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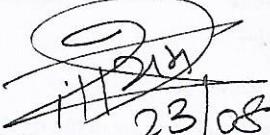
CTT/300/08/09/TECH

23 अगस्त 23/Aug 23

प्रधान सेनापति/ The Commander-in-Chief
(कृते कमान तकनीकी अधिकारी (समुद्री)/ for CTO(Marine)}
मुख्यालय/ Headquarters
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CAUSATIVE ANALYSIS OF DEFECT ON STEERING GEAR SYSTEM – INS SARYU

1. Refer to HQANC fax ANC/42000/EG/CTT dated 20 Jul 23.
2. Causative Analysis requested vide fax ibid is forwarded at enclosure.


23/08
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PM

CAUSATIVE ANALYSIS OF DEFECT ON STEERING GEAR SYSTEM – INS SARYU

1. **Introduction.** INS Saryu is a NOPV class of ship fitted with M/s Veljan Haydrair makes steering gear system. The steering system comprises of two hydraulically operated rudder stocks that are mechanically linked together and dual hydraulic power units connected via common distribution valve block to the rudder operating cylinders. The pump output at the power unit is controlled by independent electric control sub-systems. They can be operated in Auto/Manual & Follow Up/Non Follow Up modes from bridge. Power pack can be operated in Follow Up/Non-Follow Up mode from ASP.

2. **Summary of events.** The ship had closed up SSD for leaving harbour on 18 Jul 23. During SSD both steering pumps were operating in FU mode and control were from Bridge. ASP ME observed abnormal noise from stbd steering pump and the same was switched off, however with only the port steering pump running the abnormal sound continued to exist. Controls were shifted from FU to NFU at bridge but abnormal noise persisted. Further, during a hard stbd order from bridge, the rudder was stuck at maximum deflection to stbd side. Further manual mode was connected, but there was no response from the steering gear. During DI and trials by SS/NSRY(Pbr) with stbd outer actuator assemble isolated, heavy noise was observed from both steering pumps in FU mode from bridge with intermittent response in channel 1/2 and no abnormal noise observed while operation from local(ASP) in NFU mode from both steering gear pumps. Slight creep was observed with no inputs given in NFU mode from local.

3. **Defect History.** Multiple defects have been observed on control system of steering gear in the past. Details of such defects in the past two years are as follows: -

Ser.	Defect Reference	Defect Description	Work Undertaken
(a)	E-02186 dated 15 Mar 21	Steering not available in channel 2 with Stbd motor <i>Suspected servo amplifier card malfunction.</i>	Card tuning carried out.
(b)	E-02193 dated 28 Mar 21	Steering gear Rudder not responding to input signal on FU mode from both channels with STBD motor <i>Suspected VME COU</i> and power supply unit defective.	Power supply unit changed
(c)	E-02330 dated 03 Aug 21	Stbd steering motor not starting in remote from bridge <i>Suspected control circuit malfunctioning.</i>	Control circuit checked

(d)	E-02336 dated 03 Aug 21	Steering gear system not available in channel 1. Suspected processor card and <i>servo amplifier card malfunctioning.</i>	Processor card replaced
(e)	E-02437 dated 26 Oct 21	Steering gear not available in FU mode with both motors. Suspected <i>feedback potentiometer and servo amplifier card malfunctioning</i>	Feedback Potentiometer replaced with new one by OEM
(f)	E-02596 dated 28 May 22	Steering gear system intermittently malfunctioning in channel 1 suspected grounding fault in circuit.	Grounding fault defect rectified by SS
(g)	E-02653 dated 07 Jul 22	Steering gear IP carrier card observed to be malfunctioning	New IP carrier card fitted
(j)	E-02716 dated 30 Aug 22	Port Steering motor not starting from bridge.	Soft Starter replaced. OEM report dated 29 Sep 22
(k)	E-02727 dated 23 Sep 22	Port steering motor not starting from bridge. False Stbd over travel alarm observed consol. Suspected ASP control circuit malfunctioning.	Soft Starter replaced.
(l)	E-02745 dated 23 Sep 22	Port RU tank low level false while Stbd steering motor.	Level sensor calibrated
(m)	E-02777 dated 15 Oct 22	Rudder hunting observed while Stbd steering motor running in FU mode.	RAFU Potentiometer replaced.
(n)	E-02862 dated 11 Feb 23	Steering gear observed to erratic in FU mode from bridge. Rudder demand observed against to be fluctuating between zero and -30 degree against Nil hand wheel input.	Potentiometer calibration carried out
(p)	E-02912 dated 20 Mar 23	Sluggish response observed from Stbd steering pump timing to observed 52 secs as against in single motor mode. Suspected Swash feedback potentiometer and <i>servo amplifier card malfunctioning.</i>	Servo amplifier card tuning carried out by yard. Defect rectified.

(q)	E-02912 dated 20 Mar 23	Stbd steering motor not starting from bridge suspected LCP control circuit malfunctioning.	No work undertaken till date
(r)	E-02914 dated 20 Mar 23	Port steering HMI reading not available in ASP. Suspected cabling defective.	No work undertaken till date
(s)	E-02975 dated 24 Apr 23	HMI display on LCP of both steering motor malfunctioning.	No work undertaken till date

4. **Initial Assessment by OEM.** Veljan Haydrair limited (OEM) undertook trials of steering gear pumps from 25 to 28 Jul 23 with Stbd actuator and port inner actuator assemblies isolated and the following were observed: -

- (a) Abnormal noise observed with boost, servo and discharge pressure dropping when movement of rudder is given to port side with port and Stbd pump individually.
- (b) No abnormal noise observed when movement of rudder is towards Stbd side. However, the **discharge pressure is exceeding 160 bar** as against 15 - 20 bar at harbour with port steering pump.
- (c) No abnormal noise observed when movement of rudder is towards Stbd side. However, the **discharge pressure exceeding 200 bar** as against 15 - 20 bar at harbour with stbd steering pump.
- (d) Relief valve of Stbd steering pump (set pressure-200 bar) and two relief valves of oil distribution box (set pressure-200 bar) **did not operate** when discharge pressure of Stbd steering pump crossed 200 bar while rudder movement towards stbd.
- (e) Both rudders creep towards port side in NFU mode.
- (f) Stbd outer actuator assembly bulging observed upto an approx. length of 70 mm at rudder side end.
- (g) Scoring marks observed on piston rod of Port inner actuator assembly.

5. **Ship's Appreciation.** Ship has raised OPDEF vide DTG 181730/Jul. **No initial assessment of the defect by ship has been brought out** in the preliminary report 24 Jul 23. DI by NSRY(Pbr) has indicated material failure as the probable reason for the failure of steering gear system.

6. **Analysis by CTT.** A technical team from CTT (PBR) was deputed towards undertaking causative analysis leading to defect in steering gear onboard INS Saryu. DART, Maintenance Schedule, EMAP, POL reports were scrutinised for establishing the probable cause for defect in steering gear. Visual inspection of system and components, study of system diagrams and manual operation of hand pump was also undertaken. SPM and Vibration checks were carried out on steering motors and relevant photographs are placed at **Appendix P**. Hydraulic system drawing is placed at **Appendix Q**.

7. **Work undertaken on Steering System during SR in 2021:-**

- (a) SR routines undertaken as per maintops.
- (b) All defects related to controls rectified in SR.
- (c) New power supply unit and UPS fitted.
- (d) 02 Panel ACs, one for each LCP panel fitted (Minor As and As).
- (e) Rudder bush clearance measured.
- (f) Rudder stock jumping clearance measured.
- (g) 03 old Hemp packing removed.
- (h) 04 new PTFE stop leak fitted.

8. **Trend of Lub oil report:** Trending of monthly 'basic' lub oil tests of steering system since Jan 23 does not indicate any abnormality. Lub oil sample is to be chemically analysed every six months, however, the facility for 'advanced' lub oil test (SOAP analysis) at NSRY(Pbr) is not being utilised and actual condition of hydraulic oil could not be assessed and further actions not taken.

Month	K' viscosity (CSt) Limit	Port K' Viscosity (CSt)	Stbd K' Viscosity (CSt)
Jan 23	26-33	26.77	27.55
Feb 23	26-33	30.13	29.97
Mar 23	26-33	32.00	30.2
Apr 23	26-33	30.8	29.2
May 23	26-33	27.83	27.91
Jun 23	26-33	29.97	32.79
Jul 23	26-33	26.19	32.95

9. Observations: -

(a) The ship till the occurrence of defect was following Maintops No.43049 of Jan 22 (Amendment 3). However, the current maintop in effect is Maintops No.43049 of Dec 22 (Amendment 6). The following routines were not carried out view non-compliance to Maintenance schedule amendments issued vide no 4, 5 & 6.

Occasional routines: -

- (i) During Post Sailing checks, carry out following :-
 - (aa) Check rudder for any physical damage to the rudder/rudder stock.
 - (ab) Inspect securing bolts for their physical presence.
 - (ac) Inspect intactness of epoxy fairing compound applied over nuts.
- (ii) In case of any abnormality suspected by the diver, i.e physical damage to a specific appendage, he is to assisted by the concerned department to carry out further investigation. Videography/ still photography of the suspect areas to be carried out for investigation on-board.
- (iii) In case refits are delayed due to unavoidable circumstances, dedicated diving operations are to be conducted periodically to ascertain the state of all underwater fittings and corrective actions are to be taken as necessary.
- (iv) Check protection equipment indicator lamps. Check the pressure, temperature and speed indicators.
- (v) Check the control panel covers and securing bolts for looseness. Tighten if required.
- (vi) Inspect externally all the switches, push buttons, indication lamps for any damage, dents, cracks and corrosion if any.

Monthly routines: -

- (i) Open the panel front cover and clean the interior of the panel thoroughly using soft brush.
- (ii) Checks all indication lamps, switches, meters, fuses and other accessories proper condition.
- (iii) Check and ensure all connections are tight.
- (iv) Checks and ensure all indicating lamps are in working condition and fixed properly to their holders.

- (v) Carry out insulation resistance of all supply cables.

Three Monthly Routines: -

- (i) Carry out timing checks from all position in all channel both in FU and NFU mode.
- (ii) **Manually operate limit switches and checks for functionality.**
- (iii) Check starting and running currents of both the motors.
- (iv) **Checks all setting/ thresholds on the panel** and prove all alarms and trips.

Six Monthly Routine: -

- (i) Check that the control panel rubber/gaskets are place and in good condition.

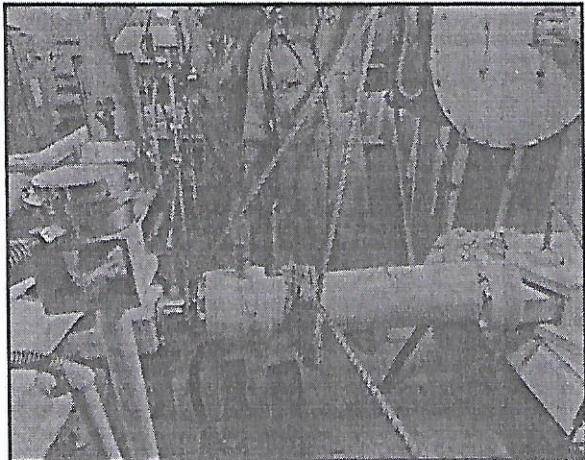
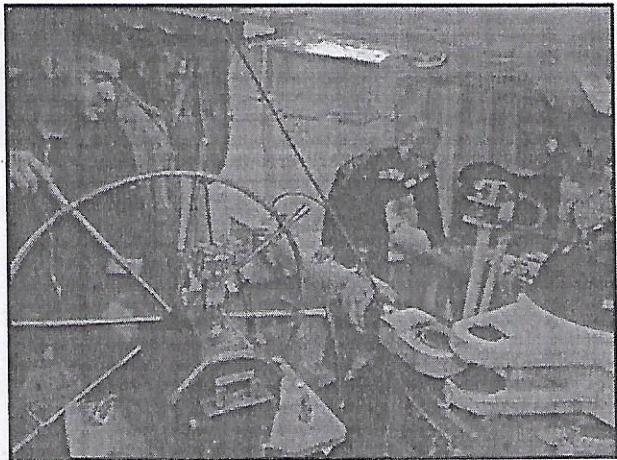
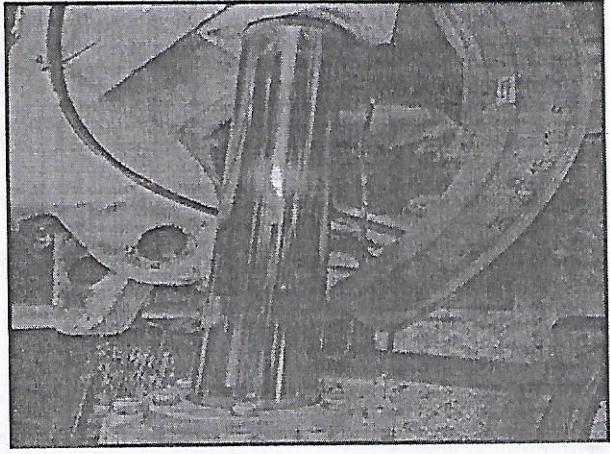
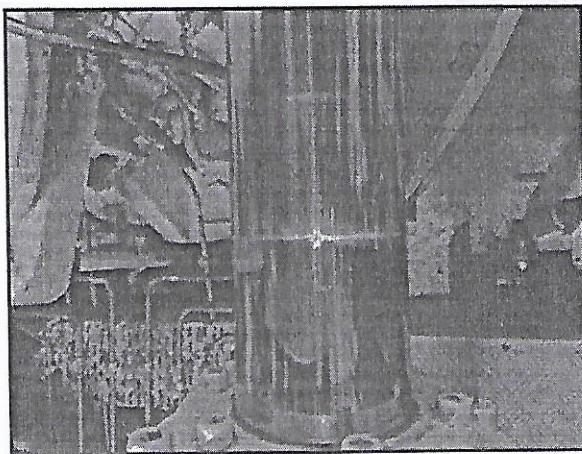
Annual Routine: -

- (i) Calibrate all gauges, panel nodules and alarm/ Trip cutouts.
 - (aa) **Calibrate all relief valves.**
 - (ab) Check all service tallies and cables for current securing.
- (b) Ship was commissioned in the year 2013 and NR was due in 2021. Since the refit was converted to a SR, **no NR routine has been carried out till date on both steering gear pumps.**
- (c) Though the NR was converted to SR in 2021, the ship had not assessed the condition of steering system and **projected critical routines on the system** including overhauling of steering gear pump as part of defect list of SR 21.
- (d) The ship is **not in possession of operating instruction** manual of steering gear in FU/NFU/local/manual mode.
- (e) Calibration certificate of relief valves (one on each pump and two in OD box) not held.
- (f) SPM reading of both steering motors found in yellow zone.
- (g) On manual operation of hand pump, it was observed that the hydraulic actuator was easy to operate on one direction compared to the movement on the opposite side. This could indicate obstruction in hydraulic system, presumably on return line of oil.

10. **Probable Cause of Failure.** Premature failure of the steering system in the present case is attributable to material failure of the hydraulic actuator caused due to slippage in running hour / condition based routines specified in MAINTOPS. Cause of defect could be excessive pressure beyond the designed capacity of 160 Bar. The reason for the excessive pressure is due to obstruction in hydraulic system line (malfunctioning of NRV fitted on pump which could be established post dismantling of stbd steering pump). Non-operation of relief valve at designed value lead to further increase in pressure resulting in bulging of stbd outer actuator assembly.

11. **Recommendations.** In order to validate the reason for the defect and operationalise the steering system, following are recommended:-

- (a) Replacement of stbd outer actuator and port inner actuator assemblies.
- (b) Overhaul/ replacement of both steering pumps.
- (c) Overhauling/ replacement of bearings on both steering motor.
- (d) Flushing through of hydraulic system and renewal of oil.
- (e) Operational checks of all system valves and overhaul & calibration of relief values.
- (f) Carry out routines due / missed i.a.w latest MAINTOPS.
- (g) Instances warranting delay in NR / major routines of critical equipment to be taken up during AMP.

Appendix 'P'**DISMANTLING OF HYDRAULIC ACTUATOR****MANUAL OPERATION OF STEERING GEAR
USING HAND PUMP****SCORING MARKS ON PORT INNER ACTUATOR**

