

No. 38 Guidelines for the Survey of Offshore Mooring Chain Cable in Use

(1995)
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1. Application and Purpose

The information herein is intended to provide guidance to Surveyors for inspection of position mooring systems which have been classed by the Society for Mobile Offshore Drilling Units. Temporary mooring equipment is to be surveyed under the Rules for Building and Classing Steel Vessels of the Classification Society.

2. Survey Interval, Purpose and Extent

2.1 Annual Surveys are to be conducted at approximately twelve (12) month intervals, with the vessel at operational draft, with the position mooring system in use.

2.1.1 The purpose of the Annual Survey is to confirm that the mooring system will continue to carry out its intended purpose until the next annual survey. No disruption of the unit's operation is intended. Ideally, the Annual Survey would be done during a relocation move.

2.1.2 The scope of the Annual Survey is limited to the mooring components adjacent to the winch or windlass. Depending on the mooring component visible from the unit, particular attention should be given to:

Chain

- Wear on the chain shoulders in way of the chain stopper and windlass pockets;
- Support of chain links in the windlass pockets.

Wire Rope

- Flattened ropes;
- Broken wires;
- Worn out or corroded ropes.

The surveyor should determine if any problems have been experienced in the previous twelve (12) months period with the mooring system, e.g. breaks, mechanical damage, loose joining shackles, chain or wire jumping.

If the Annual Survey reveal severe damage or neglect to the visible part of chain or cable, a more extensive survey should be performed.

Typical damage warranting a more comprehensive survey could be:

Chain

- Reduction in diameter exceeding 4%;
- Missing studs;
- Loose studs in Grade 4 chain;
- Worn out cable lifters (i.e. gypsies) causing damage to the chain.

Wire Rope

- Obvious flattening or reduction in area;
- Worn cable lifters causing damage to the wire rope;
- Severe wear or corrosion;
- Broken wires.

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2.2 Special Periodical Surveys are carried out at intervals of approximately five (5) years and will require extensive inspection, usually associated with a sheltered water visit. When considered necessary by the Society, the interval between Special Periodical Surveys may be reduced.

2.2.1 The purpose of the Special Periodical Survey is to ensure that each chain is capable of performing its intended purpose until the next Special Periodical Survey, assuming that appropriate care and maintenance is performed on the mooring system during the intervening period.

2.2.2 The Special Periodical Survey should include:

- Close visual examination of all links of mooring chains, with cleaning as required
- Enhanced representative NDT sampling
 - 5% on general chains
 - 20% on chain which has been in way of fairleads over last five (5) years
 - All connecting links
- Dimension checks, including length over five (5) links

2.2.3 Particular attention should be given to:

- Those lengths of chain (or wire rope) which have frequently been in contact with the windlass and fairleads during the unit's operation since the last survey. The Surveyor should ensure that these lengths are rated for use in the way of the windlass and fairlead.
- The looseness and pin securing arrangements of the joining-shackles.
- All windlass and fairlead chain pockets for:
 - Unusual wear or damage to pockets;
 - Rate of wear on pockets, including relative rate of wear between links and pockets;
 - Mis-match between links and pockets, and improper support of the links in the pockets.
- A functional test of the mooring system during anchor-handling operation for:
 - Smooth passage of chain links and/or wire rope and joining-shackles over the windlass and fairleads pockets;
 - The absence of chain jumping or other irregularities.

2.2.4 The thickness (diameter) of approximately 1% of all chain links should be measured. The selected links should be approximately uniformly distributed through the working length of the chain. The above percentage may be increased/decreased if the visual examination indicates excessive/minimal deterioration.

2.2.5 All joining-shackles of the Kenter type and bolted type which have been in service for more than four (4) years should be dismantled and an MPI performed on all machined surfaces as per 8.2.

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(cont)**2.3 Special Continuous Surveys**

In lieu of a special periodic survey, the Owner may opt for a Continuous Survey, by providing an extra mooring line which may be regularly inspected on shore and exchanged with lines installed on the unit on an annual or other appropriate schedule.

3. Anchor Inspection

The anchor head, flukes and shank should be examined for damage, including cracks or bending. The anchor shackle pin and crown pin should be examined and renewed if excessively worn or bent. Moveable flukes should be free to rotate between stops on the anchor head.

Bent flukes or shanks should be heated and jacked back in place according to an approved procedure, followed by Magnetic Particle Inspection.

4. Anchor Swivels

Although swivels are no longer in common use, anchors have been lost due to corrosion of the threads engaging the swivel nut. These threads should be carefully examined and, if significant corrosion is found, the swivel should be removed or replaced.

5. Chain Inspection Criteria**5.1 Chain Types Considered**

This section applies only to "Offshore" or "Rig Quality" chains with studs secured by one of the following means:

- Mechanically locked adjacent to the link's flash-butt-weld and fillet welded on the other end (IACS R3 chain for example)
- Studs mechanically locked in place on both ends (IACS R4 chain for example)

Other types of chain will require special consideration.

The service environment of offshore mooring chain is more severe than the service environment for conventional ship anchoring chain. Offshore chain is exposed to service loads for a much longer period of time. The long term exposure to cyclical loadings in sea water magnifies the detrimental effect of geometric and metallurgical imperfections on fatigue life. Moreover the increased number of links in offshore chains renders the chain more susceptible to failure from a statistical standpoint.

Due to the effect of "notches", e.g. the stud footprint, higher strength steels, such as that used for IACS R4 chain, have a lower ratio of fatigue strength to static tensile strength than typical lower strength steel such as used for IACS R3 chain.

5.2 Chain Link Diameter Loss due to Abrasion and Corrosion

Diameter measurements should be taken in the curved or bend region of the link and at any area with excessive wear or gouging. Particular attention should be given to the 'shoulder' areas which normally contact the windlass or fairlead pockets.

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Links with minimum cross-sectional area less than 90% of the original nominal area should be rejected. If repair is permitted, it should be done by qualified personnel using an approved procedure.

*Note: WELD REPAIR IS NOT PERMITTED ON IACS R4, R4S and R5 CHAIN
(See paragraph 5.3.1)*

A 5% reduction in diameter is equivalent to 10% of the reduction in cross-sectional area to original.

Two diameter measurements should be taken 90 degrees apart and the average compared with original diameter considering with allowable diminution.

5.3 Chain Stud Defects and Repair or Replacement

Studs prevent knots or twist problems during chain handling and support the sides of the links under load to reduce stretching and bending stresses, resulting in longer fatigue life. Links with missing studs should be removed or the studs should be refitted using an approved procedure.

5.3.1 Chain Studs Secured by Fillet Welds on one End

The stud is likely to fall out if it is loose or the weld is cracked.

Any axial or lateral movement is unacceptable and the link must be repaired or replaced.

Links with studs fillet welded on the flash-butt-weld end of the stud are unacceptable.

Rejection of links with gaps exceeding 3 mm (1/8 inch) between the stud and the link at the flash-butt-weld end of the stud should be considered. Closing the gap by renewing the fillet weld may be considered, where permitted.

Field repair of cracked welds should be avoided. Welding must be performed by qualified personnel using approved procedures.

*Note: WELD REPAIR IS NOT PERMITTED ON IACS R4, R4S and R5 CHAIN
Chains with studs mechanically locked in place on both ends may only be repaired by an approved mechanical 'squeezing' procedure to reseal the stud.*

Fillet welding of studs on both ends is not acceptable nor is welding on the stud end adjacent to the link's flash-butt-weld.

Existing studs with fillet welds on both ends will require special consideration and will be subject to special crack detection efforts. A reduction in mechanical properties in way of the flash-butt-weld will normally be required and approval of the coastal Administration may also be required.

5.3.2 Chain Studs Secured by Press Fitting and Mechanical Locking

It is very difficult to quantify excessive looseness of chain studs. The decision to reject or accept a link with a loose stud must depend on the surveyor's judgment of the overall condition of the chain complement.

Axial movement of studs of 1 mm or less is acceptable. Links with axial movement greater than 2 mm must be repaired by 'squeezing' or removed. Acceptance of chain links with axial movements from 1 to 2 mm must be evaluated based on the environmental conditions of the unit's location and expected period of time before the chain is again available for inspection.

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Lateral movement of studs up to 4 mm is acceptable.

5.4 Link Repairs

Cracks, gouges and other surface defects (excluding weld cracks) may be removed by grinding provided the resulting reduction in link diameter does not exceed 5% and the cross-sectional area, due to abrasion, wear, and grinding is at least 90% of the original nominal area. Cross-sectional area should be calculated for the lowest average of two diameters taken 90 degrees apart.

Links with surface defects which cannot be removed by grinding should be replaced.

5.5 Chain Link Replacement

Defective links should be removed and replaced with joining-shackles, i.e. connecting links, guided by the following good marine practice:

- The replacement joining-shackle should comply with IACS W22 or API 2F.
- Joining-shackles should pass through fairleads and windlasses in the horizontal plane.

Since joining-shackles have much lower fatigue lives than ordinary chain links as few as possible should be used. On average, joining-shackles should be by 122 m (400 ft) or more apart.

If a large number of links meet the discard criteria and these links are distributed in the whole length, the chain should be replaced with new chain.

6. Fairlead and Windlass Inspection - Chain Systems**6.1 Fairleads**

Inspection should verify that all fairleads move freely about their respective Z-axes, to the full range of motion required for their proper operation. All bolts, nuts and other hardware used to secure the fairlead shafts should be inspected and replaced, as required.

Fairlead attachment to the hull should be verified and NDT conducted, as necessary.

Note: There have been cases of closing plates on the fairlead shaft coming loose due to corrosion of the threads of the securing bolts, resulting in serious damage to the fairlead arrangements and the complete jamming of the fairlead and chain. Consequently, the securing bolts should also be checked to ensure that the bolt material does not corrode preferentially, should the sacrificial anode system fail to function in way of the fairlead.

6.2 Windlasses

Special attention should be given to the holding ability of the windlass. The chain stopper and the resultant load path to the unit's structure should be inspected and its soundness verified.

6.3 Chain Pockets and Chain Support

It is essential that a link resting in a chain pocket makes contact with the fairlead at only the four shoulder areas of the link to avoid critical bending stresses in the link.

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Satisfactory chain support is to be verified, and excessive wear in the pockets should be repaired as required, to prevent future damage to the chain.

Chain pockets may be repaired by welding in accordance with the standard procedures supplied by the fairlead/windlass manufacturer. Normally, the hardness of the pockets should be slightly softer than the hardness of the chain link, and procedures must be specific for the chain quality used.

7. Fairleads and Winches Inspection - Wire Rope Systems

7.1 Fairleads

See 6.1.

7.2 Winches

Special attention should be given to the holding ability of the winch and the satisfactory operation of the pawls, ratchets and braking equipment. The soundness of the resultant load path to the unit's structure should be verified.

Proper laying down of the wire on the winch drum should be verified to the satisfaction of the Surveyor, and drums and spooling gear adjustments made, if required.

8. Inspection of Jewellery and Miscellaneous Fittings

8.1 General

Anchor shackles, large open links, swivels and connecting links should be visually inspected. Certain areas should be examined by MPI. Areas to be examined should be clearly marked on each item. Links and fittings should be dismantled, as required. Damaged items should be replaced as required by the attending surveyor. Illustrations showing the areas of concern may be found in API RP 2I, Figure 7.

General guidance on the areas requiring MPI is provided below:

- Large open links: the interior contact surfaces of large open links
- Bolted shackles: the inside contact areas and the pins
- Swivels: the swivel pin and threads and mating surface

8.2 Joining Shackles (Connecting Links)

8.2.1 Experience has shown that an undue number of anchors and chains have been lost due to connecting link failure. Joining-shackles used for higher strength chains, such as ORQ and above, which do not have certificates of equivalent quality should receive special attention.

8.2.2 Magnetic Particle Inspection

All joining-shackles of Kenter or similar design which have been in service for more than four (4) years should be dismantled and MPI carried out. Illustrations showing the areas of concern may be found in API RP 2I, Figure 7.

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General guidance on the areas requiring MPI is provided below:

- Joining shackle links: all machined and ground surfaces of the link and the sides of the curved portions of the link
- Joining shackle stud: machined surfaces only
- Joining shackle pin: 100%

8.2.3 Fatigue is considered to be the critical criteria in way of the machined surfaces. On the remaining surface, the profile should be ground smooth and MPI should be carried out upon completion of grinding. In general, the radius of the completed grinding operation should produce a recess with a minimum radius of 20 mm and a length along the link bar greater or equal to six times its depth.

Note: Sandblasting prior to MPI may damage the machined surfaces and should be avoided. Alternative methods of cleaning should be used. The maximum permissible depth of grinding is 5% of the nominal diameter. The minimum acceptable cross-sectional area in way of the grinding repair, due to the combined effect of local grinding and general corrosion/abrasion is 90% of the nominal cross-sectional area. The minimum acceptable diameter in way of the grind repair, due to the combined effect of local grinding and general corrosion/abrasion, is 95% of the nominal diameter.

8.2.4 General Corrosion/Abrasion

The minimum acceptable cross-sectional area due to generally uniform corrosion/abrasion is 90% of the nominal cross-sectional area (equivalent to a uniform 5% reduction in diameter).

8.2.5 Tapered pins holding the covers of connecting links together should make good contact at both ends and the recess of counterbore at the large end of the pin holder should be solidly plugged with a peened lead slug to prevent the pin from working out.

8.2.6 Looseness Upon Re-Assembly

Any joining-shackles of Kenter or similar designs which are loose upon re-assembly should be accepted only after special consideration in each case.

Note: Looseness between the mating faces will significantly reduce the remaining fatigue life of a joining-shackle. Stud movement in the longitudinal direction of the stud of more than 0.5 mm is also likely to significantly reduce the remaining fatigue life of a joining-shackle.

9. Wire Rope Surveys

9.1 Acceptance Criteria

Acceptance criteria should be guided by ISO-Standard 4309. Further insight may be gained from the 'discard' guidance provided by API RP 2I, Figures 18 and 19.

It should be borne in mind that ISO-Standard 4309 is primarily intended for lifting appliances where the Factor of Safety may be higher than for mooring wires.

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The Surveyor should exercise great care in his interpretation of the condition of the wire. An obvious acceptance or rejection is comparatively easy, but the "grey" area between is difficult to evaluate. The Surveyor must make a sound evaluation and technical judgment based on all available evidence.

In general, the age or time in service of the wire does not directly have a bearing on the acceptance or rejection of the wire other than as a factor to be taken into consideration by the Surveyor when deciding on the extent of survey.

9.2 Survey and Inspection

100% visual examination and diameter measurements should be performed.

9.2.1 Visual examination should identify and record the following items for each steel wire anchor line:

- The nature and number of wire breaks;
- Wire breaks at the termination;
- External wear and corrosion;
- Localized grouping of wire breaks;
- Deformation;
- Fracture of strands;
- Termination area;
- Reduction of rope diameter, including breaking or extrusion of the core.

9.2.2 Diameter measurements should be taken at approximately 100 m intervals, at the discretion of the attending Surveyor. If areas of special interest are found, the survey may be concentrated on these areas and diameter measurements taken at much smaller intervals.

9.2.3 An internal examination should be undertaken as far as practicable if indications of severe internal corrosion or possible breakage of the core or wire breaks in underlying areas. See API RP 2I, Section 2.3.6.3, for guidance on the internal inspection of wire rope.

9.3 Guidance on Wire Rope Damage

The cause of wire rope failures may be deduced from the observed damage to the rope. The information summarized below covers most types of wire rope failure.

More detailed information, including photographic examples, is available in ISO-Standard 4309 and API RP 2I.

9.3.1 Broken wires at the termination indicate high stresses at the termination and may be caused by incorrect fitting of the termination, fatigue, overloading or mishandling during deployment or retrieval.

- Distributed broken wires, illustrated by figures 9 through 12 of API RP 2I may indicate the reason for their failure.

Crown breaks or breakage of individual wires at the top of strands may be caused by excessive tension, fatigue, wear or corrosion.

Excessive tension is indicated by necking down of the broken end of the wire.

Fatigue is indicated by broken faces perpendicular to the axis of the wire.

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Corrosion and wear may be indicated by reduced cross sections of the wire.

Valley breaks, at the interface between two strands indicate tightening of the strands, usually caused by a broken core or internal corrosion which has reduced the diameter of the core.

Valley breaks can be caused by high loads, tight sheaves, and sheaves of too small a diameter.

- Locally grouped broken wires in a single strand or adjacent strand may be due to local damage. Once begun, this type of damage will usually worsen.

9.3.2 Changes in rope diameter can be caused by external wear, interwire and interstrand wear, stretching or corrosion.

A localized reduction in rope diameter may indicate a break in the core. Conversely, an increase in rope diameter may indicate a swollen core due to corrosion.

9.3.3 Wear on the crown of outer strands in the rope may be caused by rubbing against fairleads, unit structure, or the sea bed depending on the location of the wear. Internal wear between individual strands and wires in the rope is caused by friction and is accelerated by bending of the rope and corrosion.

9.3.4 Corrosion decreases rope strength by reducing the cross-sectional area and accelerated fatigue by creating an irregular surface which invites stress cracking. Corrosion is indicated by:

- The diameter of the rope at fairleads will grow smaller;
- The diameter of stationary ropes may actually grow larger, due to rust under the outer layer of strands. Diameter growth is rare for mooring lines.

9.3.5 Deformation, i.e. distortion of the rope from its normal construction, may result in an uneven stress distribution in the rope. Kinking, bending, scrubbing, crushing and flattening are common wire rope deformations. Ropes with slight deformations will not lose significant strength. Severe distortions can accelerate rope deterioration and lead to premature failure.

9.3.6 Thermal damage, although rare for mooring ropes in normal service, may be indicated by discoloration. Prompt attention should be given to damage caused by excessively high or low temperatures. The effect of very low temperatures on wire rope is unclear except for the known detrimental effect on lubricants.

10. References

10.1 Wire Rope

API RP 2I and ISO-Standard 4309.
(Please see 9.1 regarding the ISO-Standard)

10.2 Chain

API RP 2I: "Recommended Practice for In-Service Inspection of Mooring Hardware for Floating Drilling Units".

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