Caribbean Fantasy - July 21th to 25th

Replacement of the port engine bearing n° 9 shells

Objet: due to the delivery time of the OEM repair size – 6 mm bearing shell, a temporary solution has been fitted to allow the departure of the vessel from Bizerte.

Considering the current stop of the ship in Navantia Shipyard of Cadiz Spain it has been decided to replace by the permanent bearing shells available and already on board the vessel.

Intervention is realized by the shipyard and considering the sensibility of this specific bearing it has been decided that Alliance Diesel Refit assists and supports operation in the direct continuity of the repairs done in Bizerte.

The present intervention is realized as per the sequence already transmitted to France Ferries. And communicated to the Shipyard.

1) <u>Checks before dismantling:</u>

a) <u>Web deflection:</u>

Measurement taken with Shipyard tools – electronic type.

Web n°	Position A	Position B	Position C	Position D	Position E
7	0	+1,8	+3,7	+1,8	0
8	0	-5	-12	-6,6	-1,7

The engine is cold and the current readings especially on web n°8 exactly corresponds to those measured after assembly completion.

b) Main bearing clearance:

Bearing n°	Top	Above cut	Below cut	Bottom	Above cut	Below cut
8 timing side	45	25	25	0,05	18	30
9 opposed timing side	42	30	25	0	20	25

Clearances are also well in accordance with assembly measurements.

As a reminder: due to the position of the thrust bearing it is impossible to take clearances either on bearing n° 9 timing side or on bearing n° 10 forward side.

2) <u>Dismantling:</u>

a) <u>Losing the lateral stud bolts of the bearings n° 8, 9 and 10 to open the block</u>
<u>Position of the</u>

2 dial gauges were installed on the block to verify crankshaft displacement during tightening releasing.

From Zero position we have noted +0,03 mm vertically (corresponding to the shaft lift) and -0,06 m horizontally corresponding to the expected displacement of the shaft due to the spring effect of the lateral shims.

b) <u>Losing the vertical stud bolts of the bearing n° 9</u>

Major problems were permanently experienced with the hydraulic tools. In order to release stud tightening we were obliged to use Shipyard hydraulic pump as the ship unit is out of order.

After lowering the bearing n° 9 saddle inspection of the journal and the bearing shell shows a good condition generally speaking – very few scratches on both side and no need to polish pin once again.

This confirms the efficiency of the Moatti filters sole protection of the bearing with such a polluted lubrication circuit.

3) <u>Assembly:</u>

a) <u>Reference of the new bearing shells:</u>

Upper shell: MAN D&T 1622.02169-2648 G G27 Dia 434.0 A2.1 US
Lower shell: MAN 1622.02169.3075 E G27 Dia 434.0 A3 R US

Thickness test	Previous shells	New shells
Upper Shell	12,75	12,75
Lower Shell	12,70/12,75	12,70

b) Assembly attempts:

After several unfruitful attempts to fit the new upper bearing shell, we were obliged to use the T tool to try to introduce the upper bearing shell but this leads to the seizure at 100 mm of the final position causing damaged to the shell and troubles to bring it out. In this respect we were also obliged to remove the forward thrust pad in order to open the access.

This upper bearing shell is no longer usable

We were obliged to consider that we cannot fit properly the upper bearing shell without giving additional clearance and thus we have released the bearing n°10 coupling side.

The result largely improved situation but even not enough to bring the shell in position be hand. This is most probably the consequence of the poor condition of the upper bore and the deep scratches we feel under the finger.

It is also a direct consequence of the extra rigidity of the +6 mm bearing shell making this part especially strong and heavy.

The upper bearing shell has finally been installed using Teflon piece introduce in the shell hole (one by one) and pushed by the rotation of the crankshaft. Advantage of this operation it allows to keep the perfect centering of the upper shell in its bore.

c) Final assembly process:

- Tightening of the bearing n° 10 vertical stud bolts to 1000 bar – no clearance between cage and saddle after tightening
- Installation of the thrust pad – Checking lateral clearance of the crankshaft and found 0,56 mm (We have just measured the first displacement not tried to push the shat to its extreme position as the bearings are already dry.
- Installation of the bearing n° 9 lower shell
- Lifting bearing n°9 saddle in contact with its cage
- Checking clearance of saddle in its cage on exhaust side: upper spot = 0,13 mm and lower shim in contact (those reading correspond to the measurements done during assembly)
- Tightening exhaust side lateral stud of the bearing n° 9 to 250 bar no more clearance on the upper spot.
- Tightening the vertical stud to 700 bar – Due to the very bad condition of one of the 2 jacks we were oblige to make a double check with the one working not too bad. Both nuts rotate 6 holes after tightening from 250 bar to 700 bar however this tightening remain doubtful and critical in case of further intervention.
- Tightening the bearing n° 8, 9 and 10 lateral studs to 700 bar
  We have experience continuous troubles during this operation. As a conclusion each hydraulic tightening is a nightmare!

d) Final checks after assembly:

Measurement taken with Shipyard tools – electronic type.

Web n°	Position A	Position B	Position C	Position D	Position E
7	0	+1.5	+3.7	+2.7	+2.0
8	0	-4.3	-13.7	-6.3	+1.5

The engine is cold and readings match with situation before intervention.

a) Main bearing clearance:

Bearing n°	Top	Above cut	Below cut	Bottom	Above cut	Below cut
8 timing side	45	30	25	0.05	32	25
9 opposed timing side	40	25	25	0	22	30

Clearances are also well in accordance with assembly measurements and before dismantling.

The landing of the bearing n°9 is well centered no clearance 30 ° to 40° before and after bottom dead center.

Clearances were taken in two opposite position of the crankshaft. The situation of the bearing n°8 which has not been released during this intervention also corresponds to the situation before intervention and at the end of the assembly. The journal is properly landing on the center of the shell however geometry of the saddle bore is not perfectly flat.

In a final check we have verified the contact between saddle n° 9 and its cage and saddle n° 10 and its cage. Perfect contact no measurable clearance.

This ends the intervention for the replacement of the bearing n°9 shells.

4) Other interventions done in parallel:

a) Inspection of the LO pump n° 3 relief valve:

Valve is using pressure pilot and piston to drive the main valve. Main valve is in good condition generally speaking however the small piston of the pilot valve is worn out and scratched as a consequence of the heavy pollution of the oil before dry dock.

Considering the condition of the pilot piston we can easily conclude with the wear of the gear inside the pump

This is maybe not the sole explanation of the lack of pressure at the engine inlet experience from engine restarting meantime it is especially penalizing to operate the engine at increased power.

There is nothing that could be done on the system in order to improve situation at least nothing that could be done on the pump itself.

b) Inspection and cleaning of the Moatti filter back flow elements:

Back flow side is designed to collect the residue and it is doing a perfect job. Lot of rag residue were found- most of the residue are piece of rags however hard particle pollution is still well present

And for the time being it is not possible to see an improvement of the situation compared to the previous inspection done after flushing completion as per picture here above.

This confirms that continuous care has to be given to the filter.

In order to make training of the new crew and to make Ship' Staff confident regarding filter behavior we have decided to extend inspection of the full flow elements of the starboard engine and they were found clean as expected.

5) Recommendations:

a) Port main engine restarting:

- Full cleaning of the engine oil sump
- Closing crankcase door except the n° 9 exhaust side
- Heating oil by purifier to 50°C
- Starting the main lube oil pump rated to the minimum pressure 2 bar
- Checking visually the oil flow coming from the bearings
- Close crankcase doors
- Bring pressure to the service pressure 5 to 5.5 bar
- Keep pump running 20 minutes minimum
- Make 2 complete rotation of the crankshaft in order to create oil film all around,
- Prepare engine for starting

- Start engine 5 minutes at idle speed then stop it
- Inspect bearing n° 9 and n° 10 and check temperature by hand
- Start engine 20 minutes at idle speed then stop it
- Make final inspection and hot spot detection by hand.

If nothing wrong reported engine is ready for further operations there is no real running in operation after the replacement of the bearing shells only smooth and long loading program is required.

We can propose to load engine in 6 hours after completion of the maneuvering. Keep close eyes on temperatures reported by monitoring system.

Meantime exhaust temperature must not exceed 450°C in pic during transient otherwise valves will start suffering burning spots.

b) <u>LO pressure at engine inlet:</u>

The only action we can realize at this stage is to fill the tank to the higher possible level. This should nearly bring oil level to the pump suction level and help to compensate the pump lack of efficiency.

Running conditions will be based on a compromise: LO pressure at engine inlet depends on pump delivery and lube oil temperature:

The higher is the temperature the lower is the pressure in the present condition. This is a normal situation usually compensated by the pump but here it is no longer the case.

Normal running conditions are: **Pressure = 5.5 bar**

Temperature 52°C

After adjustment of the pump relief valve to the maximum keep temperature to a level allowing 5 bar at engine inlet. We expect something as close as possible from 50°C. When 5 bar is secured then keep LO temperature as hot as possible and as close as possible of the 52°C

Refrain to speed up the plant until the pressure issue has been fixed because the oil pressure at engine inlet is the direct result of the oil flow inside the bearing and thus the thermal dissipation of the heat.

c) <u>Moatti filters:</u>

The lube oil pressure is polluted thus we have to consider the best possible protection for the main engines.

- Good rotation of the hydraulic motor to be checked once per hour
- Every day drain 20 liters from the Moatti top cover drain to flush the back flow residues.
- Every 5 day – ocean crossing included – clean the back flow elements
- In case clogging indicator start turning red and even before the alarm level then stop engine immediately and clean the full flow side of the filter.

From now several crew members have been trained for the cleaning of the filter however in the case something happens: Maximum care is required as the filter is the sole protection of the bearings.

This process must remain in force until there is a significant improvement of the back flow side condition during inspection for cleaning.

d) Jacket water temperature:

From the log book we can read engine running 390 rpm with outlet temperature 58°C, temperatures down to 44°C are reported on the logbook. Such temperatures are critical and especially during the running in operation! It is impossible to have lube oil temperature higher than jacket water temperature. This could only lead to piston seizure or at least destruction of the cylinder tightness.

The temperature at engine inlet must be adjusted to 72°C MINIMUM and the higher is the load the higher must be the temperature at engine inlet in order to have around 85°C at engine outlet while running 75% load with heavy fuel oil.

e) Main bearing n° 10 monitoring

From now the main bearing n° 10 is secured by temperature monitoring.

Temperature of the bearing n° 10 is extremely important for the engine as the bearing n° 10 support the thrust bearing and maintain the web deflections.

Check and record carefully the temperature of the bearing n° 10 in operation for both engine. Situation is as sensible on starboard engine than it is critical on port engine.

f) Feedback from this intervention on bearing n°9

Due to the condition of the bearing n° 9 upper bore the assembly of the bearing upper shell requires extra clearance.

In this respect the bearing n° 10 must be released before engaging the new bearing shell. This condition greatly helps to introduce the bearing shell but it is not sufficient and shell must be pushed as described here above – Only using Teflon material.

Only one original lower -6 mm is available plus the 2 temporary bearing shells. The dismantled set of bearing shell is usable and stored in the starboard warehouse.

g) Hydraulic tools:

Ship's hydraulic pump is out of order and must be repaired urgently. All tightening were done using the shipyard hydraulic pump adapted to the ship's flexible hoses.

Generally speaking all jacks are in a very poor condition and require assistance. This especially concerns the main bearing ones.

The safety factor of the tightening usually given by the hydraulic tightening has disappeared and great care is required to be sure that assembly is well tightened.

We have to point out that the hydraulic pump of the ship – the sole one available on board – even no hand pump available on board – is out of order. This means that ship' Staff is not in position to realize any inspection or any kind of intervention that requires hydraulic power.

It is mandatory either to repair the pump before ship departure or to bring a new one.

h) From the information collected during my short stay on board, one of them requires specific attention:

High vibration level of the starboard engine is reported at idle speed, seems to be much more than before and sensible everywhere on board the ship.

The port engine Vulkan coupling has been replaced by new one and the position of the 4 rubber elements was well reported and marked. Position of the balancing masses as well.

We are especially concerned by the situation of the starboard coupling which is original 28 years old as per the documents given by Vulkan – CMRT Shipyard secure assembly in the previous position however we have to consider that after dismantling balancing has been altered as rubber elements look really old.

It is important to check vibration level all around in order to identify frequency and to define a new set of balancing masses to lower vibration level and avoid damages on the coupling itself on the one hand and on engine auxiliaries fitted on engine and around engine on the other hand.

In the meantime it is important to avoid critical speeds by lowering speed or increasing it above the critical steps.

It is too late to make this kind of test before departure meantime it has to be prepare with local contractor in order to be made during the first voyage.

Vibration analysis will immediately confirm the source of the vibrations and its location and how to minimize them.

Any alteration of the situation must be reported and investigations has to be made to verify the condition of the coupling.

Meantime we do confirm that replacement of the starboard Vulkan coupling is required for the same reasons it has been replaced on the port engine

With my personal thanks to the Ship' Staff and the Team from the Shipyard. Both gave maximum assistance as usual.

Done in Cadiz July 24th

François DELTOUR.