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HMS WARRIOR - Recommendations for Survey and Maintenance of Mooring Arrangements

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COMMERCIAL - IN CONFIDENCE

AMENDMENT RECORD

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EXECUTIVE SUMMARY

This document details the current mooring arrangements for HMS WARRIOR and makes recommendations for the on-going survey, maintenance and repair of the mooring equipment.

It also presents a proposal for a full survey, including the buried portions, of the mooring equipment, to determine the effects of time, erosion, corrosion, wear and SRB action on the various components.

Analysis (Ref 8) has shown that the mooring system as designed and fitted is capable of withstanding the expected loads on the system. Therefore, if the system can be maintained to the original specification, it is considered an appropriate mooring system for HMS WARRIOR. However, it should be noted that the strength of the structure used onboard HMS WARRIOR to secure mooring lines has not been assessed. It is assumed that the structure used has adequate strength. It is recommended that this element of the system is subject to further analysis.

Noting the financial constraints associated with on-going maintenance of the mooring system, BMT have proposed a survey and maintenance regime that should be seen as a minimum requirement.

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Figures

1. BACKGROUND

1.1 Scope of this Document

1.1.1 To provide the NMRN (National Museum of the Royal Navy) with the necessary information and data upon which to determine the ability of the current mooring system to meet the demands of its service demands, a model of the system will be produced for detailed analysis. This will determine whether the system is fit for purpose. This is the subject of a separate document (Ref 8).

1.1.2 Additionally, the NMRN requires that the existing installation is surveyed and that a maintenance and inspection plan is produced to ensure that the system is correctly maintained in the future. This is discussed within this document.

1.2 Existing Mooring Arrangements

1.2.1 Since June 1987 HMS WARRIOR has been permanently moored at the National Museum of the Royal Navy (NMRN) facility in Portsmouth Historic Dockyard. The mooring consists of four chain arrangements forward and another four aft. Much of the equipment has been in place since 1985, however all the cable from the 20 ton sinkers to inboard of HMS WARRIOR was replaced (following surge related failures) in 2016.

1.2.2 A generic representation of one of the 8 in number chain arrangements is shown below (credit NMRN). Following the surge failures, the Baldt cable from the 20 ton sinkers to inboard of HMS WARRIOR was replaced with Flash Butt Welded Cable.

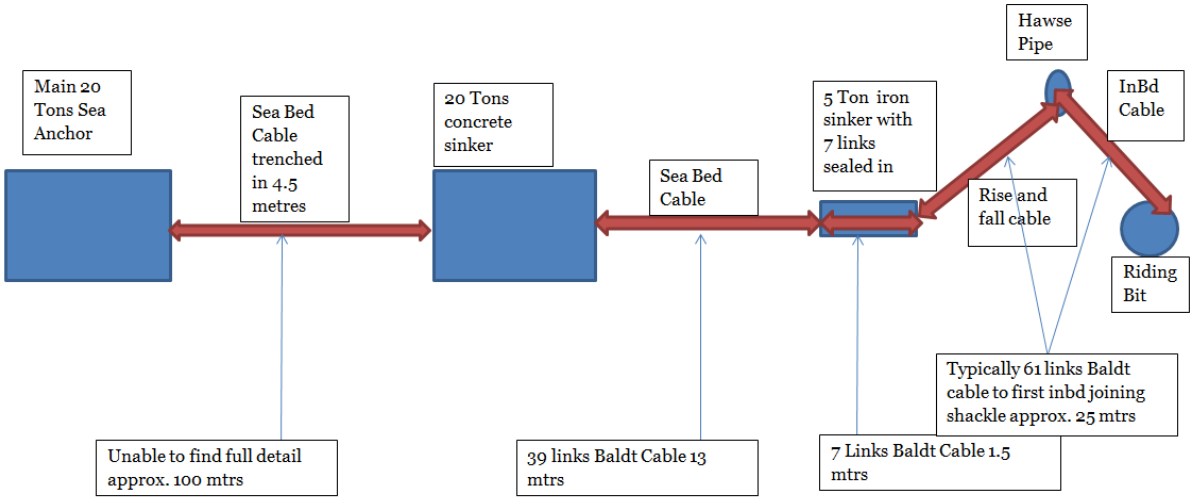

Figure 1 Schematic of Mooring Arrangements (1 of 8 chains)

1.2.3 The chain between the sea anchors 20 ton concrete sinkers (termed sea bed cable) is heavy duty 3 inch square link and this was installed in 1985. From the 20 ton sinkers to inboard of HMS WARRIOR, the cable is flash butt welded installed in 2016 following the surge failures.

1.2.4 The inboard cable is well preserved and the cable has been preserved from the ship to the low waterline. The sea bed cable has not been preserved since installation.

1.3 Current Survey Routines

1.3.1 During a ship visit by BMT (13/12/2017), discussions with the NMRN Representatives indicated that the visible (i.e. not buried in silt) portions of the mooring arrangements were viewed on an ad-hoc basis by RN Divers on completion of their Training.

1.3.2 As these inspections are provided free of charge as part of the diver training there is no set schedule. Additionally, these surveys are purely visual so do not include any element of dimensional inspection which is required to quantify the degradation of the cable and hence the remaining strength.

1.4 Cathodic Protection

1.4.1 For some part of the time that HMS WARRIOR has been moored, cathodic protection (in the form of a number of sacrificial anodes) was fitted to the portion of chains below the waterline and not buried in silt. This was fitted to the Baldt cables and was removed with them when all 8 Baldt cables were replaced.

1.4.2 Corrosion Protection Ltd (CPL) produced the recommendation (CPL 249/DES/01) for the introduction of cathodic protection to the chains and there is a subsequent Inspection and Test Report (CPL 249/ITR/01 dated 24/02/15) confirming operation.

1.4.3 It is recommended that cathodic protection (using sacrificial anodes) is reinstated for the HMS WARRIOR mooring system. This is a comparatively cost-effective method of reducing corrosion on the mooring system. It is also recommended that the condition of the anodes should be monitored once in position and replaced as required. The rate of degradation of the anodes will give an indication of the rate of degradation of the system. Additionally, if the anodes on a particular cable are degrading more rapidly than others, that cable may also degrade more rapidly.

2. CURRENT ISSUES

2.1 Responsibility for the Vessel

2.1.1 Previously, HMS WARRIOR was administered by the Warrior Preservation Trust. On April 1 2017, the Warrior Preservation Trust became a part of the National Museum of the Royal Navy and on 1st July 2017 the two staffs merged. Responsibility for the ship's ongoing maintenance and conservation has therefore passed to a centralised NMRN team. This reorganisation has meant that a number of plans for general maintenance of the vessel and her moorings are being readdressed.

2.2 Proposals in Abeyance

2.2.1 One proposal made was for the introduction of strain/load gauges on chain links either side of the sinkers so that transmitted load could be continuously monitored and any future failures would be immediately noticeable. Analysis (Reference 8) shows that the loads expected (including in a 100 year storm) give a safety factor of approximately 2 between the anticipated loads in the lines and the proof-load of the lines. Therefore, provided the lines are maintained such that they can withstand the loads they were designed to it is not so much the load in the line which is critical, rather the condition of the line and there is no requirement to install strain gauges for the purposes of continuously monitoring load. If the lines are maintained in such a way as to preserve the structural integrity and safe working load of the system, then the loads will not prove critical and it seems unnecessary to monitor loads when these are expected to be considerably lower than the design load of the lines. Therefore, it is recommended that preserving and maintaining the condition of the system is prioritised over monitoring the load.

2.2.2 As analysis shows that the failure of a single line is not critical, it is therefore not critical if a line failure goes unnoticed for some time (as with the failure of cable H, identified by ROV survey in 2015). Undertaking annual divers surveys will limit the length of time that a failure may go unnoticed. It is therefore recommended that installing strain gauges is not prioritised at this time. However when lines are replaced it is recommended that quotes are sought for including a method of monitoring strain in replacement lines. The NMRN should then assess the comparative cost of including this functionality in making a decision as to whether include this.

2.2.3 Preliminary discussions were held with CPL regarding the fitting of cathodic protection to the replacement chains (and possibly to the jetty piling) but this has not been progressed further. As discussed in section 1.4, it is recommended that cathodic protection is reinstated.

2.3 Environmental Factors

2.3.1 Surveys of the damaged cable from the surge incident conducted by Minton, Treharne & Davies Limited (Ref MTD160299UM) indicated that the links had been attacked by Sulphite Reducing Bacteria (SRB) and that the bacteria responsible were of two types; one of which acted aerobically and the other acting anaerobically.

2.3.2 Discussions with the NMRN representatives indicated that the level of SRB was increasing in the area and that there were concerns regarding the material state of the buried cable.

2.3.3 Additionally, the cable is subject to corrosion (rusting) due to exposure to sea water and a lack of protective coating.

2.3.4 The result of this is quantified in Para 3.2.4 of the Minton report which states that for several of the links the "Reduction in diameter of ~45% at the eroded locations of the link is equivalent to a ~70% loss in cross sectional area".

2.4 Condition of Existing Mooring Arrangements

2.4.1 Much of the existing mooring arrangements have been in place since 1985 and large portions of them are permanently buried in the silt. This means that there are significant portions of the 8 mooring chains/sinkers that cannot be surveyed as part of the regular diver examinations.

2.4.2 A number of the original components were obtained second hand due to cost constraints. Reference 9 details the source and condition of these components, primarily either from "Pounds" (assumed to be Pounds Scrapyard in Portsmouth) and DOT (Llandow). The 20t sinkers were manufactured by Portsmouth City Council. The information recorded prior to installation suggests that the material was initially in a good condition.

2.4.3 The effects of corrosion, wear (abrasion) and SRB damage on the removed Baldt chain links can be seen in:

- Figure 3 Example of Damaged Baldt cable (01) - Page 12
- Figure 4 Example of Damaged Baldt cable (02) - Page 12
- Figure 5 Example of Damaged Baldt cable (03) - Page 13

3. PROPOSAL FOR SURVEY AND MAINTENANCE OF THE MOORINGS

3.1 Survey Philosophy

3.1.1 In developing a survey and maintenance plan, the mooring system should be considered in two parts:

a. The system inboard of the ship: This covers the inboard cable and securing arrangements including surrounding structure, inboard stoppers and fixing shackles. In general, this element of the system is readily available for inspection;

b. The system outboard of the ship: This covers the outboard cable, sinkers and anchor. This part of the system is less easy to inspect, requiring divers to inspect all the underwater fittings and with the lengths of cable between the 20t sinkers and anchors buried in silt. The system outboard of the ship can be further subdivided into the part of the system which can be feasibly inspected through a diver survey (approximately up to the 20 ton sinkers depending on the cable in question) and the part of the system which cannot be inspected by divers due to being buried.

3.1.2 Further to this, there are two elements to the proposed survey and maintenance plan. These are:

a. Determining the current condition of the mooring system via an initial material state survey. The purpose of this survey is to provide assurance that the current condition of the system is satisfactory. If this is not the case, this survey shall identify the elements of the system in need of replacing;

b. Maintaining the condition of the system through a "steady state" programme of inspections, with maintenance where required.

3.1.3 Analysis (Ref 8) has shown that the mooring system as designed and fitted, is capable of withstanding the expected loads on the system. Therefore, if the system can be maintained to the original specification, it is considered an appropriate mooring system for HMS WARRIOR.

3.1.4 The frequency of inspection required is dependent on the age and condition of the system. Should elements of the system be replaced with new components, the inspection regime for these elements should be amended accordingly.

3.1.5 There is a requirement to physically inspect all elements of the mooring system. If it were feasible to inspect the entire system in situ, this would be a cost-effective manner to determine the current condition. However the condition of the mooring line between the 20 ton sinkers and anchor is unknown and the conditions (build-up of silt) mean much of the system is currently buried in deep trenches, so it is not practical to use divers for this inspection. Therefore, it is recommended that 2 mooring lines be removed in their entirety (and replaced with a new system of the same design and specification as the original system) to inspect the condition of the line system (cables, sinkers and anchor) as representative of the mooring system. Based on the condition of these mooring lines it can be determined if the remainder of the system needs replacing. This approach is illustrated in Figure 2.

3.1.6 Lines B and G are recommended for removal. This is because line G consistently sees the highest loading, exacerbated by the prevailing weather being in this direction. Line G is deep in the channel. Line B is opposite to Line G and while it is less highly loaded it is in a very different condition in shallow water and potentially exposed to air at low tides. Hence the condition of these lines can be used as an indication of the condition of the remaining mooring lines.

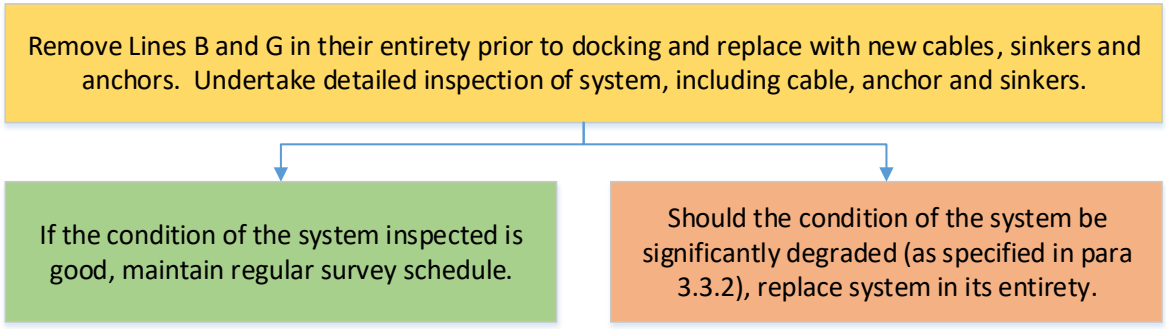

Figure 2 Approach to ascertaining the current state of the mooring system

3.1.7 Although included in the survey programme, the strength of the structure used onboard HMS WARRIOR to secure mooring lines has not been assessed. It is assumed that the structure used has adequate strength however, it is recommended that this is confirmed.

3.1.8 It is a requirement for mooring systems that the strength of the onboard structure is to be greater than that of the mooring lines. This is to ensure that the onboard structure should not suffer any permanent deformation when the associated line is tensioned to its minimum break load. The detailed requirements for this are discussed in paragraphs 3.2.3 to 3.2.6.

3.1.9 It will be necessary to maintain consistent records of surveys undertaken to allow comparison between surveys so any degradation of the system is understood and so that the future replacement, maintenance and survey requirements can be derived. Pro-formas for maintaining these records are provided in section 6 of this document. Records should be reviewed:

a. Monthly surveys - at three monthly intervals;

b. Annual surveys - after the second and each subsequent annual survey.

3.2 Initial Material State Survey

3.2.1 A material state survey should examine the totality of the mooring arrangements and should encompass the criteria set out in section 3.3.

3.2.2 Following the survey of the mooring arrangements, any defective components should be replaced and this would then form the basis of the mooring system material state for comparison in future surveys.

SYSTEM INBOARD OF THE SHIP

3.2.3 The structure used within the mooring system on board HMS WARRIOR should be inspected and assessed to ensure it possesses adequate strength. An initial survey of the structure would typically include taking thickness measurements, checking that connections between plate/stiffeners etc. are sound, accurately measuring for deflection of the structure and identifying any areas with cracking etc. This is to ensure that assumptions made in analysis are reflected on board the ship. The results of this survey and the assumptions therefore incorporated into analysis should be recorded on drawings and other formats as required that can be used as a check list during the on-going survey process.

3.2.4 The structure can then be analysed against a justifiable industry standard, for example OCIMF Mooring Equipment Guidelines (Reference 3, section 4.4). If OCIMF Mooring Equipment Guidelines are used, the Design Basis Load must be determined for the mooring arrangement on HMS WARRIOR. This is based on the minimum break load of the system and the geometry of the mooring systems (including the angles between twin bollards). The break load of the replacement chain installed in 2016 is reported as 3123kN on the Certificate for Anchor Chain Cable and Chain Cable Fittings (Reference 10). Note, this is larger than the proof load (2187kN) used to present safety factors (Reference 8) as structure should be designed to the break load of the cable.

3.2.5 Once the Design Basis Load has been determined, the structural arrangement determined by survey should be assessed against this load. Analysis should seek to confirm that:

$$Design\ Basis\ Load \leq 85\%\ Minium\ Yield\ Strength\ of\ Structure$$

3.2.6 Should analysis show that the structure does not possess adequate strength to withstand the potential loads, remedial action should be determined and implemented (for example, replacing corroded structure or adding additional stiffeners) to ensure that the structure does meet this minimum strength requirement.

3.2.7 Should analysis show that the structure does possess adequate strength to withstand the potential loads, a sensitivity study should be undertaken to review what level of degradation structure that is considered likely to corrode could withstand whilst maintaining the minimum required structural strength. This information is to be captured in a format that can then be used by surveyors.

3.2.8 During a survey undertaken as part of this project, the structure of the propeller well was identified as a potential weak spot in the onboard mooring arrangement. The condition of the Propeller Well as of December 2017 can be seen in:

- Figure 6 Internal Structure of Propeller Well (01) - Page 13
- Figure 7 Internal Structure of Propeller Well (02) - Page 14

SYSTEM OUTBOARD OF THE SHIP

3.2.9 As it is not feasible for a full survey of the entire mooring system in situ, it is recommended that two complete mooring lines are removed for thorough visual and dimensional survey. This would then act as a reference point for the remaining mooring lines and decisions regarding repair or replacement could be based on this sample.

3.2.10 Analysis (Reference 8) shows that, even in extreme weather conditions, the removal of a single line is not critical to either the motions of the ship or the loads in adjacent lines. Given this it is recommended that mooring lines B and G be removed and replaced with a duplicate line. Each line should be removed and replaced in sequence such that the ship always has a minimum of 7 lines operational.

3.2.11 The selected mooring lines should be disconnected and removed in its entirety. This would require the use of a suitable lifting barge/crane and appropriate dredging/silt clearance equipment to gain access and to prevent undue strain on buried portions of the mooring line.

3.2.12 The removed mooring line system should be thoroughly cleaned, visually and dimensionally examined where appropriate.

3.2.13 Further to this, the visible sections of the remaining cables should be subject to a visual and dimensional survey by divers against the criteria stated in section 3.3 to ensure that no other cables have obvious signs of damage or degradation.

3.3 On-going Surveys

3.3.1 Table 1 details the recommended survey and maintenance regime to be adopted. The following paragraphs describe this regime.

3.3.2 When surveying the chain, further investigation and/or replacement of components is advised if any of the conditions below are encountered:

a. Reduction in diameter of chain links exceeding 12% (Ref 1/2/3). This may be indicated by:

i. Visual evidence of wear or corrosion;

ii. Evidence of wear on the chain shoulders in way of the chain stopper;

iii. Evidence of wear on the chain shoulders in way of the connections to the sinkers.

b. Missing or loose studs;

c. Deformation of chain links - particularly elongation.

3.3.3 When surveying the sinkers, check that the sinker remains intact with no visible cracking, damage to the sinkers or degradation of the attachments and fixtures.

3.3.4 When surveying structure and other fittings, check for corrosion and thinning, deformation, loose fittings or damage to structure.

3.3.5 If the results of any surveys and/or inspections indicate wear, corrosion, damage or significant SRB action then the affected parts are to be replaced.

3.3.6 **Daily** inspections should be undertaken as part of Ships rounds. A visual inspection should be made of all inboard cable, securing arrangements and surrounding structure. Any obvious damage of deformation should be reported for further examination and repair action as required.

3.3.7 **Monthly** examinations should be undertaken by Suitably Qualified and Experienced Personnel (SQEP). Individuals undertaking these examinations should possess at least 5 years experience working with ship structures and should be familiar with the mooring and structural arrangement on HMS WARRIOR. Where possible, the same individual should be responsible for all monthly examinations to ensure continuity.

3.3.8 The same examinations should be undertaken following heavy weather (wind gusts exceeding 50 knots). This is a more detailed examination than the daily rounds and is to include checking for loose fittings and corrosion.

3.3.9 Formal records should be maintained detailing the findings and actions taken as a result of monthly examinations. A template for maintaining these formal records is provided in Section 6.

3.3.10 **Annual** surveys are to be conducted by Suitably Qualified and Experienced Personnel (SQEP). For surveys not requiring divers, it is recommended that the person responsible for undertaking monthly surveys undertakes the annual survey also. Divers surveys should be undertaken through a company registered with the Health and Safety Executive as a diving company and with membership of the Association of Diving Contractors (which provides a measure of assurance that safe standards of work are being observed). As well as the minimum qualifications required by the Health and Safety Executive, the survey should be led by a diver with a minimum of 5 years experience in the surveying of mooring systems and a qualification in underwater inspection, for example CSWIP 3.1U and 3.2U Certification of Underwater (Diver) Inspectors.

3.3.11 The vessel should be at operational draught and with the mooring system in use during the divers survey.

3.3.12 The purpose of the Annual Survey is to confirm that the criteria stated in section 3.3.2 are complied with. This indicates the structural integrity of the mooring system is sufficient and the mooring system will continue to carry out its intended purpose until the next annual survey.

3.3.13 Annual Surveys require inspection by divers. In addition to the normal safety precautions to be taken by divers inspecting the mooring lines, divers must be made aware of the potential movement of the vessel caused by passing vessels. In extreme conditions HMS WARROR may move by several meters when a vessel passes. This movement of the vessel will result in the tightening and loosening of the mooring lines and consequently rapid movement of the concrete sinkers.

3.3.14 Formal records should be maintained detailing the findings and actions taken as a result of annual surveys. These records should be compared to previous surveys to monitor the rate of degradation of the system. A template for maintaining these formal records is provided in Section 6.

4. REFERENCES

4.1.1 The following references were used in preparation of the guidelines:

1. IACS No 38 (1995) (Revision 1 Oct 201) Guidelines for the Survey of Offshore Mooring Chain Cable;
2. OCIMF Anchoring Systems and Procedures (2010);
3. OCIMF Mooring Equipment Guidelines 3rd Edition (2008);
4. Guide for Alternate Certification of Continuously Moored, Self-Propelled, Riverboat Gaming Vessels in the State of Indiana (June 2007) prepared by ABS Consulting;
5. Minton, Treharne & Davies Ltd report MTD160299UM dated 01/09/2016 - Report, HMS WARRIOR Broken Mooring Chains;
6. Corrosion Prevention Limited report 249/DES/01 dated 13/11/2014 - Cathodic Protection System Design Report;
7. Corrosion Prevention Limited report 249/ITR/01 dated 24/02/2015 - Cathodic Protection System Inspection and Test Report;
8. HMS WARRIOR Mooring System (Powerpoint presentation), BMTDSL Ref 38651/006853
9. Summary of Warrior Mooring Equipment, date approximately October 1984
10. Lloyds Registers Certificate for Anchor Chain Cable and Chain Cable Fittings, certificate number JYN 1412519/23EBA

4.2 GLOSSARY

- IACS International Association of Classification Societies
- OCIMF Oil Companies International Marine Forum
- SRB Sulphite Reducing Bacteria

4.3 REFERENCE PHOTOGRAPHS

4.3.1 The following photographs were taken during the BMT Ship visit to illustrate the condition of failed cables and the Propeller Well structure.

4.3.2 It should be noted that the pictures of chain links are from the removed Baldt type cables but are included to show the extent of corrosion, wear and SRB action.

4.3.3 The Propeller Well pictures indicate the material state of the structure. This structure is used as a load bearing component of the after mooring arrangements.

Figure 3 Example of Damaged Baldt cable (01)

Figure 4 Example of Damaged Baldt cable (02)

Figure 5 Example of Damaged Baldt cable (03)

Figure 6 Internal Structure of Propeller Well (01)

Figure 7 Internal Structure of Propeller Well (02)

Figure 8 Propeller Well External Showing Wood Blocking

5. SURVEY AND MAINTENANCE SCHEDULE

5.1.1 This Schedule lists the actions discussed in this report and presents them in a tabular form. In all cases, the Surveys and Maintenance should be carried out in accordance with the information in the body of this report and (where necessary) the guidance contained in the quoted reference documents.

5.1.2 Indicative costs for diving surveys are based on information provided by the following organisations:

a. Sub Marine Services Ltd, www.submarineservices.com, telephone 01326 211 517, ref: TR6211;

b. Quest Underwater Services Ltd, www.questmarine.co.uk, telephone 01929 405029.

Table 1 Survey and Maintenance Schedule

Frequency	Survey and Maintenance Actions	Key Indicators	Subsequent Action	Indicative costs
Daily	Visual inspection of all inboard cable and securing arrangements including surrounding structure, inboard stoppers and fixing shackles.	Obvious damage or deflection of system.	Action required will depend on the nature of the deflection or damage.	Survey: None
Monthly or following heavy weather (wind gusts exceeding 50 knots)	Detailed examination by Suitably Qualified and Experienced Personnel (SQEP) of all inboard cable and securing arrangements including surrounding structure, inboard stoppers and	Bolts or other fixings are loose or not correctly located.	Tighten loose bolts and fixings. Consider potential causes of loosening and address. Recheck tightened bolts and fixings one week after tightening to ensure loosening has not reoccurred.	Survey: None

Frequency	Survey and Maintenance Actions	Key Indicators	Subsequent Action	Indicative costs
	fixing shackles.	Corrosion and plate thinning, damage or deflection of system.	Action required will depend on the nature of the deflection or damage. Ultrasonic thickness testing in way of thinning structure.	
Annually	As monthly requirements above. In addition the following actions should be undertaken			
	Detailed examination of the internal structure forming part of the mooring system. Ultrasonic thickness testing is advised to ensure assumptions made in strength analysis are valid	Corrosion and plate thinning. Deformation of structure.	Replace corroded or deformed structure and incorporate additional structure to ensure adequate strength in the propeller well.	Survey: None
	Visual inspection of the hawse pipes including the surrounding plate and associated structure, in particular the part of the hull in contact with the mooring chains.	Corrosion, deformation and fractures of hawse pipes, surrounding shell plating and associated structure.	Replace corroded, deformed or fractured structure. Requirement for replacement will depend on the location of the degradation.	Survey: None

Frequency	Survey and Maintenance Actions	Key Indicators	Subsequent Action	Indicative costs
	Detailed examination of the mooring chain between the hawse pipe and the low water mark including examination of coatings.	Identify any wear in the system in accordance with paragraph 3.3.2.	Replace components degraded beyond the limits of paragraph 3.3.2. Note that degradation of this part of the system (unless caused by mechanical means) would also suggest degradation of other elements of the system.	Survey: None
		Identify any areas where the coating has been damaged.	Make good any areas of damaged coatings with a suitable marine coating applied in accordance with the manufacturer's instructions.	
	Detailed examination (by divers) of the submerged mooring chain and system including sacrificial anodes. Note: To be undertaken at high tide so the maximum amount of chain is raised free of the silt. Particular emphasis should be	Sacrificial anodes more than 75% consumed.	Reinstate sacrificial anodes.	£10000 - £13000
		Thinning and wear evident on links. Measurements should be taken if thinning is evident and compared to the limits specified in para 3.3.2. The general condition of	Replace any elements of the system degraded beyond the limits of paragraph 3.3.2.	

Frequency	Survey and Maintenance Actions	Key Indicators	Subsequent Action	Indicative costs
	placed on examining the chain emerging from the sinkers, checking for wear between fixed links and free links. Links are to be examined for signs of thinning due to corrosion/erosion and SRB Damage. Measurements shall be taken if thinning is evident.	the links should be compared to the requirements in paragraph 3.3.2. The concrete sinkers remain intact, with no visible cracking, damage to the sinkers or degradation of the attachments and fixtures.		
When opportunity arises (e.g. ship is moved or docked) or to be determined based on rates of degradation seen annually	Remove two lines and associated sinkers and anchor for detailed examination of all components. Note: If this is undertaken when the vessel is in place, it must be undertaken in benign conditions where the safety of the ship will not be jeopardised by removing a line.	Examine complete system for degradation of chain, sinker and anchor against the requirements specified in paragraph 3.3.2.	Should the line inspected be significantly degraded, remove and replace other lines also.	A diving survey will be required by a candidate contractor to confirm indicative costs for this.

6. SURVEY PROFORMA

6.1 Monthly Survey

Date of Survey…… **Surveyor Name**……..

Reason for Survey (delete as appropriate) Monthly / Following Heavy Weather (please provide details) / Other…….....

Considerations for review	**Potential Actions Required**
Bolts or other fixings are loose or not correctly located.	Tighten loose bolts and fixings. Consider potential causes of loosening and address. Recheck tightened bolts and fixings one week after tightening to ensure loosening has not reoccurred.
Corrosion and plate thinning, damage or deflection of system.	Action required will depend on the nature of the deflection or damage. Ultrasonic thickness testing in way of thinning structure.

I confirm I have checked the items listed on the following sheets against the considerations listed above. The notes on the following pages detail the findings of my inspection.

Where my inspection has identified further actions required or items of concern I will report and manage these as required to maintain the integrity of the mooring system.

Signature of Surveyor……

Item for review	Review complete	Observations	Action Undertaken (e.g. loose bolts tightened)	Action Required
Cable A (Port Head Line)				
Cable A structural arrangement				
Cable B (Starboard Head Line)				
Cable B structural arrangement				
Cable C (Port Fwd Breast Line)				
Cable C structural arrangement				
Cable D (Starboard Fwd Breast Line)				
Cable D structural arrangement				

Item for review	Review complete	Observations	Action Undertaken (e.g. loose bolts tightened)	Action Required
Cable E (Port Aft Breast Line)				
Cable E structural arrangement				
Cable F (Starboard Aft Breast Line)				
Cable F structural arrangement				
Cable G (Port Stern Line)				
Cable G structural arrangement				
Cable H (Starboard Stern Line)				
Cable H structural arrangement				

6.2 Annual Survey

Date of Survey..... **Surveyor Name**.....

Considerations for review	**Potential Actions Required**
Bolts or other fixings are loose or not correctly located.	Tighten loose bolts and fixings. Consider potential causes of loosening and address. Recheck tightened bolts and fixings one week after tightening to ensure loosening has not reoccurred.
Corrosion and plate thinning, damage or deflection of system.	Action required will depend on the nature of the deflection or damage. Ultrasonic thickness testing in way of thinning structure.
Detailed examination of the internal structure forming part of the mooring system. Ultrasonic thickness testing is advised to ensure assumptions made in strength analysis are valid	Corrosion and plate thinning. Deformation of structure. Once strength analysis has been undertaken, diagrams should be attached to this pro-forma to indicate the thicknesses assumed and to highlight load bearing structure to inform the surveyor. The surveyor should then mark off the elements of structure inspected.
Visual inspection of the hawse pipes including the surrounding plate and associated structure, in particular the part of the hull in contact with the mooring chains.	Corrosion, deformation and fractures of hawse pipes, surrounding shell plating and associated structure.
Detailed examination of the mooring chain between the hawse pipe and the low water mark including examination of coatings.	Identify any wear in the system in accordance with paragraph 3.3.2.

ONCE STRENGTH ANALYSIS HAS BEEN UNDERTAKEN, STRUCTURAL DRAWINGS SHOULD BE ATTACHED TO THIS PRO-FORMA. THESE DRAWINGS SHOULD SHOW THE PLATE THICKNESSES ASSUMED IN STRENGTH ANALYSIS AND DETAIL OTHER LOAD BEARING STRUCTURE. DURING THE ANNUAL SURVEY, THE SUREYOR SHOULD THEN MARK OFF AGAINST THESE DRAWINGS TO CONFIRM ALL KEY AREAS OF STRUCTURE HAVE BEEN RECORDED. WHERE ULTRASONIC (OR OTHER THICKNESS MEASUREMENT) METHODS HAVE BEEN IMPLOYED, THE REPORTED THICKNESS SHOULD BE RECORDED ON THESE DRAWINGS ALONGSIDE THE REPORTED THICKNESS FROM THE PREVIOUS ANNUAL SURVEY AND THE MINIMUM PERMISSIBLE THICKNESS FROM STRENGTH ANALYSIS. THE RATE OF DEGRADATION SHOULD BE REVIEWED TO ASCERTAIN WHETHER THERE IS AN IMMEDIATE REQUIREMENT TO REPAIR OR REPLACE STRUCTURE.

I confirm I have checked the items listed on the following sheets against the considerations listed above. The notes on the following pages detail the findings of my inspection. The following actions have been identified as being required as a result of this survey.

	Description of action required	**Date Completed**	**Name**	**Signature**
1				
2				
3				
4				
5				

Signature of Surveyor……

Item for review	Review complete	Observations	Action Undertaken (e.g. loose bolts tightened)	Action Required
Cable A (Port Head Line)				
Cable A structural arrangement				
Cable A Hawse Pipe				
Cable A chain above low water mark incl. coating				
Cable B (Starboard Head Line)				
Cable B structural arrangement				
Cable B Hawse Pipe				
Cable B chain above low water mark incl. coating				

Item for review	Review complete	Observations	Action Undertaken (e.g. loose bolts tightened)	Action Required
Cable C (Port Fwd Breast Line)				
Cable C structural arrangement				
Cable C Hawse Pipe				
Cable C chain above low water mark incl. coating				
Cable D (Starboard Fwd Breast Line)				
Cable D structural arrangement				
Cable D Hawse Pipe				
Cable D chain above low water mark incl. coating				

Item for review	Review complete	Observations	Action Undertaken (e.g. loose bolts tightened)	Action Required
Cable E (Port Aft Breast Line)				
Cable E structural arrangement				
Cable E Hawse Pipe				
Cable E chain above low water mark incl. coating				
Cable F (Starboard Aft Breast Line)				
Cable F structural arrangement				
Cable F Hawse Pipe				
Cable F chain above low water mark incl. coating				

Item for review	Review complete	Observations	Action Undertaken (e.g. loose bolts tightened)	Action Required
Cable G (Port Stern Line)				
Cable G structural arrangement				
Cable G Hawse Pipe				
Cable G chain above low water mark incl. coating				
Cable H (Starboard Stern Line)				
Cable H structural arrangement				
Cable H Hawse Pipe				
Cable H chain above low water mark incl. coating				

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