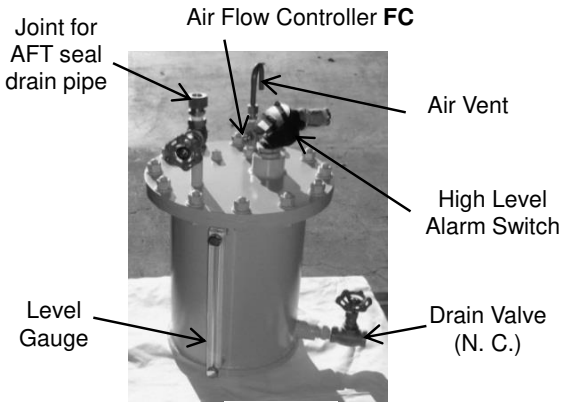
TU Top View

1.5 Oil Pressure Unit (OU – Oil Pump)

OU circulates lubrication oil via **"OU ➔ Stern Tube ➔ TU ➔ OU"**. Stern tube oil pressure is measured at the return line from stern tube to **TU**. The correct pressure is calculated by adding (or deduction on some cases) oil head pressure from the gauge height to the reading value. (See calculation example in **P.7**.) Periodically examine oil suction & discharge pressures on the pumps, and clean strainers for maintenance whenever is necessary.

1.6 Drain Collection Unit (CU)

CU is an air-tight tank with 10L capacity and is located below the shaft level. **CU** is connected to a drain pipe from **Air Chamber** in AFT seal. **Flow Controller (FC)** fitted on **CU** gives air-flow at a low speed (about 5 L/min.) from **Air Chamber** towards **CU** to removes leaking seawater and oil into **CU** through the pipe. Drain recovered can be discharged by the air pressure in **CU**, through **Drain Valve**. (Discharge drain while M/E is stopped.) **CU** is fitted with **Level Gauge** and **High Level Alarm Switch**.



CU

2. Oil Filling and Oil Pressure Test

Procedures for oil filling to stern tube and oil pressure test for Air Seal is described in **P. 6**. Confirm actual valve operation for oil filling, circulation, draining & etc. in ship's piping diagram available in finished plan.

3. Operation of Air Seal

3.1 Start-up Air Control Unit (MU)

When air supply to Air Seal become available, start-up **MU** after filling oil in stern tube by the procedures below,

1) Put valve positions in **MU** for blowing air as per Finished Plan – Piping Diagram Fig. 1.
2) Close Air Vent on **TU** and Drain Valve on **CU**.
3) Put valve positions for oil circulation via **"TU ➔ OU ➔ Stern Tube ➔ TU"**, then start-up **OU**.
4) Open air source valve for **MU**.
5) Adjust settings for **Air Regulator R1** and **Air Flow Controller FC1** if necessary.
6) Confirm air blowing at AFT seal in dry-dock, or at sea surface in stern area after launching.
7) Record all data by using the form shown in **P. 7**, and examine the system is working right.
8) Adjust stern tube oil pressure **Ps/t** by operating bypass valve on **OU** if necessary.
9) Put **Change Lever C1** on **SUB** and examine all pressures. (FM1 does not work with **SUB** in use.)
10) Put **Change Lever C1** on **MAIN** for normal operation.

In case of launching a new ship with no air blowing, examine CU periodically for possible water penetration after floatation.

3.2 Operation of Air Seal

Air Seal System is in operation when blowing air into sea is started. The system automatically controls stern tube oil pressure at the optimum level responding to changes of ship's draft. Keep blowing air and operating **OU** all the time while the ship at sea as well as at berth or anchor. **OU** may be stopped for maintenance etc. while M/E is stopped. In case air source is shut off, stern tube oil pressure stays at the level of oil head pressure from **TU**. Closely watch seawater penetration into **CU** in such an event, and recover or establish air supply as soon as possible. Maintenance of stern tube system, **MU** and **CU** is done as per the article **4** in **P. 8**.

LEAK TEST PROCEDURE in dry-dock (AIR Seal Type AX)

TYPICAL DIAGRAM - Confirm valve no.s & details in Finished Plan

Procedure Oil Filling

1) Fill Sump tank, - Open Valve **"I"**.
2) Close air source valve for **MU**, and open air vent on **TU**.
3) Close valves **"C"** & **"D"**, and open valve **"G"**.
4) Keep valves **"A"** & **"H"** open, and close valve **"B"**.
5) Fill stern tube and **TU** with oil by operating **OU**.
6) Stop **OU** after **TU** filled up with half level.
7) Close air vent on **TU**.
8) Carry out **Test Order "1" & "2"**, either by using;
   a) "X"-line, or
   b) Air pressure
9) Fill oil in #3/3S by **Test Order "3"** after **"1" & "2"**.
10) Fill oil #4/5 by **Test Order "6"** after **"3", "4" & "5"**.

Leak test via "X"-line

1) Close valves **"A"** & **"B"**.
2) Keep valve **"G"** opened. Keep valves **"C"** & **"D"** closed.
3) Operate **OU**
4) Circulate oil via **Sump Tk➡S/T➡"X"-line➡Sump Tk** for test.

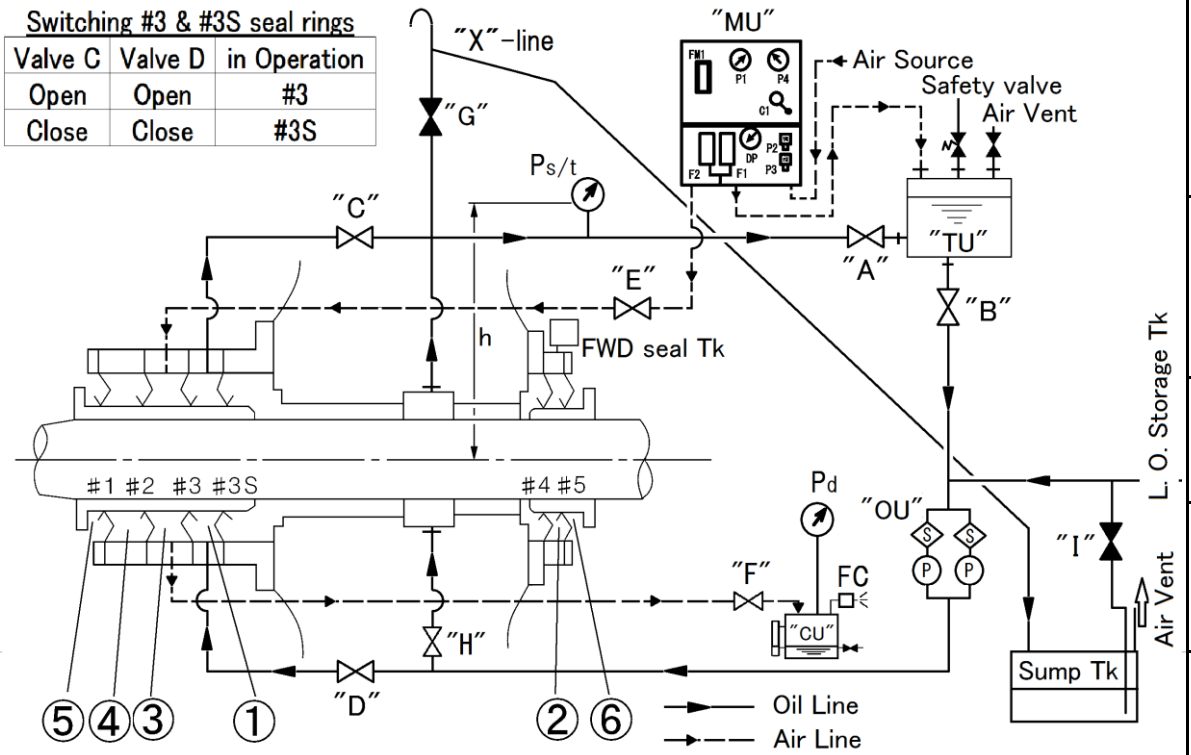
Leak test by applying air presssure in MU

1) Close valve **"G"** on oil line.
2) Open valves **"A"**, **"B"** & **"H"** on oil line.
3) Keep valves **"C"** & **"D"** closed.
4) Close air vent on **TU**.
5) Operate **OU**, and circulate oil via **TU➡S/T➡TU** for test.
6) Set valve positions in MU are for Air Blow.
7) Reduce Regulator setting (0.2 - 0.4MPa) on **"MU"** to 0.1MPa.
8) 8) Close valve **"E"**, or **V4** valve in **MU**.
9) Check Ps/t shows about 0.1MPa and proceed for the test.

Apply oil pressure in stern tube either by X-line or by air pressure, and carry out the test in accordance with the procedure shown in the table.

Switching #3 & #3S seal rings

Valve C	Valve D	in Operation
Open	Open	#3
Close	Close	#3S



1. Valve positions shown above are for "Normal Operating Condition" of Air Seal System.
2. "X"-line is for oil circulation via the gravity line, not in use during operation of Air Seal System.

Test Orde	Seal Ring	Procedure
1	#3S	1) Fill stern tube and **TU** with oil. - See left "Procedure Oil Filling". 2) Keep valves **"C"** & **"D"** closed. 3) Apply oil pressure in stern tube. 4) Remove bottom plug between #3 & 3S seal rings on AFT seal casing. 5) Clean up seal casing/liner/oil holes to remove oil wet. 6) Leave the plug opened for more than 3 hours. 7) Confirm no oil leaking through the bottom hole. 8) Confirm no oil leaking at other area, i. e. sheet packing, "O" ring & etc.
2	#4	1) Same procedures as 1) & 2) for testing #3S above. 2) Remove bottom plug between #4 & 5 seal rings on FWD seal casing. 3) Clean up seal casing/liner/oil holes to remove oil wet. 4) Leave the plug opened for more than 3 hours. 5) Confirm no oil leaking through the bottom hole. 6) Confirm no oil leaking at other area, i. e. sheet packing, "O" ring & etc.
3	#3	1) Plug all oil holes/drain holes between #3 & 3S on AFT seal casing. 2) Open valves **"C"** & **"D"**, to apply pressure in #3/3S chamber. 3) Close valve **"H"** for about 30 sec. to direct oil flows into #3/3S chamber. 4) Keep valve **"H"** open again for the test. 5) Remove bottom plug between #2 & 3 on AFT seal casing. 6) Clean up seal casing/liner/oil holes to remove oil wet. 7) Leave the plug opened for more than 3 hours. 8) Confirm no oil leaking through the bottom hole.
4	#2	1) Leave bottom plug between #2 & 3 opened. 2) Plug bottom hole between #1 & 2. 3) Remove two plugs on top between #1 & 2, for filling and air venting. 4) Fill #1/2 chamber with "Fresh Water" through the top hole. 5) Clean up seal casing/liner/filling holes to remove wet. 6) Confirm no water leaking through the bottom hole between #2 & 3.
5	#1	1) Same procedures 1) - 5) for testing #2 seal ring above. 2) Confirm no water leaking out. 3) Drain out Fresh Water after the test. 4) Confirm all holes for filling, draining & air venting on AFT seal plugged.
6	#5	1) Plug all holes between #4 & 5 on FWD seal casing. 2) Fill #4/5 chamber with oil. 3) Clean up seal casing/liner to remove oil wet. 4) Confirm no oil leaking out. 5) Confirm all oil holes on FWD seal plugged after the test.

REMARKS
1. Carry out leak test after completion of flushing pipes.
2. Take wear-down readings before and after overhauling AFT seal, for repair ship.
3. Protect seals from sand blasting, painting, welding, chemicals, excessive heat & etc.
4. Use stainless steel fitting bolts (SUS 316 or equivalent) for AFT seal installation.
5. Secure all the fitting bolts and plugs for AFT seal by using stainless steel wire.
6. Put all valves (and regulator setting) back to "Normal Operating Condition" after the test.
7. Check P2 pressure indication for Regulator on the green mark.
8. Oil level may suddenly reduce when air-locking dissolved. Fill oil in such an event.

RECORD FORM – KEMEL Air Seal System

yy ______ mm ______

M/V ____________________

Date	AFT Draft (M)	Air Control Unit: P1 Air source press. (MPa)	P2 Reg. air press. Main (MPa)	P3 Reg. air press. Sub (MPa)	P4 Blow air press. (MPa)	DP Diff. air press. (MPa)	F1 Air filter	F2 Oil mist filter	**FM1** Air flow meter (L/min.)	C1 Change lever	Drain Collection Unit (10L): **Pd** Air press. (MPa)	FC Air flow control	Level gauge: Liquid in tank	Level gauge: Level from Tk bottom (cm)	S/T L.O. Tank Unit: Level gauge Level from Tk bottom (cm)	**Ps/t** S/T oil press. (MPa)	Oil Pressure Unit: SUC. Oil press. (MPa)	DISC. Oil press. (MPa)	in Use	Oil level FWD seal Tk (L)	M/E rpm	S/T B'rg Temp. (Deg.. C)	Remark
1	10.4	0.7	0.3	0	0.11	0.01	Clean	Clean	**40**	Main	**0.09**	flow	empty	0	43	**0.11**	0.11	0.17	#1	7	0	32	Sample
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
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							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
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							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				
							Clean/Dirty	Clean/Dirty		Main/Sub		flow/no	empty/oil/sw						#1/#2				

1. Recording intervals; Once a day
2. **P4**, **Pd** & **Ps/t** pressures automatically follow change of water pressure from the draft.
3. Clean filters in case of pressure rise in **DP** gauge.
4. Clean pump strainers in case of suction pressure drop on **Oil Pressure Unit**.
5. Put air vent pipe of FC in a water cup to check air flowing at Drain Collection Unit.
6. Use this form in operating the system while the vessel at sea, at berth or in sea trials.

Initial Setting

Symbol	Standard setting
DP	Green range (less than 0.1MPa)
FM1	**40** or **50L/min.** ***
P1	More than **0.4MPa**
P2	**0.25 – 0.35MPa** on MAIN, 0MPa on SUB ***
P3	0MPa on MAIN, **0.25 – 0.35MPa** on SUB ***

*** Adjust settings shown in Finishied Plan – Piping Diagram Fig. 1.

Height of shaft centerline above keel (m)	

Calculation of differential pressure at shaft centerline

Check point 1.	Symbol	Value	Remark	Example
Gauge height above shaft C/L (m)	h		**Ps/t** gauge	**1.5**
Head pressure (MPa) **Ps/t** gauge *	Hp		Gauge height x 0.009	**0.0135**

* Fill (–) minus value in case the gauge located below shaft level.

Check point 2.	Symbol	MPa	Remark	Example
Stern tube oil pressure	Ps/t		Variable by draft. Pd shows nearly draft pressure.	**0.11**
Press. in Drain Collection Unit	Pd			**0.09**
Differential Pressure **Ps/t – Pd**	ΔP		–	**0.02**
Head Pressure **Ps/t** gauge *	Hp		by calculation	**0.0135**
Differential pressure compensated	ΔP + Hp		**below 0.05MPa**	**0.0335**

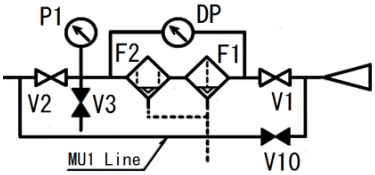
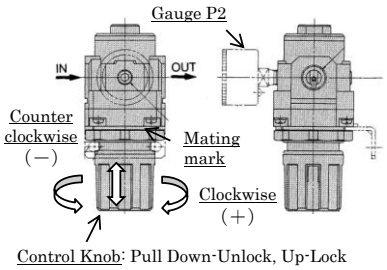
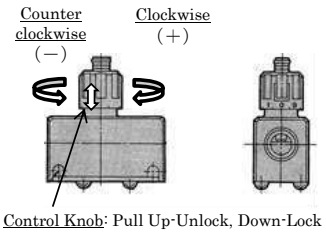
4. Daily Maintenance

4.1 Stern Tube System

Record and monitor operation of Air Seal as per the form in **P. 7**. Also monitor stern tube system as per **Operating Guideline** shown in **KEMEL COMPACT Seal Type CX, DX & AX INSTRUCTION MANUAL**. In case of questions on the data or operating condition, send the record to Technical Service Dept. at **"techservice@kemel.com"** for examination and comments.

4.2 Air Control Unit & Drain Collection Unit

Table below shows maintenance of **MU** and on **CU**. Also refer to photo manual in **P. 9**.

Unit	Devices	Symbol	Standard setting	Maintenance
MU	Air Source	—	0.4MPa Min.	Fully open air source valve and keep the pressure above 0.4MPa all the time.
	Differential Pressure Gauge	DP	Less than 0.1MPa in green zone	**In red zone ➡ Clean or renew filters.** ① Open V10 and close V1 & V2 in MU. ② Open V3 to release air in the line. ③ Remove filter covers. (Secure O-ring fitted) ④ Remove filters. ⑤ Clean & re-set filters, or renew filters. ⑥ Close V3. Open V1 & V2, then close V10. 
	Air Filter	F1 F2		
	Air Regulator	R1/P2 & R2/P3	Set Value **See Note *)** Allowance ±0.05MPa	**Pressure setting** (Set value is shown in Finish Plan – Piping Diagram Fig.1) ① Pull-down the knob to unlock. ② Turn the knob for pressure setting. ③ Push-up the knob to lock. Check positions of Green Markers in P2 & P3 gauges for indication of the set value. **Note: Initial setting is made for R1 & R2 at the time of delivery.** 
	Air Flow Controller	FC1 & FC2	Set Value **See Note *)** Allowance ±5L/min.	**Flow setting** (the value shown in Finished Plan-Piping Diagram Fig.1.) ① Pull-up the knob to unlock. ② Check air flow rate at FM1. ③ Turn the knob for flow setting. ④ Push-down the knob to lock. **Note: Initial setting is made for FC1 & FC2 at the time of delivery.** 
	Air Flow Meter	FM1		
	Change Lever	C1	on MAIN	① On MAIN: Air blows into sea via R1➡P2➡FC1➡FM1. ② On SUB: Air blows into sea via R2➡P3➡FC2, bypassing FM1. ③ SUB is only for temporally use. (FM1 does not work.) ④ Recover MAIN to replace SUB as soon as possible.
CU	Air Flow Controller	FC	Slight Open	① Check ventilation through the vent, with low air-speed. ② Turn the knob to adjust flow speed after the lock nut loose, if necessary. ③ Tighten the lock nut after setting air flow. **Note: Initial setting is made for FC at the time of delivery.** **Put air-vent pipe in a water cup to check ventilation bubbles.**
	Level Gauge	—	—	① Remove drain in case of high level alarm activated. ② Slight-open drain valve for discharge by air pressure in CU. ③ Discharge while M/E stopped. (Do not open the valve when M/E in operation.)

Note *) Adjust settings shown in Finished Plan – Piping Diagram Fig. 1.

OPERATION of AIR CONTROL UNIT and DRAIN COLLECTION UNIT

Photo 1. Air Control Unit (MU)

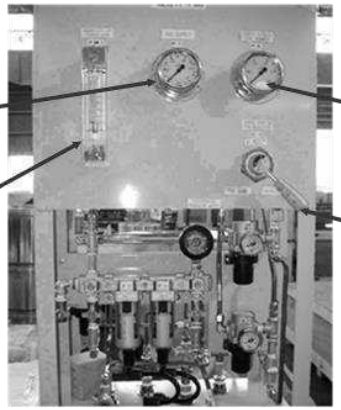


Photo 2. Air Flow Controller FC1 (Side View－Left)

1. Pull up the knob for unlock.
2. Turn the knob for setting airflow.
3. Check the rate by Flow Meter.
4. Push down the knob for locking.

Photo 3. Air Regulator & Air Filters

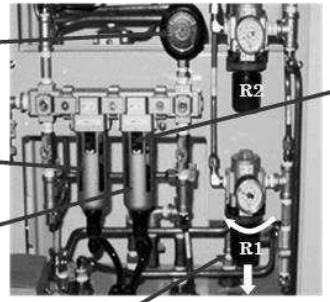
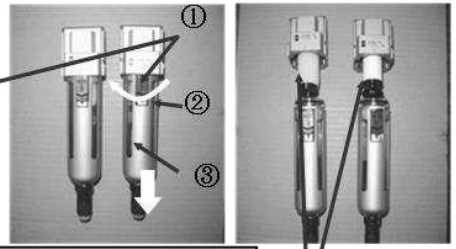


Photo 4. Removal Filter Elements



Detatch Filter Cover
① Pull down locking tab.
② Turn the cover.
③ Pull down the cover.

・F1
Air Fliter Element
・F2
Oil Mist Filter
(Rotate to detatch them.)

NOTE: Do not open filters before isolating them from air pressure line!

Procedure for isolating filters
①Open V10 to keep bypassing airline.
②Close V1 & V2 for isolation.
③Open V3 for air release.
④Open filters.

Procedure for re activating filters
①Install filters.
②Close V3.
③Open V1 & V2.
④Close V10.

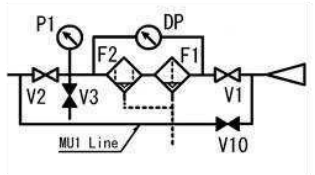
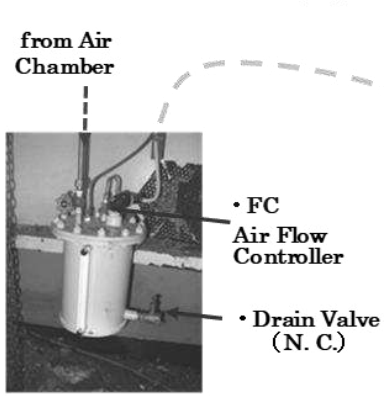
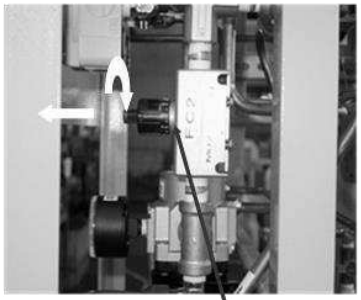


Photo 5. Drain Collection Unit (CU)



Discharge Drain (with stop M/E)
①Open drain valve
②Discharge by air pressure
③Close drain valve

Photo 6. Air Flow Controller FC2 on SUB (Side View－Right)



1. FC2 works with change lever C1 on SUB.
2. The initial setting is made at 40 or 50L/min.
3. Change flow rate as same manner as FC1.
4. Flow meter FM1 does not work with FC2.
5. SUB is used only for temporally operation.
6. Recover MAIN at the earliest opportunity

5. Trouble Shooting

5.1 Abnormalities of Air Pressures/Air Flow & Actions

Unit	Gauge	Abnormality	Possible Cause	Action
MU	**P1**	Low, or "Zero" pressure. （Minimum 0.4MPa required.）	Air source valve closed. Air source pressure low. **P1** gauge malfunction.	Open air source valve. Keep the pressure above 0.4MPa. Replace **P1** gauge.
	P2	Low, or "Zero" pressure.	Change Lever **C1** is on **SUB**. Air Regulator **R1** setting changed. **P2** gauge malfunction. Air regulator **R1** malfunction.	Put **C1** on **MAIN,** if it works. Re-adjust **R1** setting. Replace **P2** gauge Put **C1** on **Sub**. Replace **R1**.
	P3	Low, or "Zero" pressure.	Change Lever **C1** is on **MAIN**. Air Regulator **R2** setting changed. **P3** gauge malfunction. Air regulator **R2** malfunction.	No action required. Keep **C1** on **MAIN**. Re-adjust **R2** setting. Replace **P3** gaugeReplace **R2**.
	P4	Rises up to **R1** (or **R2**) set pressure.	Valves on Air Blow Line are closed. 3-way valve on Air Blow Line in direction F/W cleaning.	Open the valves. Put 3-way valve in direction of Air Blowing.
		Gets higher pressure in same draft level before. Gets larger deviation from **Pd** than ever before.	Blockade proceeding in Air Blow Line.	Clean pipe by using fresh water line in **MU**, while M/E stopped.
		Low, or "Zero" pressure.	Air leakage from air pipes	Check pipes by spraying soap water, and repair.
		The pressure does not follow change of draft.	**P4** gauge malfunction	Replace **P4** gauge.
	DP	Indicator needle in "Red Zone".	Dirty filters **F1** & **F2**.	Clean or replace filters.
	FM1	Out of setting range.	Air Flow Controller **FC1** setting changed. Air Flow Controller **FC1**malfunction. Air Flow Meter **FM1** malfunction.	Re-adjust **FC1** setting. Put **C1**on **SUB**. Replace **FC1**. Put **C1**on **SUB**. Replace **FM1**.
CU	**Pd**	Pressure low.	Drain valve or Air Flow Controller **FC** fully opened. Blockage or air leakage at drain pipe lead to **CU**.	Close drain valve or re-adjust **FC** slight open. Clean pipe by fresh water line in **MU**, repair pipe.
		Does not follow change of draft.	**Pd** gauge malfunction	Replace **Pd** gauge
	Level Gauge	Filled with seawater. Filled with oil.	Seawater leakage through the #1 & 2 seal rings. Oil leakage through the #3 seal ring.	Remove water. Record daily amount and report. Remove oil. Record daily amount and report.
TU • OU	**Ps/t**	**Ps/t** stays at head pressure of **TU**, or does not rise.	Air vent valve on **TU** is opened. Air leakage at the pipe lead to **TU** or **TU** itself. **Ps/t** gauge malfunction.	Close air vent valve. Check pipes by spraying soap water, and repair. Replace **Ps/t** gauge
		"Ps/t – Pd" value is greater than 0.05 MPa, with compensation of **Ps/t** gauge height.	Valve "A" on return line to **TU** is not fully opened. Bypass valve on **OU** is fully closed.	Fully open valve "A", shown in P. 2 diagram. Re-adjust the bypass valve. Set **R1** & **FC1** lower, at the minimum values.

5.2 Alarms & Actions

ALARM	Unit	Check Point	Abnormal Condition	Possible Cause	Action	Report to KEMEL
A1 (MU) Air pressure Low	**MU**	**DP** Gauge	The indicator in Red Zone, exceeding 0.1MPa.	Dirty filters.	Clean or replace filter elements.	
		P2 Gauge	**P2** indicates below the minimum set pressure. (see Finished Plan – Piping Diagram Fig. 1)	R1 setting changed. Malfunction **R1**. Malfunction **P2**.	Re-adjust **R1** setting. Put **C1** on **SUB**. Replace **R1**. Replace **P2**.	
		FM1 Flow Meter	Flow rate is below the minimum value. (see Finished Plan – Piping Diagram Fig. 1)	FM1 setting changed Malfunction **FM1**.	Re-adjust **FC1** setting. Put **C1** on **SUB**. Replace **FC1**.	
		Valve positions	Wrong position. (see Finished Plan – Piping Diagram Fig. 1)	–	Correct valve positions.	
	TU	Safety relief valve Air pipe joints Air vent	The relief valve activates at lower pressure. Air leakage. (Check by spraying liquid soap.) Air vent valve opened.	Malfunction valve. Loose joints etc. –	Repair/Replace the relief valve. Repair leaking joints/pipes. Close the valve.	
	CU	Flow Controller **FC** Air pipe joints Drain Valve	Excessive air flow at **FC**. Air leakage. (Check by spraying liquid soap.) Drain valve left opened.	Setting changed. Loose joints etc. –	Re-adjust **FC** with 2-3 air bubbles/sec. Repair leaking joints/pipes. Close drain valve.	
	Air Source		Loss of air source pressure.	–	Take actions in P. 13. Recovery of air	
A2 (TU) Oil Level High	**OU**	Pressure gauge Strainer Oil color	Negative pressure at pump suction, causes air sucking. Dirty strainer. Air bubbles（Increased oil volume by air inclusion.）	Dirty strainer Particles in S/T oi Air inclusion	Clean strainers.	
	TU	Level gauge	Level increase in shallow draft and decrease in deep draft	Air-pocket in S/T.	Dissolve air-pocket.	**Yes**
	S/T	Stern tube drain	Sign of seawater penetration.	AFT seal damage	Increase air flow rate at 60－80L/min. Conduct diver inspection. Repair AFT seal.	**Yes**
	CU	Level gauge	Filled with seawater immediately after draining.			
	FWD seal	Level gauge	Decrease oil level in FWD seal tank, and increase the level in **TU** with same amount. (Pumping effect.)	Pressure fluctuation in S/T.	Increase S/T oil pressure. *** Re-fill oil in FWD seal, whenever is necessary.	**Yes**
A2 (TU) Oil Level Low	**TU**	Oil pipe joint	Oil leakage	Loose joint	Repair pipe joints.	
	CU	Level gauge	Oil level increases over 2L/day.	Leakage from the #3 seal ring	Activate the #3S seal ring.	**Yes**
	FWD seal	Level gauge	Oil level increases over 2L/day.	Leakage from the #4 seal ring	Recovery. Repair the #4 seal ring.	**Yes**
A3 (CU) Liquid Level High	**CU**	Level Gauge Drain	Continuous seawater recovery. Filled with seawater in a day.	Damage of the #1 & 2 seal rings	Increase air flow rate at 60－80L/min. Conduct diver inspection. Repair AFT seal.	**Yes**
			Recovery of oil over 2L/day	Damage of the #3 seal ring	Activate the #3S seal ring.	**Yes**

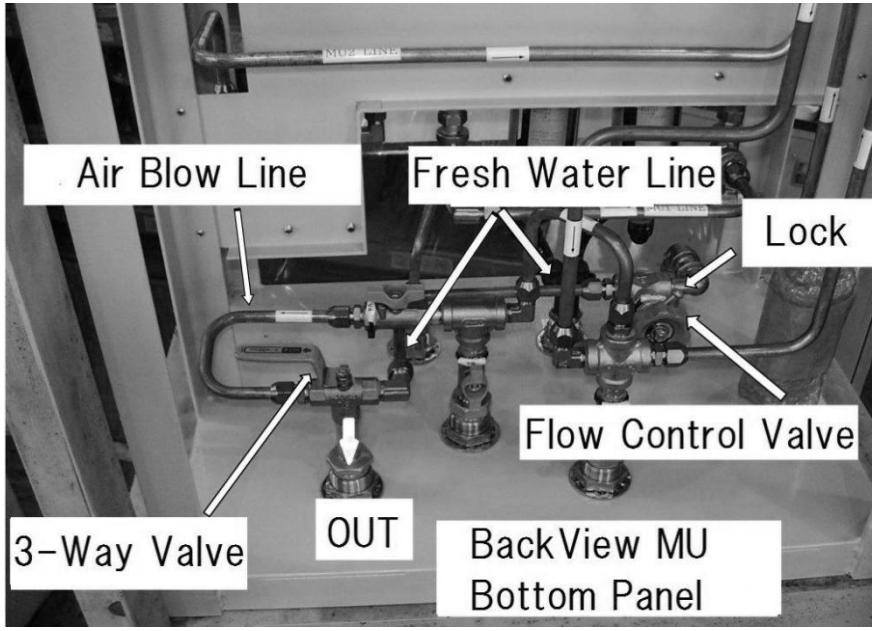
*** Increase oil pressure by operating bypass valve on **OU** or valve **"A"** on return line.
The differtial pressure "Ps/t - Pd" should not exceed 0.05MPa. (See P. 7 Calculation of pressures)

5.3 Other abnormalities & Actions

Abnormalities	Check Point	Possible Cause	Actions	Report to KEMEL
Seawater penetration into stern tube with no seawater collected in **CU**.	Air pressure in **CU**. Stern tube oil condition.	Blockade in drain pipe.	Increase air flow rate at 60－80L/min. Clean pipe by using Fresh Water Line in **MU**. Conduct diver inspection, if necessary.	Yes
Stern tube oil leak with no collection of oil in **CU**.	Pressure in **CU**. Oil level in **TU**.	Broken pipe in stern tube Blockage in drain pipe.	Activate the #3S seal ring and keep monitoring. Cleaning Air pipe by Fresh Water.	Yes
Air pressure high alarm (Option) from **A1**.	Valve position on Air Blow Line. **P4** pressure on **MU**.	Valves remain closed. Blockade in Air Blow Line.	Open the valves. Clean pipe by using Fresh Water Line in **MU**.	Yes

Cleaning Air Pipe by Fresh Water

In case P4 pressure become higher than Pd over 0.03MPa difference, it is possible that air flow pipes started to have blockage due to extraction of salt etc. MU has a fresh water line to dissolve the blockage and to clean the pipe. It is recommended that the ship clean the pipe by using the line with 6months intervals.



Procedure for Fresh Water Cleaning (To be done while M/E stopped or on turning gear.)

1) Open drain valve on **CU**.
2) Turn 3-Way Valve in **MU**, to the direction of Fresh Water Line. - **Note 1**
3) Open the valve and start supply fresh water.
4) Clean the air pipe till fresh water coming out from the drain valve on **CU**. - **Note 2**
5) Stop fresh water supply.
6) Turn 3-Way Valve in **MU**, to the direction of Air Blow Line.
7) Close the drain valve on **CU** after blowing out water by the air.
8) Examine all pressures and air flow being in normal condition.

Note1. When 3-way Valve is turned to the direction of Fresh Water, Air Blow line is shut off and air pressure set by **R1** is directly given to **TU**. This may cause activation of Safety Relief Valve on **TU**, which is not harmful. The activation of Safety Relief Valve may be stopped by reducing **R1** setting during Fresh Water Cleaning. However, do not reduce **R1** setting in case of continual seawater leakage into **CU**. Also make sure **R1** should be back to the set value after the cleaning.

Note2. It takes a time to have cleaning water coming out at **CU** drain. (Flow Control Valve on fresh water line is initially set and locked at very slow speed so that the water does not penetrate into stern tube by sudden rise of water pressure. In case the initial setting is lost, fully close the control valve then turn the wheel 180 degree, half-turn, for re-setting.

6. Switch-over to normal Oil Seal System for emergency

Losing air supply to AFT seal causes oil pressure drop in stern tube. In case of air lost while the vessel is at sea, immediately examine seawater penetration in **CU**. It is possible to operate the system without air if no seawater is observed in **CU**. Air supply, however, should be recovered to raise the oil pressure at the earliest possible. During the operation with no air, keep monitoring **CU** by frequent examination of the drain. In case no air supply to **MU** may continue for a long period, study possibilities of slow-down or stop M/E till air supply is recovered.

If seawater continuously fills **CU** in a short time, conduct protection of stern tube bearing from seawater by switching Air Seal system over to normal oil seal system as per the procedures below,

1) Switch-off all alarms on **MU**, **TU** and **CU** and stop air supply.
2) Stop **OU**, and then take action 3) with no delay.
3) Change oil circulation via **X-line** as per "Valve Operation for switching to **X-line**" below.
4) Re-start **OU** with no delay.

While operation with **X-line**, keep **OU** running all the time to maintain the oil head pressure which minimizes the chance of seawater penetration into stern tube. Strengthen examination of stern tube oil drain and remove contaminated oil when it is found. It is necessary to recover air source failure as soon as possible. At the same time, investigate possibility of earlier inspection and repair of AFT seal for seawater leakage.

Valve Operation for switching to X-line

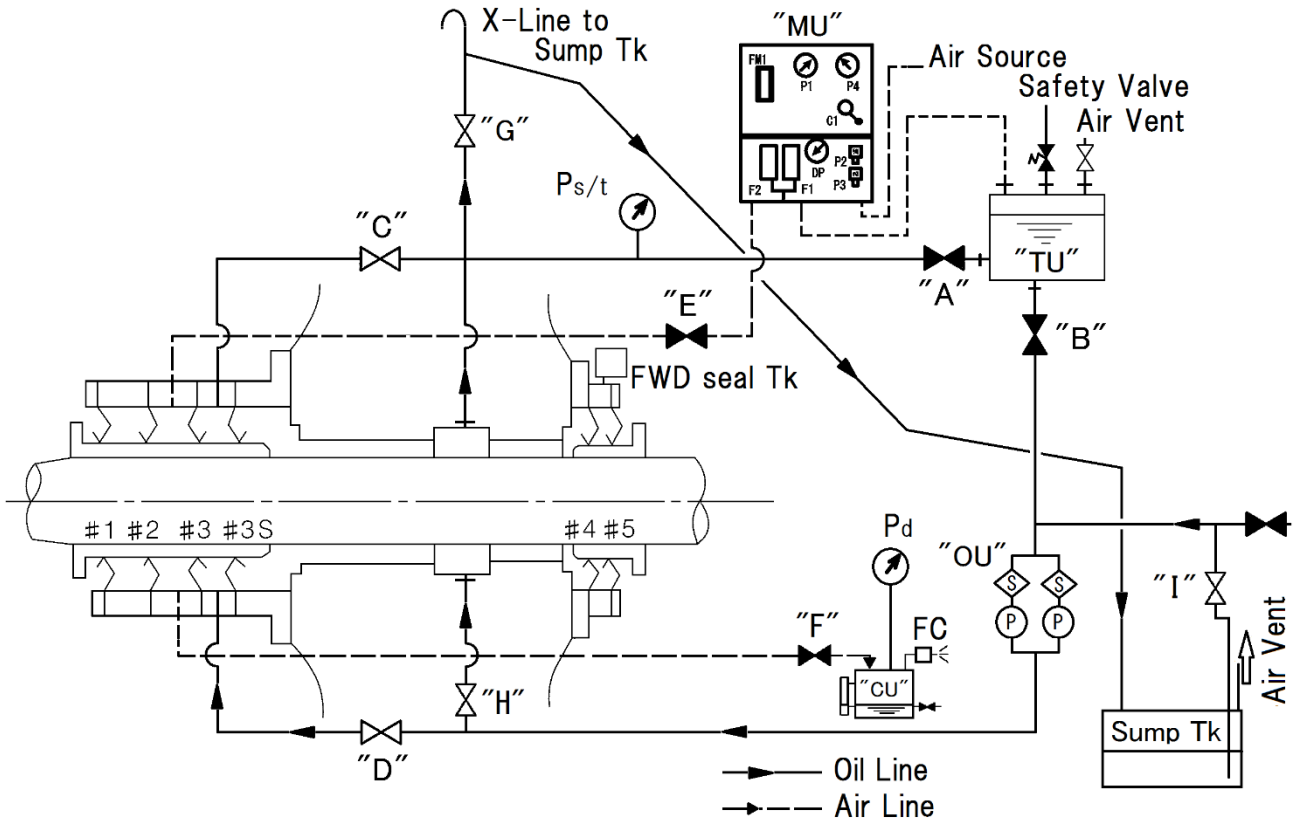
	MU		CU	TU			OU	X-line
Valve	V8	E	F	A	B	Air Vent	I	G
Operation	Close	Close	Close	Close	Close	Open	Open	Open

Note 1. V8 valve is located in MU, on the line to pressurize TU.

Note 2. Confirm detail valve operation in Finished Plan – Piping Diagram Fig. 2.

Valve Operation for switching back to Air Seal

	X-line	OU	TU			CU	MU	
Valve	G	I	Air Vent	B	A	F	E	V8
Operation	Close	Close	Close	Open	Open	Open	Open	Open



7. Operation for Dry-docking, Undocking and Laying-up

7.1 Dry-docking & Undocking

In case of dry-docking and undocking, shut-down and re-start Air Seal system as the manners below,

1) Stop all alarms on **MU**, **TU** and **CU**, and then stop air supply to **CU** to shut-down before entering dock.
2) Discharge oil in stern tube, AFT seal and FWD seal for seal repair after dry-up.
3) Carry out inspection or repair of the seal unit as necessary.
4) Fill stern tube and carry out oil pressure test as necessary. (See P. 6 for oil filling and pressure test.)
5) Re-start the system before undocking. (See articles 2 & 3 for the procedures.)

7.2 Laying-up

In case of laying-up the ship with no power and no air, shut-down Air Seal system as the manners below,

1) Stop all alarms on **MU**, **TU** and **CU**.
2) Stop **OU** to shut-down the system.
3) Examine existence of seawater in **CU** through the drain valve.
4) In case of no seawater observed, carry out drain check once a week after the shut-down.
5) In case seawater fills **CU** in a short time, conduct protection of stern tube bearing from seawater by switching Air Seal system over to normal oil seal system using **X-line** as per article 6.
6) Circulate stern tube oil via **X-line** by operating **OU**.
7) Check oil pressure at **Ps/t** gauge.
8) Stop **OU** to shut-down the system.
9) Confirm the oil head is maintained.
10) Examine **Ps/t** once a week and stern tube drain.
11) Recover the pressure by the procedures 6) – 9), if necessary.

Re-start Air Seal after the laying-up period as the manners below,

1) Operate the valves as per article 6 “Valve operation for switching back to Air Seal”.
2) Confirm drain valve on **CU** is closed.
3) Operate **OU**.
4) Supply air to **MU** and activate all alarms on **MU**, **TU** and **CU** to re-start.
5) Examine all pressures and air flow of the system.

It is possible that marine growths around AFT seal area during laying-up period may cause reduction of seal tightness. Recommend cleaning and overhaul inspection of the seal at the earliest opportunity after re-activation of the system.

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