Anchoring and Anchoring Equipment

Introduction

Recent incidents reported to ***CHIRP*** have highlighted that a more informed use of anchoring equipment may lead to safer practices and outcomes. In addition, P+I Clubs and Classification Societies state that "Anchor losses and associated costs have been on the rise since 2012, but the large majority could have been prevented" (DNV-GL, GARD, and the Swedish Club 2016).

Guidance for best practice navigation in the vicinity of anchorages has been widely discussed in maritime industry circulars and papers. In this paper, ***CHIRP*** underlines the principles and best practices for anchoring and preserving equipment – this is supported by aspects of navigation practice that will ease the stresses on equipment to reduce failures.

Safe Anchorages

Safe anchorages are normally clearly marked on charts and most anchoring will preferably be done within them. This reduces the risk of fouling anchors on uncharted obstructions and the nature of the sea bed normally makes for good holding ground. If choosing to anchor outside of a charted anchorage risks may well be greater and unknown.

Safe Swinging Distance

Safe anchorage location is best achieved by selecting the largest available distance from other anchored vessels or shore within the anchorage as your preferred location to anchor. If the anchorage has allocated designated locations within it, A1, A2 etc., often advised to you by port control in which to anchor your vessel, then even better. In this case, safe swinging distances from other vessels are assured, as long as you aim to locate your anchor in the centre of the allocated anchoring circle.

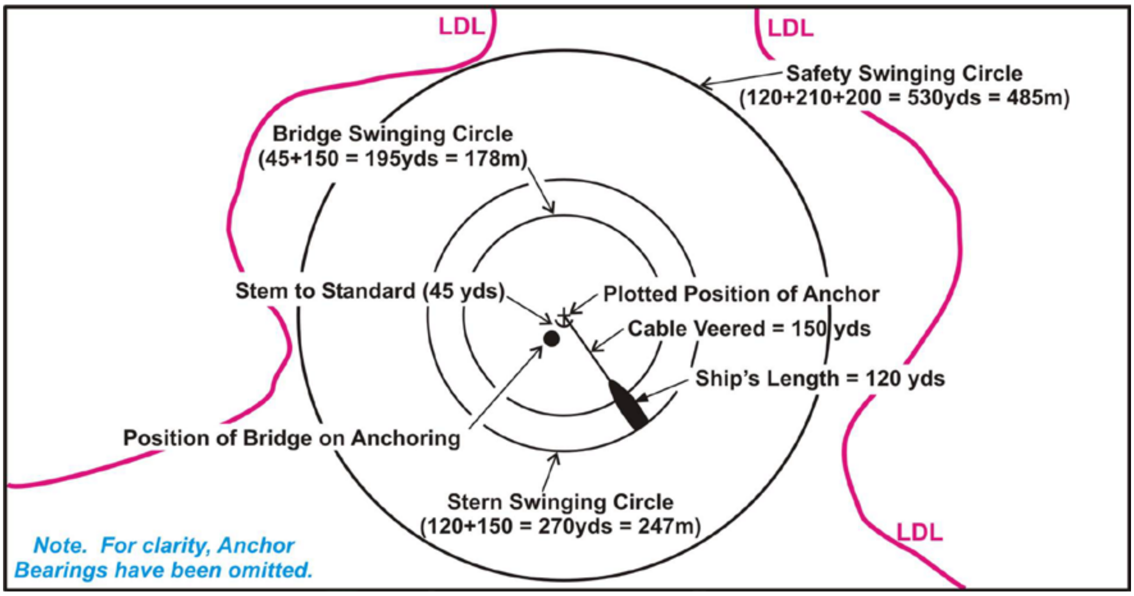

Figure 1 – Safe swinging distances. (Illustration courtesy of the Royal Navy)

In the diagram above, LDL references the "Limiting Danger Line", possibly more commonly referred to as a safety contour with ECDIS, or "no go area" when shaded on a traditional chart. The concept is further discussed in Figure 3.

Safe swinging distances are calculated from the length of cable paid out, plus the length of the vessel, with the minimum comfortable passing distance from another vessel added. It is important to allow for the fact that on change of tide or wind not all vessels will swing to their new heading at the same time or in the same direction of rotation. It is therefore quite possible that two vessels lying quite safe to their cables at the turn of the tide may well then find their sterns swinging towards each other - often quite quickly. This is the point at which a minimum safe passing distance must be assured by choice of initial anchoring location. In doing so this very worst case, with adverse timing and environmental influence, will still ensure that a safe distance is maintained. If the luxury of a comfortable safe swinging distance cannot be assured in the initial choice of anchoring location, consideration must be given to having the ship's engines on standby for immediate use at the time of the turn of the tide or when any adverse influence such as weather is predicted. Having the ship's engines ready for immediate manoeuvre will mean they are available to be used in an emergency to move your stern away from a swinging vessel coming into close proximity, or indeed if you have to weigh immediately. It should be noted that any anticipated engine shut down for maintenance at anchor, a common need during this normally quiet period, must only be considered if a safe anchor swinging distance is assured and the prevailing weather forecast is favourable. If not, the engines may well be needed quickly and they may not be ready until it is too late. A general safety allowance for larger vessels may be considered to be three cables. However, this is to be considered as a minimum and should be increased if there is to be a long duration of stay at anchorage, forecast of deteriorating weather, prolonged unavailability of engines, etc. Marking a safe swinging distance on the chart as a circle centred on the anchor position and not the vessel's position will be a helpful indicator to judge safe proximities.

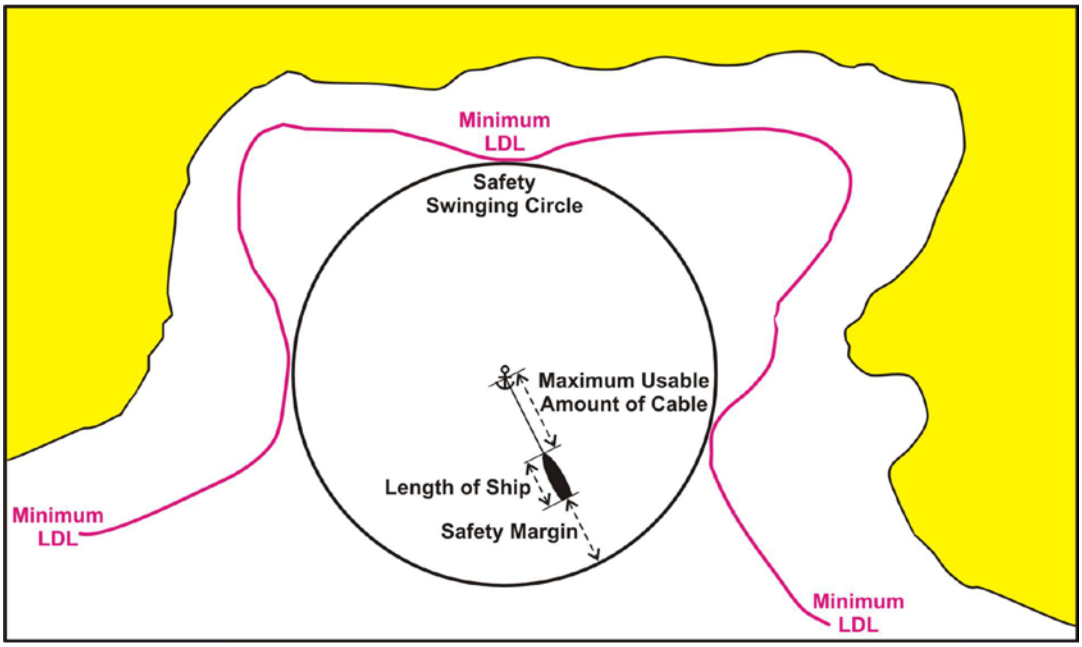

Figure 2 – Safe swinging circle. (Illustration courtesy of the Royal Navy)

Anchoring Principles

Ships anchor to the weight of the catenary in the cable and not to the anchor, length of cable, brake, stopper or any other equipment. This is a point of principle in anchoring that needs to be well understood. Neglect of understanding of this essential principle underlies many failures of anchors, cables or windlass brakes. It is worth considering this carefully for a moment, since anchoring equipment failures may be avoided if this key principle is both clearly understood and taken into account with anchoring procedures. The catenary in the cable is that length of anchor cable that curves upwards in an arc from the seabed and includes where it comes up from the surface of the sea and into the hawse pipe. Ships are best anchored to a gentle curve in this cable so most of that catenary lies under the surface of the water. It is gravity acting vertically down on this length of catenary that anchors the vessel and nothing else. If the length of cable catenary paid out for anchoring is too short, this curve is too steep for gravity to act successfully upon it. When the strain on the cable is high the anchor will be raised from lying flat on the seabed and dragged in the direction of load. The vessel will drag her anchor down tide, wind or current. Even if a long length of cable is paid out, if that cable is under high load and straight from the hawse pipe to the sea this indicates that the limit of gravity on the catenary anchoring the vessel has now been exceeded. A straight lead, whatever the length of cable, indicates it is only the anchor that is now holding the vessel and it may already be dragging. Vibration in a straight cable may exist if the anchor is dragging. Generally, a straight anchor cable lead indicates the need to pay out more cable so that a catenary curve is re-established, and gravity is restored as the principle by which the vessel is anchored to her cable. A straight cable lead is also indicative that the cable is under excessive forces, which are outside of the design parameters, (see section on Technical Constraints).

A close anchor watch, on both cable lead, weight, changes in weather and tide and of course position are basic principles that should be obvious. It must be stressed, however, that close monitoring at all times will give the earliest indication of any change of state and allow timely decisions to be made. This will avoid the inevitably poor outcomes if a close anchor watch is not maintained

Length of Cable

The length of cable needed to anchor a vessel varies according to the depth of water, the safe swinging radius needed from other vessels, length of stay, weather forecast and holding ground suitability. As a general rule for vessels anchoring in a depth of water comparable to the length of a single shackle of cable (20~25 metres of water), allow four shackles for the depth of water (4 shackles for a depth of 1 shackle). Then add an extra shackle to allow for moderate loading and catenary - one shackle length will be taken up from the gypsy to the waterline so that the 4 shackles are from the waterline to the anchor. Then consider adding an extra shackle to allow for deteriorating weather. The reader will see we arrive at 4+1+1= 6 shackles of cable for a water depth of 20~25 metres. Add another one shackle at a time for worsening factors such as long duration, holding ground warnings, history of strong squalls etc. Then consider the safe swinging distance and remember that more cable will require greater swinging distance.

The following rule of thumb formula for length of cable suited to depth of water, taken from the Admiralty Manual of Seamanship, may be helpful.

$$\textit{Amount of cable required (in shackles)} = 1\tfrac{1}{2}\sqrt{\textit{depth (in metres)}}$$

Caution must be taken when anchoring in greater depths of water than a shackle length. Deep water anchorages such as Fujairah in the United Arab Emirates may be 100 metres deep. Walking the anchor out in gear at depths above one shackle length is almost certainly necessary to avoid an anchor being carried away. Mariners should also be aware of the limitations on the strength of the windlass to recover an anchor and cable from such depths. Wear on the windlass motor over a period will certainly reduce the depths at which an anchor may be recovered. At all times vessels must be absolutely stopped for anchoring and weighing in deep water.

Preparations for Anchoring

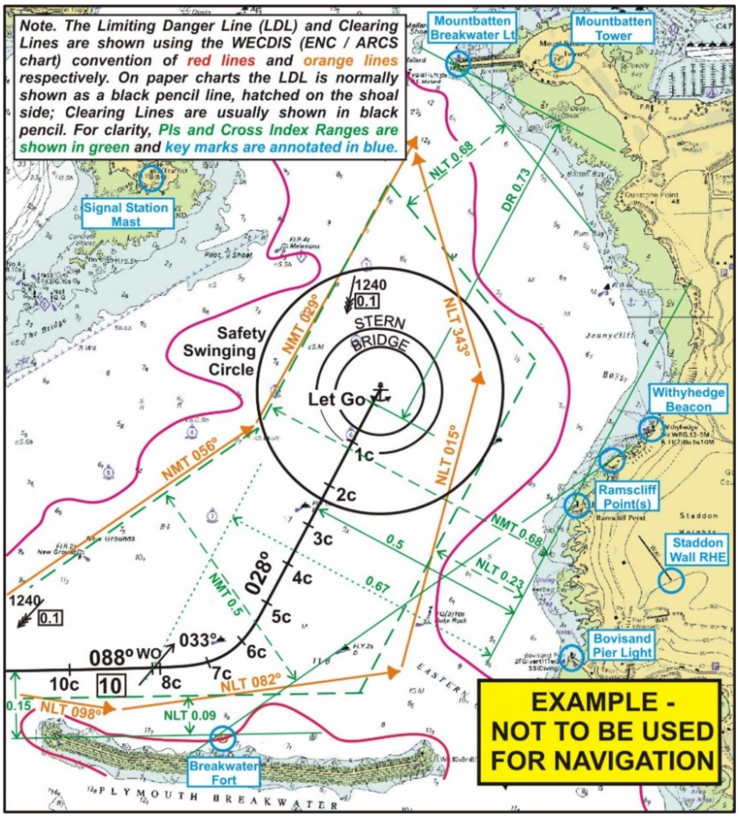

Figure 3 – Limiting Danger Lines and Clearing Lines. (Illustration courtesy of the Royal Navy)

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In preparing for anchoring the master may decide to walk the anchor back to the water line. On large vessels, in particular those which may be fitted with a large bulbous bow, and may also have a flush-decked design limiting the clearance of the anchor from the bulb, there is distinct possibility of the anchor swinging into contact with the plating in way of the bulb. This may be further exacerbated by the vessel rolling into the trough as the way is taken off. On such vessels, it is good practice to lower the anchor to a position below the waterline and more level with the vessel's keel. This is best done when most of the way is off the vessel to prevent hydrodynamic forces causing contact. Once in the lower position the anchor will be dampened in any swing by the water, and any contact with plating is likely to be by the chain and not by parts of the anchor. Penetration of the plating could go undetected, and subsequent flooding due to water ingress may result in internal and/or shell plating damage. In very large vessels carrying dense cargoes the resulting trim by the head could seriously threaten the vessel's safety. On such vessels, it is a good policy to regularly inspect shell plating in way of fore peak tanks and anchor paths to detect indentations that could lead to cracking and later failure. Of course, full enclosed entry procedures should **always** be observed during such inspections.

Letting go

Letting go and free running of anchor cable on any but small vessels, is best limited to depths of water equivalent to one shackle length or less. The weight and momentum of free running cable of any long length will tax both the centrifugal brake limiter, (if fitted), and the band brake for stopping considerably. In depths over one shackle length walking out the cable in gear to a position just above the sea bed may give a more controlled anchoring and save taxing the brake unduly. Note should be made that where an internal automatic centrifugal governor brake is fitted it is this that controls the speed of letting go and not the application of the external band brake. When releasing the external brake, it must be fully opened for free running and then fully closed to stop the cable when the necessary amount has been let go. Under no circumstances should control of the letting go speed be attempted by partial application of the band brake to slow the running out speed. This incorrect practice is known as riding the brake. The thin lining will rapidly overheat as it is not meant to be a speed friction brake like the governor. The lining will glaze smooth with the heat, may well catch fire and become completely glazed losing friction and be unable to stop the cable running out at all. The loss of the cable completely and an unsafe uncontrolled release with a real danger to personnel will result. This is a not an infrequent dangerous occurrence when riding the brake is attempted. Be warned "riding" any brake is poor practice and will lead to premature equipment failure.

Brought up and anchored

Being successfully anchored to the catenary of the cable is known as being "brought up". When the cable is paid out to bring the ship to anchor and the vessel moves aft to take the load, the cable will straighten and load with weight. The moment comes when this aft movement is then stopped, and the cable is at its highest load. After this point, the vessel should then move ahead as the gravity acting upon the catenary of the cable is greater than the momentum of the ship moving astern, and the ship starts to move ahead under the force of this gravity. The load on the cable is noted as easing and a dip in the cable is observed. This is the moment of being safely anchored and "brought up". Do note that if the load continues to be high with a straight un-dipped cable, there is the possibility that the anchor is dragging, and the ship will still be moving astern. The bridge will be able to monitor this by observing the speed over the ground and will also be able to detect whether or not the vessel has started to come ahead or is still moving astern and dragging anchor. There may be a period of stretching out any cable that lies piled up on the seabed. This period needs to be carefully observed, and patience is needed until the first signs of being "brought up" are noted with any stern way arrested. Only then is the anchoring complete.

Large Vessels

A different anchoring process applicable to large vessels is well worth noting. As the cable tension increases as the vessel is brought up, there is a transfer of energy created by the moving hull. This energy transfers through the anchor, the cable and the point on board the vessel where the windlass machinery is fixed. This peak of energy transfer can, in larger vessels, result in extreme forces at the windlass mountings. The momentum of a vessel of 200,000 tonnes displacement or more is not easily dispersed, and damage can result. One solution known as Orthogonal Anchoring has been advocated by Capt. A. McDowall in his *Nautical Institute Monograph, Anchoring Large Vessels: A New Approach*, (ISBN 1870077563, 9781870077569). Briefly, and where there is room in the anchorage to do so, the technique involves positioning the vessel across the direction of travel imposed by external forces of tide, current or wind so that the cable runs out on the beam. Even without tide, current or wind a hard-over turn will impose a sideways momentum on the vessel that will enable the anchor to run out on the beam rather than being aligned with the keel. As the cable is moderately braked then stopped, the energy, instead of all being concentrated on the windlass mounts as the cable attempts to stop the way of the vessel over the ground, is absorbed by the turning moment that results in the vessel's position becoming gradually aligned with the cable direction. As the hull aligns in this way, the peak of energy will have been dispersed in the force used to turn the hull. At this point, it may also be opportune to use an ahead movement to disperse any remaining momentum and bring the vessel to a complete stop over the ground.

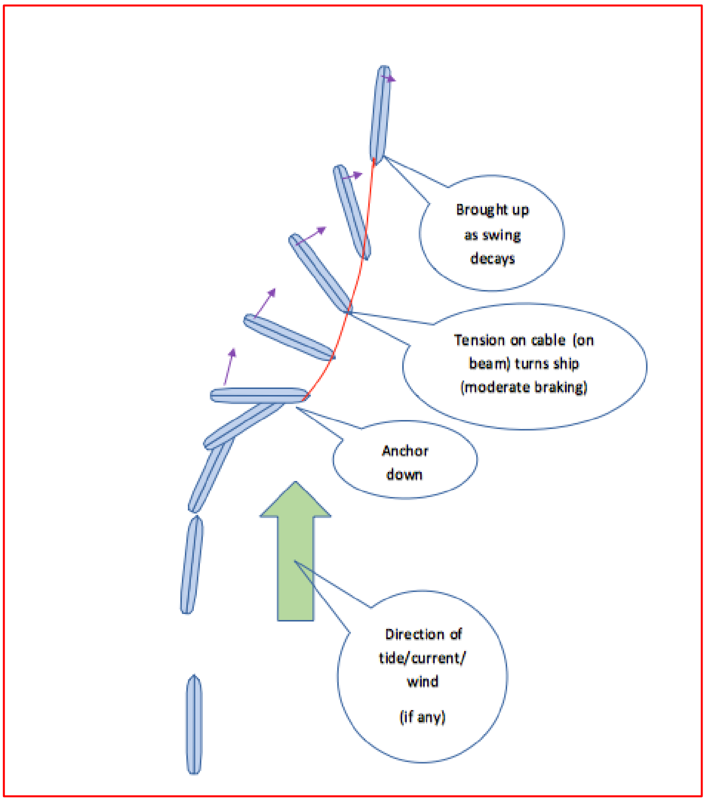

Figure 4 – Example of Orthogonal Anchoring. (Illustration courtesy of D. Barber)

Completion of anchoring

Once anchoring is complete, the anchor may be secured by screwing down the band brake and lowering the guillotine over a flat cable link, or applying whatever patent stopper is fitted on your vessel. This may require the crew to clutch in a windlass motor to adjust the exact lay of the cable links. When secured, fit a small flag pole or marker to the top of the gypsy where the cable is visible from the bridge. Note that is essential that the vessel is properly brought up, and that there is no possibility of movement of the chain prior to setting a flag. Retro-reflective tape may be used for night marking. This ensures that the cable is easily observed from the bridge and that no movement under strain takes place unobserved. Some vessels commonly practice leaving a small gap between the cable vertical link and the guillotine to test if the band brake renders onto the guillotine (a form of brake test). Others prefer to rest the vertical link against the guillotine so that although the brake is still fully applied, the main weight is taken on the guillotine. Both practices have merits and disadvantages and it is a matter of choice and practice, but using them assures an independent means of securing the cable at all times

Weakness of Equipment

Consider the weakest parts of the anchor equipment to be:

1. The windlass motor,
2. The brake,
3. The anchor.

A windlass is only rated to recover half the length of the total anchor cable vertically in deep water. In deeper water there is greater risk that an aging motor will not be able to recover the cable. When recovering the anchor cable, the windlass should only be used when the cable is "up and down", meaning only the weight of the cable is acting upon it. Use the vessel's engine to move the ship ahead, guided by reports from the forecastle of the lead of the cable, so that the cable is only recovered with its own weight on the motor. Do not heave a cable leading away from the ship as the windless could become overloaded and stall, and may well be damaged by such overloading and then no longer be capable of heaving any cable at all. Good forecastle reporting of lead direction (by points on the bow) and loading (short, medium or long stay) are essential. Careful use of engines and rudder to keep the cable "up and down" minimises the loading on the weakest part of the equipment…. the windlass motor. Effective communication with the bridge at all times is critical.

It must be stressed that there is a danger of overstressing hydraulic windlass motors, especially when trying to pick up anchors in heavy weather. Anchoring equipment is only warranted to Beaufort Force 6 which emphasises the need for masters to be proactive when the weather deteriorates, i.e. reduce strain on the anchor by sensible use of the engine(s) and pick up the anchor at an early stage before the weather deteriorates to a point where this becomes too difficult, especially when on a lee shore. There have been serious accidents when windlasses have exploded through overpressure when the hydraulic motor has acted like an over-pressured pump (there are usually no relief valves on the system).

In deteriorating environmental conditions the decision to weigh and recover anchor early is a critical one. Experience, judgement and anticipation are key. To postpone that decision and be forced to make it later in failing conditions significantly increases the risk of anchoring equipment failure.

Addition reference material may be found in the following publication - IACS Requirements concerning Mooring, Anchoring and Towing 2017 which consists of the following unified requirements;

- A1 Anchoring Equipment Corr.2 Mar 2017;
- A2 Shipboard fittings and supporting hull structures associated with towing and mooring on conventional ships Corr.2 Mar 2017; and
- A3 Anchor Windlass Design and Testing June 2017.

Securing for Sea

When securing the cable for sea, ensure the anchor is fully home and made fast with anchor lashings in good condition, strong enough for purpose, and made as tight as possible to keep that anchor from moving. A moving anchor in heavy seas is capable of fracturing the hull or, in extreme cases, punching a hole in the bow. In heavy weather, turn the vessel daily to ensure safe personnel access and inspect the anchors to ensure they remain secure. What prevents the vessel from moving in an anchorage, can sink her if it starts to move at sea.

Technical constraints

A consideration of the design technical constraints of anchoring equipment will be helpful. According to a DNV-GL article, "*Most Anchor Losses Are Preventable*" there is a general lack of awareness of the environmental loads for which anchoring equipment is designed. Class societies have unified rules for the design of anchoring equipment, but the rules are based **ONLY** upon sheltered waters. Safety Management Systems often ignore this vital fact!

The maximum environmental loads are:

Current velocity:	maximum 2.5m/s or 5 knots
Wind velocity:	maximum 25m/s or 48 knots
No waves	(sheltered waters).

Investigations into the root causes for losses of anchors have shown that, in a majority of the cases, the environmental conditions exceeded those stated above. Many anchoring locations are outside sheltered waters and an equivalent environmental load for such areas is regarded as:

Current velocity:	maximum 1.5m/s or 3 knots
Wind velocity:	maximum 11m/s or 21 knots
Significant wave height:	maximum 2m.

In broad **Beaufort** wind scale terms it is generally accepted that anchoring limits are set at **Force 6**.

Conclusions

Key points that will prevent most anchoring equipment incidents are…

1. Remember it is the catenary in the cable that anchors the ship.
2. Pay out more cable to establish catenary often re-anchors a dragging vessel **BUT**….
3. Always allow room for swinging towards other vessels. If adequate room is a concern then engines must be on immediate standby, (or alternatively heave anchor and find a safer location).
4. Never ride the band brake letting go. It **WILL** overheat and it will FAIL. Full off - Full on only.
5. Nurture the windlass motor by only ever heaving in slack cable…. It is the weakest link!
6. Keep anchors tightly secured at sea especially in heavy weather and check securing daily.
7. Always take account of the maximum environmental loads for the equipment as designated by Class.