

SAFE HANDLING OF DEEP-SEA INSTRUMENTED MOORINGS

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ABSTRACT

Aquisition of long-term time series data by the instruments operated from a research vessel is very expensive because of the enormous cost of ship time. If the various sensors for measuring different oceanographic and meteorological parameters are installed in a specially designed mooring system, data collection will become highly economical and the much needed long-term data on waves, currents, temperature, salinity, wind etc. can be conveniently acquired over an extended period of time. A brief description has also been given indicating how a research vessel such as ORV Sagar Kanva can be used for handling such a mooring system. Importance and care to be given in the selection of various hardware components and their interconnections, type of deck equipment required including deployment and retrieval techniques have been highlighted in the paper. It is recommended that proper documentation of all the mooring shots in a mooring system has to be made particularly when a large number of oceanographic sensors are used to measure important parameters at different depths.

INTRODUCTION

For designing and constructing an offshore structure for mining or exploitation of other ocean resources such as ocean thermal energy etc, it is necessary to thoroughly understand and evaluate the environmental conditions at the site. Further it would be necessary to design these offshore structures to withstand the forces arising due to waves, winds and currents under all conditions including cyclones. The long-term time series measurements and synoptic coverage of the large oceanic areas can be obtained by deployment of moored instrumented buoy systems. Such arrays constitute instruments capable of monitoring and recording the spatial and temporal oceanographic parameters such as waves, currents, temperature, salinity as well as various surface meteorological parameters.

This paper presents a brief description on various aspects of deep sea surface instrumented mooring system including deployment, retrieval techniques using research vessels.

INSTRUMENTED MOORING CONFIGURATION

Deep sea single point instrumented moorings can be classified into three general configurations namely surface moorings, intermediate moorings and bottom moorings. Surface mooring system is employed when the major monitoring parameters are at the air-sea interface and in the upper layer of water column. An intermediate mooring is basically a sub-surface mooring usually adopted when surface meteorological and oceanographic parameters of the upper layer of oceans are not proposed to be measured. Bottom mooring systems are employed for near bottom measurements and transponder placements.

Mooring description

Fig. 1 shows a tant surface instrumented mooring system with a surface data buoy. The surface buoy is designed for sensing and recording the oceanographic and other meteorological parameters at or near the sea surface. Instruments as shown in fig. 1 are attached to the mooring at various depths where oceanographic parameters such as current speed and direction, temperature, salinity, depth etc. are to be measured.

A single cluster of floats near the sea bed just above the acoustic transponding release constitutes the backup recovery section. The glass spheres are enclosed in clam-shell like plastic 'hard hats'. This back-up recovery section will ensure the recovery of any part of the mooring during a mooring failure. Two acoustic transponding releases are connected in parallel as shown in fig. 1 wherein, release of one of the two would separate the anchors from the rest of the mooring system. Chains connected below the acoustic release and surface buoy provides protection against chafing during deployment and retrieval operations. Usually a dead weight anchor is used in combination with an embedment anchor. Presence of a dampening plate above the acoustic transponding release would considerably reduce the rate of fall of the anchor along with the mooring line consisting of instrument array in the sea and prevents the damages to the release device and other instruments during deployment. Below the acoustic release, is a short length of nylon line, usually not more than 50 meters in length called as "adjustable shot" (Anchor tagline). This permits matching mooring length with the water depth at the deployment location. In addition it acts as a shock absorber to withstand the impact forces when anchor is dropped in sea.

Hardwares and interconnections

All ropes and hardwares should be tested on suitable test rigs before connecting them in the mooring. Metallurgical analysis is necessary in respect of stainless steel hardware to make sure that it is constituted of correct alloy. As far as possible all interconnected hardwares should be of identical metals. Isolation links are to be connected between the dissimilar hardwares to prevent the physical contact. If connecting of dissimilar metals is unavoidable, in such cases a large sacrificial anode should be coupled to the small cathode.

To facilitate the smooth deployment and retrieval operations all interconnections in the mooring line should consist of at least one weldless sling link connected in between as shown in fig. 2. The sling link being used should be wide enough so that sufficient room is left between the two shackles after connecting it.

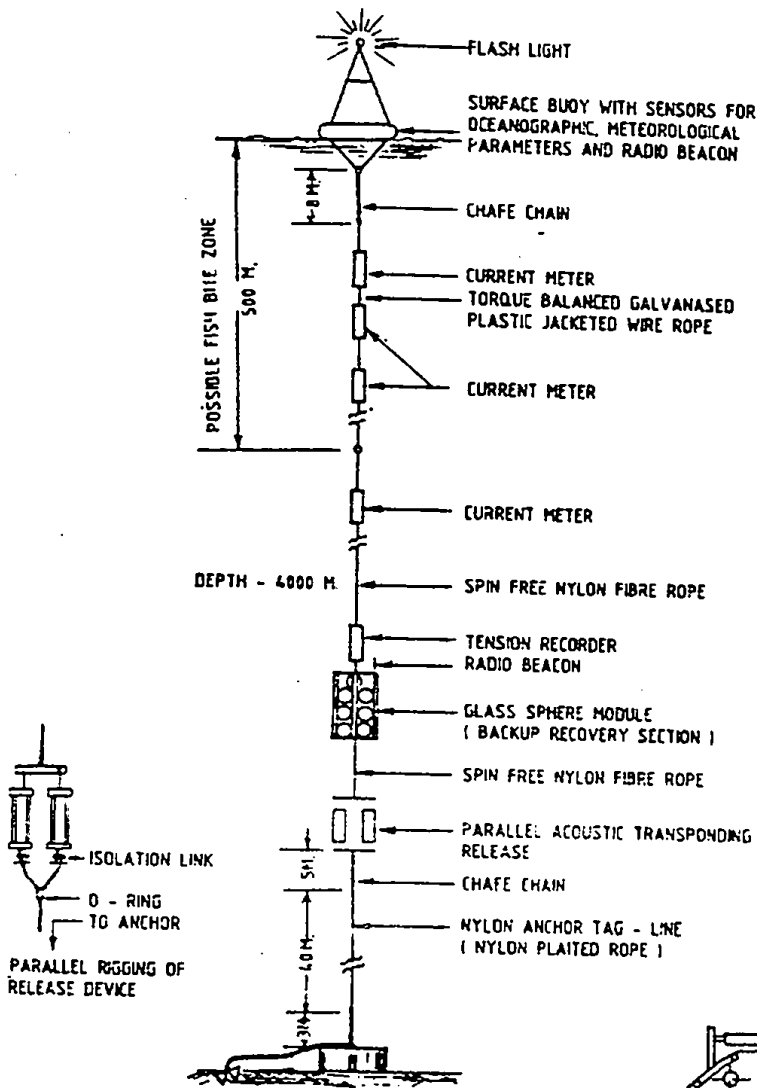


FIG. 1 TYPICAL DEEP SEA MOORING SYSTEM

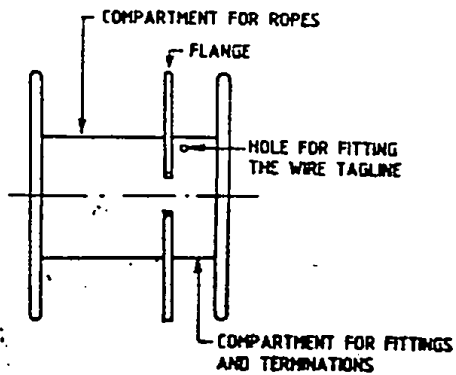


FIG. 4 A TYPICAL WINCH REEL DRUM

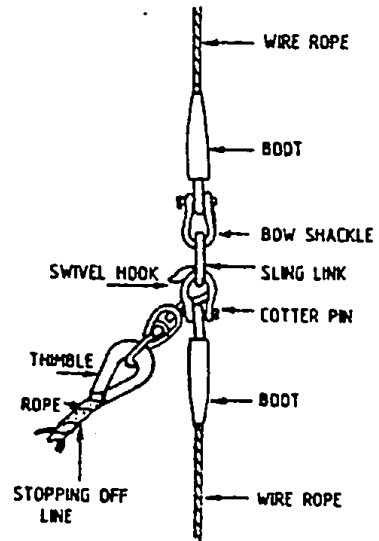


FIG. 2 TYPICAL CONNECTION OF A MOORING SHOT

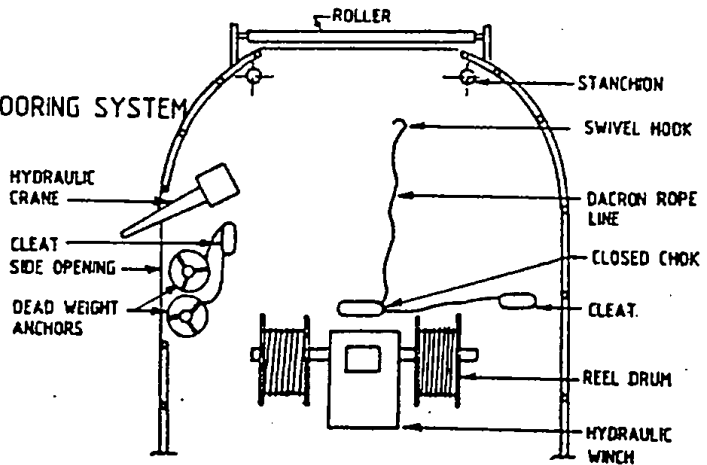


FIG. 3 PLAN VIEW WORKING DECK OF VESSEL

MOORING DEPLOYMENT

Deck equipment

Fig. 3 depicts a schematic plan view of the stern of the vessel. The freely rotating roller mounted at the stern would prevent damages to the mooring line and instruments passing over it. The surface of the deck between the winch and roller should be a smooth sliding surface. A wide chute as in ORV Sagor Kanva is an alternative to the roller system. An hydraulic winch is generally recommended for deployment and retrieval operations. It should have provision for mounting reels on either side. Fig. 4 shows a typical reel with two compartments one of which is wider than the other. While winding the mooring lines the terminations and connecting hardwares are isolated from the mooring line. Also wire ropes can be isolated from the synthetic ropes, thus damage to the synthetic mooring ropes would under tension can be avoided. A fairly long line with one end tied on to a tiedown and other end carrying a swivel hook acts as a stopping off line as shown in Fig. 2 & 3.

Basic considerations before deployment

Instrumented moorings are deployed either by the anchor first or the anchor last method. Anchor last method of deployment is preferred due to its simplicity and ease of handling of the instruments in the mooring.

Based on the experiences, it is generally preferable to start paying out the mooring gear from a location on the down wind/current side of the actual deployment location. This starting point should be at a distance from the actual deployment location approximately equal to twice the depth measured at the deployment location. The vessel should be driven in a straight line path while approaching the desired location to reduce occurrence of kinking in the mooring line. The vessel should be run at a speed less than 2 knots to avoid exerting additional tension in the mooring line.

Deployment procedure

The basic mooring design should be finalised on the shore. All the mooring shots should be wound on different reels in a definite order and the same should be stored in a definite sequence near the working deck. The operational sequences in the surface mooring deployment with anchor last method are:

- (i) launching of the surface buoy,
- (ii) paying out the mooring line and miscellaneous oceanographic instruments connected to it,
- (iii) launching of the bottom recovery buoyancy module,
- (iv) launching of release device and in the end launching of the bottom dead weight including the anchor.

The buoy is untied from its lashings and dropped in sea through a quick release hook mounted on the starboard side of the fib room (Telescopic) crane. The mooring shot below the surface buoy is paid out from the launch winch reel as shown in fig. 5. When an instrument is to be connected in the mooring, the swivel hook of the stopping off line is snapped to the sling link between the subsequent mooring shots. The

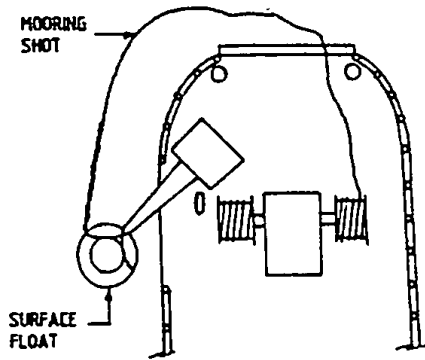


FIG. 5

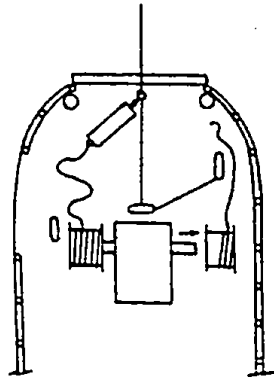


FIG. 6

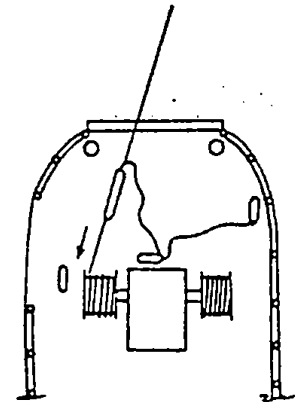


FIG. 7

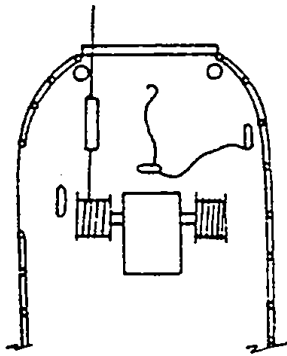


FIG. 8

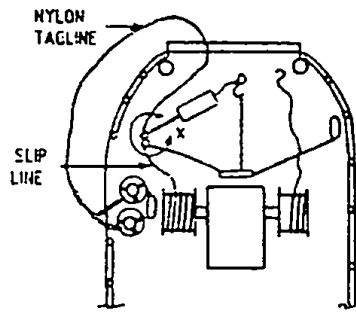


FIG. 9

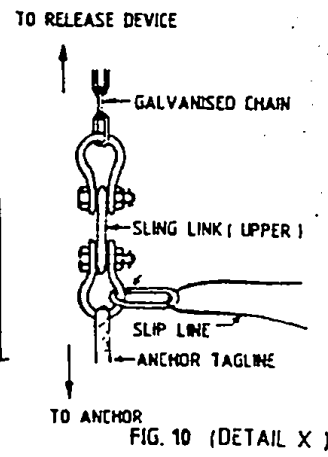


FIG. 10 (DETAIL X)

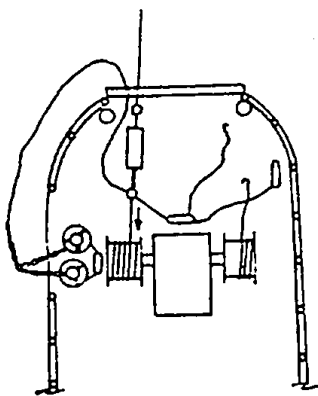


FIG. 11

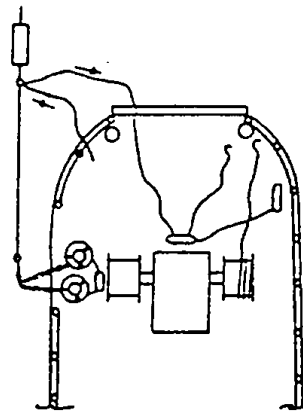


FIG. 12

VARIOUS STAGES OF DEPLOYMENT OPERATIONS

upper end of the instrument is shackled to the lower end of the mooring shot paid out as shown in fig. 6. The lower end of the instrument is then shackled to the upper end of the next mooring shot to be paid out. Now the slackened mooring line below the instrument is hauled on the reel, thus the tension on the stopping off line is relieved and tension is transferred to the mooring line as shown in fig. 7 & 8.

If two mooring shots have been shackled together on a reel and no instrument is to be connected in between, the mooring line need not be stopped by the stopping off line. The termination should be stopped just aft of the winch and final check can be made over the termination and their interconnections. Throughout the deployment period, the vessel should be manoeuvred by operating side thrusters to facilitate the alignment of the instruments and the mooring line nearly at the centre of the stern roller/chute.

The steps involved in launching of backup recovery float is similar to that of surface float.

The acoustic release along with its chafe chain nylon anchor tagline are connected as shown in fig. 9. An additional sling link is inserted in one of the two shackles as shown in fig. 10. A slip line is passed through this sling link. One end of this slip line is tied securely on to a tiedown near the winch and the other end is wound on an empty reel attached to the winch. The slip line is hauled and tension is relieved from the stopping off line as shown in fig. 11. Slip line is paid out slowly. Once the slip line is cleared and the anchor tagline is taut the vessel is put into a sharp turn away from the deployed mooring away. When full length of the mooring becomes taut the anchor lashings are cut and anchor is dropped using the starboard side crane as shown in fig. 12.

MOORING RECOVERY

Deck equipment:

Recovery of the mooring is to be carried out from the starboard side of the vessel. An hydraulic folding type fibboom crane (Telescopic crane) is mounted on the starboard side. The crane should have sufficient reach say 4-5 meters outboard the hull of the vessel. The pulley block hung from the jib of the crane has a wide sheave with a dial indicator facility.

Basic considerations before recovery

If the surface buoy is found to be missing at the expected location of the mooring a check should be made for the acoustic transponding release in case only the upper part of the mooring has parted. If an acoustic contact could be established with the acoustic transponder release the bottom part of the mooring can be recovered by firing the release and allowing the backup recovery floats to pop up along with the release and the mooring to the surface. If it is not possible to establish an acoustic contact at the expected location it may be inferred that the recorded position of the mooring may be wrong or the entire mooring array might have drifted from its original position. Hence, an area search would then be required. A hull mounted acoustic transducer with a directional aid would facilitate speedy search for the acoustic transponding release device. For the drifted upper portion of the mooring a visual search has to be carried out with the aid of radio beacon

receiver.

Recovery procedure

The operational sequences in surface mooring recovery are:

- (i) locating and releasing the acoustic transponding release;
- (ii) hauling of the surface buoy,
- (iii) hauling of the connected instruments; and
- (iv) hauling of the backup recovery float module.

Before sending the acoustic release command for releasing the acoustic release, the vessel should be positioned towards downwind/current side at a fairly enough distance away from the mooring array.

When it is confirmed that the backup recovery floats are surfaced, then the vessel is made to proceed towards the surface buoy. It should be ensured that the surface buoy is ahead of the backup recovery floats. It is necessary to note that the vessel will be drifting leeward during hauling of the mooring from the down wind/current side.

Once the surface buoy is alongside of the vessel the swivel hook of the stopper chain suspended from the meter wheel block is snapped to the loop made on the surface buoy as shown in fig. 13. Life boat of the mother vessel can be used for attaching the loop on the surface buoy to the hook on the crane fig. A separate stopping off line with one end tied to the Liedown is snapped to the chafe chain of the surface buoy as shown in fig. 14.

Now onwards for handling of the lower part of the mooring along with the instruments, the winch has to be put into operation. A reel with sufficiently long tagline is passed over the sheave of the meter wheel block and the swivel hook at its free end is snapped to the upper end of the chafe chain of surface buoy as shown in fig. 15.

Hauling begins with the instruments being removed as they reach a certain convenient height above the deck surface. The swivel hook of the chain "stopping off" line hanging from the meter wheel block is snapped to the sling link attached below the instrument. Then the winch line is slackened and afterwards the instrument is unshackled from both its upper and lower ends. Thus the tension is transferred to the chain stopper line before disconnecting the instrument as shown in figs. 16, 17 and 18.

For replacing the fully wound reels the tagline from the new reel is led through the meter wheel block and shackled to the mooring shot hanging on the chain stopper line. Tension is transferred on to the reel tagline from the chain stopper line and hauling is commenced as shown in figs. 19, 20 & 21.

ORV SAGAR KANYA FOR DEEP SEA MOORING WORK

The vessel ORV Sagar Kanya has facilities and accessories specially meant for deep sea instrumented mooring deployment and retrieval operations. The friction winch on the main deck has provisions for attaching the specially designed winch reels. The horizontal jib-boom on the forecastle deck with a gallow can be used for deployment purposes.

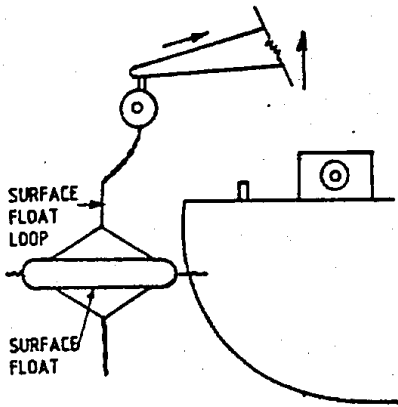


FIG. 13

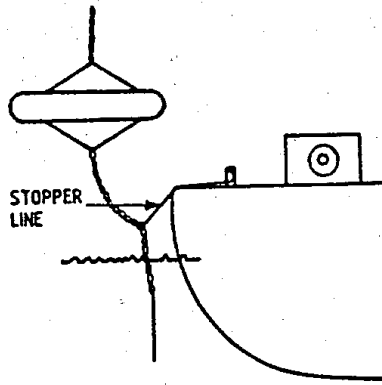


FIG. 14

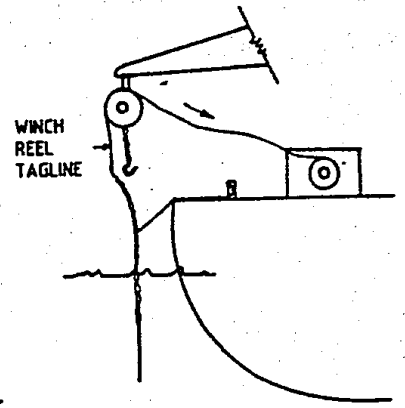


FIG. 15

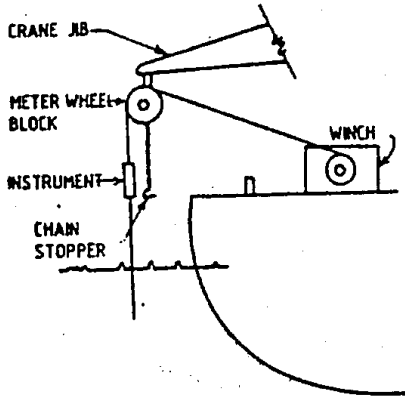


FIG. 16

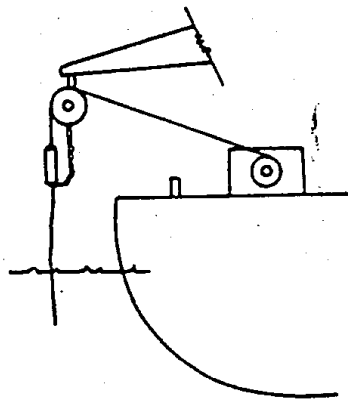


FIG. 17

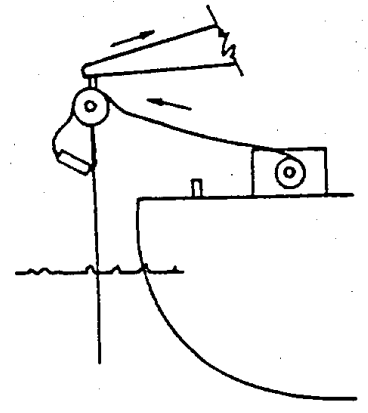


FIG. 18

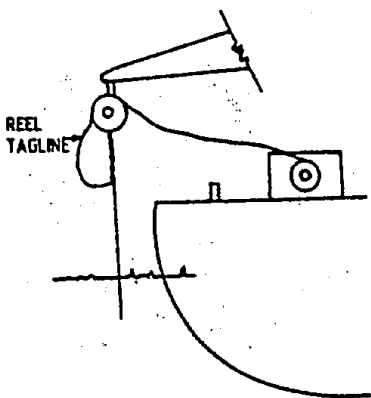


FIG. 19

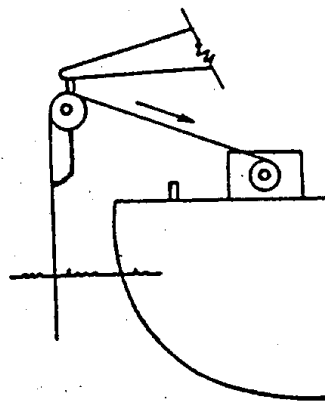


FIG. 20

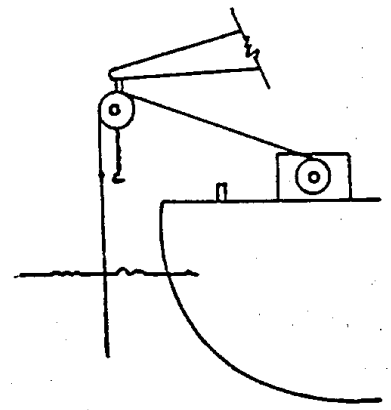


FIG. 21

VARIOUS STAGES OF RETRIEVAL OPERATIONS

TABLE I: TYPICAL RECORD OF MOORING SHOTS IN ANCHOR LAST METHOD OF DEPLOYMENT

Mooring shot no. starting from surface float	Type of rope used	Rope specification	Rope termination details	Type of shackle sling links used	Details of hardware/instrument connected at the terminal
1	Torque balanced, galvanised and plastic jacketed wire rope	12mm. dia. 8 m. long 6 x 19 construction with 7080kg as minimum breaking strength.	Swaged eye at both ends.	Bow shackle of 20 mm. pin dia. with SWL of 2000 kg at both ends. Weldless oval sling link of 16mm. stock dia. with SWL of 2200 kg at both ends	Upper end connected to surface float Chafe chain & lower end of RCM 4 current meter
2	-do-	-do-	-do-	-do-	RCM 4 Currentmeter is connected at both upper & lower ends
3					
4					
.					
.					
10					
.					
.					
19	Spin-free nylon fibre rope	18mm dia. 20 m. long, 3-strand construction with 6700 kg as minimum strength	Spliced at both ends over plastic thimble	Bow shackle of 20 mm. pin dia. with SWL of 2000 kg at both ends. Weldless oval sling link of 16mm stock dia. with SWL of 2200 kg at both ends	Upper end connected to bottom end of back-up recovery module and lower end to top end of the acoustic release
20	Spin-free nylon fibre rope	18mm dia. 20 m long, 3-strand construction with 6700 kg as minimum strength	Spliced at both ends over plastic thimble	Bow shackle of 20 mm pin dia. with SWL of 2000kg at both ends. Weldless oval sling link of 16 mm stock dia. with SWL of 2200 kg at both ends.	Upper end connected to acoustic release chafe chain and lower end to the anchor

Remarks: The length of the line was increased to 40 m to match the depth at the location.

This jib-boom projects horizontally outward on the starboard side of the vessel. A chain stopping off line with one end fixed on the jib boom and a swivel hook at the other end can be used for transferring tension. Mooring lines are passed through a wide sheaved pulley block suspended from the jib-boom. All the mooring shots need to be wound over different reels in a definite order.

During deployment the vessel needs to be positioned in such a way that the direction of the surface current/wind (whichever is dominant is from the port side to the starboard side of the vessel. This brings the starboard side of the vessel to the leeward side. While recovery operation the vessel position/manoeuvring is same as described earlier.

CONCLUSIONS

Deployment and retrieval of deep sea instrumented mooring system depends on the availability of suitable handling facilities on board the vessel, the size of vessel and its manoeuvrability. Specially designed handling facilities as described in this paper would ensure safe and successful deployment and retrieval of deep sea instrumented mooring systems. Medium size vessels in the range of 60-100 M length with the provision of side thrusters would be ideal for such operations. The sea state at the time of deployment or retrieval operations also plays an important role in determining the success of the operation.

Before undertaking deployment of the mooring system in waters deeper than say 2000 m, it would be advisable to undertake a trial operation in shallower water to acquaint with the various deck machinery and to test the various mooring components. This would also help to familiarize the officers and crew of the vessel with the various aspects of handling deep-sea mooring. Trial mooring can also assist in evolving the best and safe method of handling the deep-sea mooring systems with the vessel and the manpower provided for the purpose. It is recommended that a proper documentation of mooring shots with instruments connected at their ends may be maintained as shown in Table I. For the safe deployment and retrieval of a mooring system, it is essential to manoeuvre the vessel taking into consideration the dominant wind and current directions. Improper manoeuvring of the vessel can lead to entanglement of the mooring array with the propellers, rudders of the vessel or the vessel may run over the mooring array.

REFERENCES

1. Berteaux H O and Roberth H H (1973). Back-up recovery of deep sea moorings. Joul. Marine Technology Society, Vol. 7, No. 3.
2. Berteaux H O (1976): Buoy Engineering, John Wiley and Sons, New York.
3. Robert H H (1976): Mooring operations techniques of the buoy project at the Woodshole Oceanographic Institution. Unpublished manuscript. Technical report Ref. no. WHOI-76-69.
4. Suryavanshi A K and Nayak B U (1985): Some salient features of deep sea instrumented moorings and their deployment and retrieval techniques. Technical report no. NIO/TR-3/85.