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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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.

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Control Unit (MU)</td>
<td>Supply air to AFT seal</td>
</tr>
<tr>
<td></td>
<td>Regulate supply air pressure</td>
</tr>
<tr>
<td></td>
<td>Regulate air flow</td>
</tr>
<tr>
<td></td>
<td>Pressurize S/T L. O. Tank</td>
</tr>
<tr>
<td></td>
<td>Clean air pipe by fresh water</td>
</tr>
<tr>
<td>S/T L. O. Tank Unit (TU)</td>
<td>Supply oil to Pump</td>
</tr>
<tr>
<td></td>
<td>Pressurize stern tube</td>
</tr>
<tr>
<td>Oil Pressure Unit (OU)</td>
<td>Circulate stern tube oil - Pump</td>
</tr>
<tr>
<td>Drain Collection Unit (CU)</td>
<td>Recover leaking oil/water</td>
</tr>
<tr>
<td></td>
<td>Recover cleaning fresh water</td>
</tr>
<tr>
<td>FWD seal L. O. Circulation Unit</td>
<td>Circulate FWD seal L. O.</td>
</tr>
</tbody>
</table>
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 Air Relay (AR1) to give the pressure of air blowing as an input signal. Another branch line taken after Air Filters is lead to S/T L. O. Tank Unit (TU) through AR1 to pressurize it, called TU Line. AR1 regulates the pressure in TU Line at the level of the signal pressure from air blowing. AR1 has a hand wheel for fine adjustment of the regulating pressure. TU Line has change lever C2 to bypass AR1, through SUB Line, which gives TU a direct pressure from Air Blow Line. 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 stetting 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”.

The diagram shows Air Seal operation using MAIN LINE.
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 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 stem tube with 2 - 2.5M of the oil height above shaft centerline. In addition, TU is connected with an air pipe via AR1 equalizing the line pressure at Air Chamber Pressure. By the arrangement, stem 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 stem tube oil.
1.5 Oil Pressure Unit (OU – Oil Pump)

OU circulates lubrication oil via “OU ➔ Stern Tube ➔ TU ➔ OU”. Stem tube oil pressure is measured at the return line from stem 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 remove 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.

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 stem 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 and AR1 on MU 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 C2 on SUB and examine all pressures.
11) Put Change Levers C1 & C2 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 stem 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, stem tube oil pressure stays at the level of oil head pressure from TU. Closely watch seawater penetration in 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 “F”.
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”.
3. Operate OU

**Leak test by applying air pressure in MU**

1. Close valve “G” on oil line.
2. Open valves “A”, “B” & “H” on oil line.
4. Close air vent on TU.
6. Set valve positions in MU are for Air Blow.
7. Reduce Regulator setting (0.1 - 0.4MPa) on “MU” to 0.1MPa.
8. Open valve “E”, or V4 valve in MU.
9. Check P/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**

<table>
<thead>
<tr>
<th>Valve C</th>
<th>Valve D</th>
<th>In Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>Open</td>
<td>#3</td>
</tr>
<tr>
<td>Close</td>
<td>Close</td>
<td>#3S</td>
</tr>
</tbody>
</table>

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

**Procedure**

1. Fill stern tube and TU with oil. - See left "Procedure Oil Filling".
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.

**Test Order Seal Ring**

<table>
<thead>
<tr>
<th>Test Order</th>
<th>Seal Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>#3S</td>
</tr>
<tr>
<td>2</td>
<td>#4</td>
</tr>
<tr>
<td>3</td>
<td>#3</td>
</tr>
<tr>
<td>4</td>
<td>#2</td>
</tr>
<tr>
<td>5</td>
<td>#1</td>
</tr>
<tr>
<td>6</td>
<td>#5</td>
</tr>
</tbody>
</table>

**Procedure**

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.

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.

**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 installation.
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**

**Air Control Unit**

<table>
<thead>
<tr>
<th>Date</th>
<th>AFT Draft (M)</th>
<th>Air source press. (MPa)</th>
<th>Reg. air press. Main (MPa)</th>
<th>Reg. air press. Sub (MPa)</th>
<th>Blow air press. (MPa)</th>
<th>TU line air press. (MPa)</th>
<th>Diff. air press. (MPa)</th>
<th>Air filter</th>
<th>Oil mist filter</th>
<th>Air flow meter (L/min)</th>
<th>Change lever</th>
<th>Change lever</th>
<th>Air press. (MPa)</th>
<th>Air flow control</th>
<th>Liquid in tank</th>
<th>Level from Tk bottom (cm)</th>
<th>Level from Tk bottom (cm)</th>
<th>S/T L.O. Tank Unit (MPa)</th>
<th>Oil Pressure Unit (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.4</td>
<td>0.7</td>
<td>0.3</td>
<td>0.11</td>
<td>0.01</td>
<td>Clean</td>
<td>Clean</td>
<td>40</td>
<td>Main</td>
<td>Flow empty</td>
<td>0.09</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.17</td>
<td>0.03 - 0.05 MPa range</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Recording intervals: Once a day
2. P4, P5, 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**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Standard setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP</td>
<td>Green range (less than 0.1 MPa)</td>
</tr>
<tr>
<td>FM1</td>
<td>40 or 50L/min. ***</td>
</tr>
<tr>
<td>P1</td>
<td>More than 0.4 MPa</td>
</tr>
<tr>
<td>P3</td>
<td>0.25 - 0.35 MPa on MAIN, 0.01 MPa on SUB ****</td>
</tr>
</tbody>
</table>

**Calculation of differential pressure at shaft centerline**

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

**Check point 1.**

- Gauge height above shaft C/L (m): \( h \)
- Head pressure (MPa) \( Ps/t \) gauge: \( H_p \)
- Gauge height x 0.009: \( 0.0135 \)

**Check point 2.**

- Stern tube oil pressure: \( Ps/t \)
- Press in Drain Collection Unit: \( Pd \)
- Differential Pressure \( Ps/t - Pd \): \( \Delta P \)
- Head pressure \( Ps/t \) gauge: \( H_p \)
- Differential pressure compensated: \( 0.03 - 0.05 \) MPa range: \( 0.0335 \)

---

**Remarks:**

- Height of shaft centerline above keel (m)
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.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Devices</th>
<th>Symbol</th>
<th>Standard setting</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source</td>
<td></td>
<td></td>
<td>0.4MPa Min.</td>
<td>Fully open air source valve and keep the pressure above 0.4MPa all the time.</td>
</tr>
<tr>
<td>Differential</td>
<td>DP</td>
<td></td>
<td>Less than 0.1MPa</td>
<td>In red zone ➟ Clean or renew filters.</td>
</tr>
<tr>
<td>Pressure Gauge</td>
<td></td>
<td></td>
<td>in green zone</td>
<td>① Open V10 and close V1 &amp; V2 in MU.</td>
</tr>
<tr>
<td>Air Filter</td>
<td>F1/F2</td>
<td></td>
<td></td>
<td>② Open V3 to release air in the line.</td>
</tr>
<tr>
<td>Air Regulator</td>
<td>R1/P2 &amp;</td>
<td>R2/P3</td>
<td></td>
<td>③ Remove filter covers. (Secure O-ring fitted)</td>
</tr>
<tr>
<td>Air Flow</td>
<td>FC1 &amp;</td>
<td></td>
<td></td>
<td>④ Remove filters.</td>
</tr>
<tr>
<td>Controller</td>
<td>FC2</td>
<td></td>
<td></td>
<td>⑤ Clean &amp; re-set filters, or renew filters.</td>
</tr>
<tr>
<td>Air Flow Meter</td>
<td>FM1</td>
<td></td>
<td></td>
<td>⑥ Close V3. Open V1 &amp; V2, then close V10.</td>
</tr>
<tr>
<td>Pressure setting</td>
<td>(See Note *)</td>
<td>Allowance ±0.05MPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow setting</td>
<td>(the value shown in Finished Plan – Piping Diagram Fig.1)</td>
<td>Allowance ±5L/min.</td>
<td>Note: Initial setting is made for FC1 &amp; FC2 at the time of delivery.</td>
<td></td>
</tr>
<tr>
<td>Adjust Ps/t</td>
<td>AR1</td>
<td>&quot;Ps/t - Pd&quot; value in the range 0.03 - 0.05 MPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change Lever</td>
<td>C1</td>
<td></td>
<td></td>
<td>① On MAIN: Air blows into sea via R1 ➟ P2 ➟ FC1 ➟ FM1.</td>
</tr>
<tr>
<td>Change Lever</td>
<td>C2</td>
<td></td>
<td></td>
<td>② On SUB: Air blows into sea via R2 ➟ P3 ➟ FC2, bypassing FM1.</td>
</tr>
<tr>
<td>Air Flow</td>
<td>FC</td>
<td></td>
<td></td>
<td>③ SUB is only for temporarily use. (FM1 does not work.)</td>
</tr>
<tr>
<td>Controller</td>
<td></td>
<td></td>
<td></td>
<td>④ Recover MAIN to replace SUB as soon as possible.</td>
</tr>
<tr>
<td>Change Lever</td>
<td>C2</td>
<td></td>
<td></td>
<td>① Main: AR1 controls air pressure in TU line by using Air Blow Line pressure as a signal.</td>
</tr>
<tr>
<td>Change Lever</td>
<td>C1</td>
<td></td>
<td></td>
<td>② Sub: bypass AR1 and pressurize TU line by direct pressure of Air Blow Line.</td>
</tr>
<tr>
<td>Air Flow</td>
<td>FC</td>
<td></td>
<td>Slight Open</td>
<td>③ SUB is only for temporarily use.</td>
</tr>
<tr>
<td>Controller</td>
<td></td>
<td></td>
<td></td>
<td>④ Recover MAIN to replace SUB as soon as possible.</td>
</tr>
<tr>
<td>Level Gauge</td>
<td></td>
<td></td>
<td></td>
<td>① Remove drain in case of high level alarm activated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>② Slight-open drain valve for discharge by air pressure in CU.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>③ Discharge while M/E stopped. (Do not open the valve when M/E in operation.)</td>
</tr>
</tbody>
</table>

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)
- P1: Press. Gauge Air Source
- AR1: Control Wheel Air Relay
- FM1: Air Flow Meter
- P5: TU Line Air pressure
- C1: Main-Sub Change Lever
- P4: Press. Gauge Blowing Air
- C2: Main-Sub Change Lever

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
- DP: Differential Press. Gauge
- F2: Oil Mist Filter
- P1: Air Filter
- P2 & R1: Air Regulator Main (Lower)
- P3 & R2: Air Regulator Sub (Upper)

Photo 4. Removal Filter Elements
1. Detach Filter Cover
   - Pull down locking tab.
   - Turn the cover.
   - Pull down the cover.

Photo 5. Drain Collection Unit (CU)
from Air Chamber
- FC: Air Flow Controller
- Drain Valve (N.C.)

Photo 6. Air Flow Controller FC2 on SUB (Side View - Right)
- Pd: Pressure Gauge

NOTE: Do not open filters before isolating them from air pressure line!
Procedure for isolating filters
① Open V10 to keep bypassing airline.
② Close V1 & V2 for isolation.
③ Open V3 for air release.
④ Open filters.
Procedure for re-activating filters
① Install filters.
② Close V3.
③ Open V1 & V2.
④ Close V10.

1. FC2 works with change lever C1 on SUB.
2. The initial setting is made at 40 or 50 l/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 temporarily operation.
6. Recover MAIN at the earliest opportunity.
## 5. Trouble Shooting

### 5.1 Abnormalities of Air Pressures/Air Flow & Actions

<table>
<thead>
<tr>
<th>Unit</th>
<th>Gauge</th>
<th>Abnormality</th>
<th>Possible Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td></td>
<td>Low, or “Zero” pressure. (Minimum 0.4MPa required.)</td>
<td>Air source valve closed. Air source pressure low. (P1) gauge malfunction.</td>
<td>Open air source valve. Keep the pressure above 0.4MPa. Replace (P1) gauge.</td>
</tr>
<tr>
<td>P2</td>
<td></td>
<td>Low, or “Zero” pressure.</td>
<td>Change Lever (C1) is on (SUB). Air Regulator (R1) setting changed. (P2) gauge malfunction. Air regulator (R1) malfunction.</td>
<td>Put (C1) on (MAIN), if it works. Re-adjust (R1) setting. Replace (P2) gauge.</td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td>Low, or “Zero” pressure.</td>
<td>Change Lever (C1) is on (MAIN). Air Regulator (R2) setting changed. (P3) gauge malfunction. Air regulator (R2) malfunction.</td>
<td>No action required. Keep (C1) on (MAIN). Re-adjust (R2) setting. Replace (P3) gauge.</td>
</tr>
<tr>
<td>MU</td>
<td>P4</td>
<td>Rises up to (R1) (or (R2)) set pressure.</td>
<td>Valves on Air Blow Line are closed. 3-way valve on Air Blow Line in direction F/W cleaning.</td>
<td>Open the valves. Put 3-way valve in direction of air blowing.</td>
</tr>
<tr>
<td>P4</td>
<td></td>
<td>Gets higher pressure in the same draft level before. Blockade proceeding in Air Blow Line.</td>
<td>Air leakage from air pipes</td>
<td>Check pipes by spraying soap water, and repair.</td>
</tr>
<tr>
<td>MU</td>
<td>Pd</td>
<td>The pressure does not follow change of draft.</td>
<td>Pressure gauge malfunction. Wrong setting (AR1). Air leakage on (TU) line. Malfunction (AR1).</td>
<td>Replace pressure gauges. Re-adjust (AR1). Check pipes by spraying soap water, and repair.</td>
</tr>
<tr>
<td>P5</td>
<td></td>
<td>Considerably lower than (P4) pressure.</td>
<td>Pressure gauge malfunction. Wrong setting (AR1). Air leakage on (TU) line. Malfunction (AR1).</td>
<td>Replace pressure gauges. Re-adjust (AR1). Check pipes by spraying soap water, and repair.</td>
</tr>
<tr>
<td>DP</td>
<td></td>
<td>Indicator needle in “Red Zone”.</td>
<td>Dirty filters (F1) &amp; (F2).</td>
<td>Clean or replace filters.</td>
</tr>
<tr>
<td>FM1</td>
<td></td>
<td>Out of setting range.</td>
<td>Air Flow Controller (FC1) setting changed. Air Flow Controller (FC1) malfunction. Air Flow Meter (FM1) malfunction.</td>
<td>Re-adjust (FC1) setting. Put (C1) on (SUB), Replace (FC1). Put (C1) on (SUB), Replace (FM1).</td>
</tr>
<tr>
<td>CU</td>
<td>Pd</td>
<td>Pressure low. Pressure does not follow change of draft.</td>
<td>Drain valve or Air Flow Controller (FC) fully opened. Blockage or air leakage at drain pipe lead to (TU).</td>
<td>Close drain valve or re-adjust (FC) slight open. Clean pipe by fresh water line in (MU), repair pipe.</td>
</tr>
<tr>
<td>Level</td>
<td>Gauge</td>
<td>Filled with seawater.</td>
<td>Seawater leakage through the #1 &amp; 2 seal rings. Oil leakage through the #3 seal ring.</td>
<td>Remove water. Record daily amount and report. Remove oil. Record daily amount and report.</td>
</tr>
<tr>
<td>TU</td>
<td>Ps/t</td>
<td>“Ps/t – Pd” value is greater than 0.05 MPa, with compensation of (Ps/t) gauge height.</td>
<td>Air vent valve on (TU) is opened. Air leakage at the pipe lead to (TU) or (TU) itself. (Ps/t) gauge malfunction.</td>
<td>Fully open valve “A”, shown in P. 2 diagram. Re-adjust the bypass valve.</td>
</tr>
<tr>
<td>OU</td>
<td>Ps/t</td>
<td>Filled with oil.</td>
<td>Seawater leakage through the #1 &amp; 2 seal rings. Oil leakage through the #3 seal ring.</td>
<td>Remove water. Record daily amount and report. Remove oil. Record daily amount and report.</td>
</tr>
</tbody>
</table>
### 5.2 Alarms & Actions

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

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*** Increase oil pressure by operating Air Realy “AR1” on MU.

The differential pressure “Ps/t - Pd” should not exceed 0.05MPa. (See P. 7 Calculation of pressures)
### 5.3 Other abnormalities & Actions

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

**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 6 months 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.

**Note 1.** 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.

**Note 2.** 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 stem 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 Oil Seal System for emergency

Losing air supply to AFT seal causes oil pressure drop in stem 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 stem 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 I via X-line as per “Valve Operation for switching to X-line” shown 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 stem tube. Strengthen examination of stem 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**

<table>
<thead>
<tr>
<th>Valve</th>
<th>MU</th>
<th>CU</th>
<th>TU</th>
<th>OU</th>
<th>X-line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>Close</td>
<td>Close</td>
<td>Close</td>
<td>Close</td>
<td>Close</td>
</tr>
<tr>
<td>Valve</td>
<td>V11</td>
<td>E</td>
<td>F</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

Note 1. V11 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**

<table>
<thead>
<tr>
<th>X-line</th>
<th>OU</th>
<th>TU</th>
<th>CU</th>
<th>MU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>Close</td>
<td>Close</td>
<td>Close</td>
<td>Open</td>
</tr>
<tr>
<td>Valve</td>
<td>G</td>
<td>I</td>
<td>Air Vent</td>
<td>B</td>
</tr>
</tbody>
</table>

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 stem tube. Strengthen examination of stem 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.
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 stem 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.