# 10. Fittings and navigational aids


## SUMMARY

Once the basic infrastructure (breakwater, quays, slipway, etc.) has been constructed, various minor mechanical components are required to render the harbour efficient and safe. These components include safety equipment, fenders and fendering systems, mooring systems, chains, anchor systems, winches, hydrants, access ladders, marine lanterns, floating marker buoys, fixed marker beacons or lighthouses and power supply.

This chapter reviews the various types of fittings required to complete a port. The objective is to enable the reader to understand the multitude of essential components that together with the main infrastructure are required to run a port safely and efficiently.

## CONTENTS

## 10.1 FENDERING

Basically, fenders are installed to protect both vessel and quay during berthing operations; they also function as a rubbing surface during mooring to protect the vessel's sides against undue damage to its paint system.

### 10.1.1 Artisanal fenders

For solid quays, the basic fender system is the used car tyre, which can be effectively recycled into quayside fenders as shown in Figure 1. Used car tyres function properly as rubbing surfaces if the method of suspension, which may be fibre rope, chain or wire rope, does not come into contact with the vessel's hull. Figure 1 illustrates the correct way to suspend tyres for use as fenders and rubbing surfaces. If one tyre is not enough for large vessels, two tyres may be bolted together to form a thicker fender. Tyre fenders may also be placed one below the other under certain tide and weather conditions.

If the tidal variation is negligible, the cope line of a quay may also be protected by strips of timber placed along the outer edge as shown in Figure 2. The timber may be bolted directly to the concrete or inserted in between galvanized angles, themselves bolted to the concrete, Figure 3.

FIGURE 1
**Rubber tyre fender**

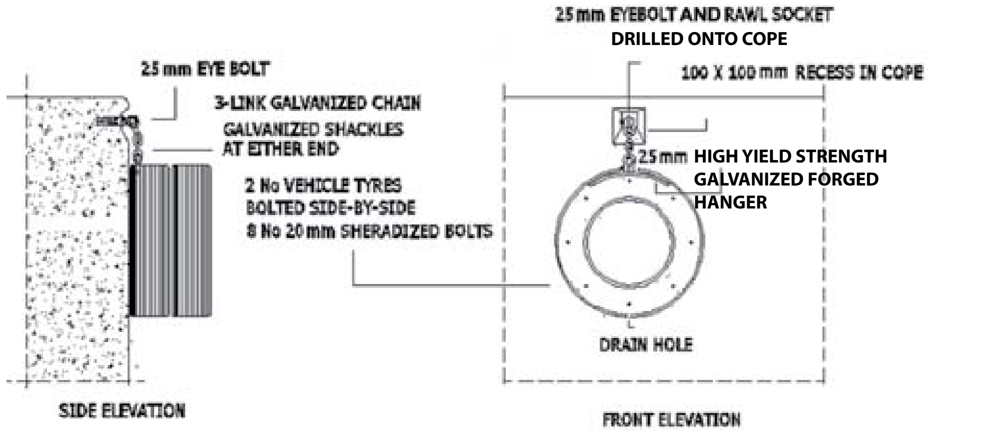



FIGURE 2
**Timber coping and strip fender**

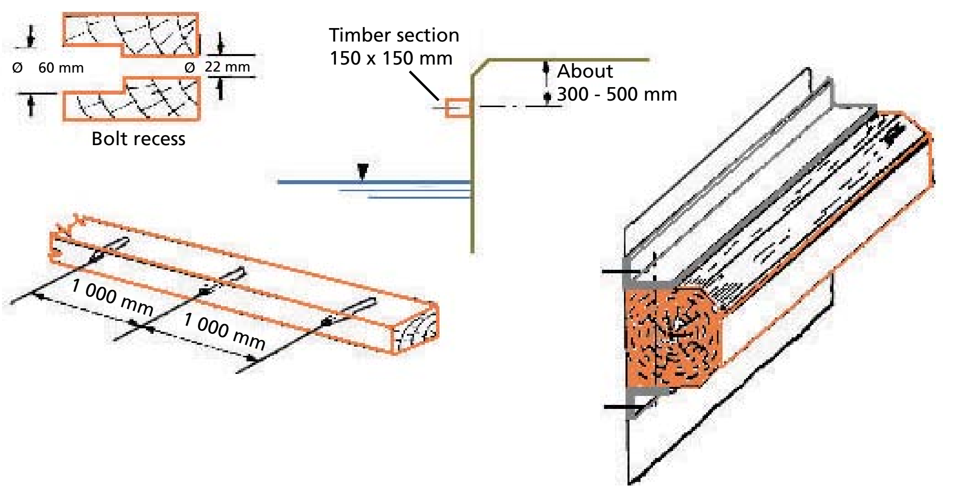
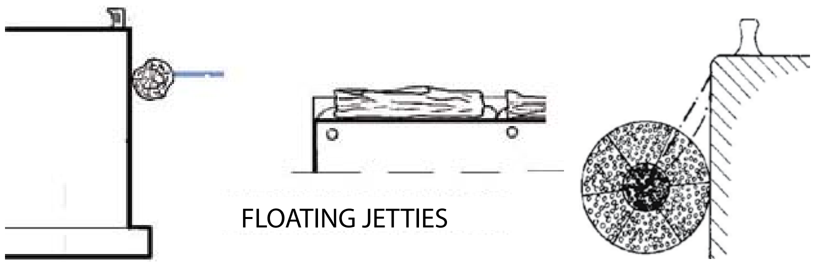


FIGURE 3
**Timber strip fender on a sheet-piled quay**


FIGURE 4
**Other types of fenders in natural materials**




In some tropical countries where large timber plantations may be available, forest brushwood or whole log fenders may also be used, Figure 4. Log fenders (left) are particularly useful on floating structures. The brushwood fenders (right) may be rolled into a fascine (with natural or man-made fibres) with a minimum diameter of 500 mm (no metals) and suspended in front of the quay.

### 10.1.2 Other fender types

Open piled jetties also need protection against accidental impact. In a piled structure, not all the structural components may be designed to absorb side impacts, especially in the presence of a large tidal variation. The vertical piles holding up a jetty deck, for example, must not be impacted sideways as this will result in permanent damage to the structure. Piled jetties are generally designed in such a way that the heavy concrete deck absorbs the impact from the fender system and then transmits this energy to the raked piles situated along the rear of the deck (see Figure 15 in Chapter 8). However, with lighter structures, especially finger jetties, a separate timber pile must be installed to transmit the side impact to the deck and protect the supporting piles, Figure 5.

FIGURE 5

**Open piled structures**

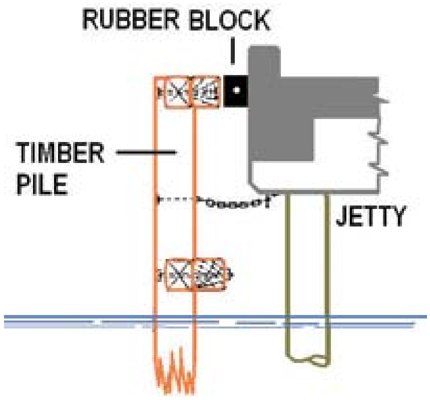
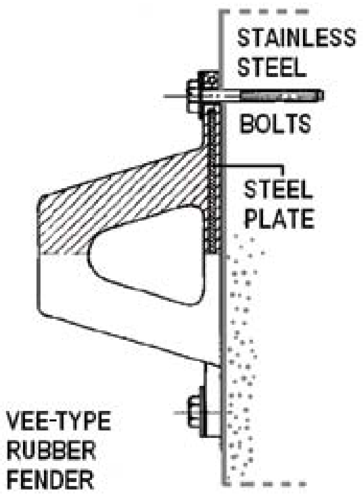



FIGURE 6

**VEE-type rubber fender**




Nowadays, moulded rubber sections have become the industry standard in most ports. These fenders may be solid plain square sections, hollow cylindrical sections, flat slabs or VEE-type sections, Figures 6.

The most common section in use is the VEE-type moulded section. This section incorporates a sheet of steel sealed inside the rubber base as an aid to anchoring. The section is bolted straight onto the concrete surface via stainless steel bolts.

The VEE-type fenders may be placed horizontally as illustrated, or vertically when the tidal variation exceeds about 500 mm. This fender comes in a range of cross sectional sizes and may be ordered to any length up to 6 metres. Although this type of fender is more expensive than other types of fenders, it is maintenance-free and has a long useful life. When installing fixed rubber fenders, careful consideration must be given to areas where:

- the moored vessels carry exposed riggings, as these may damage the fender; and
- the vessels have their own steel belt fenders just above the waterline as these may also damage the fender.

The suspended hollow cylindrical rubber sections, illustrated in Figure 7, are no longer used due to their high maintenance costs. The chains and chain anchor points tend to corrode and snap.

Sliding fenders, as opposed to soft rubber fenders, consist of relatively thin slabs of UHMW polyethylene (ultra-high molecular weight) plastic. This hard plastic is very tough and has a very low coefficient of friction, enabling vessels to slide along without sustaining damage. It affords the best protection to the concrete cope. The slabs are bolted directly to the concrete and cover most of the exposed vertical surface of the deck, Figure 8.

FIGURE 7
**Suspended hollow cylindrical sections**

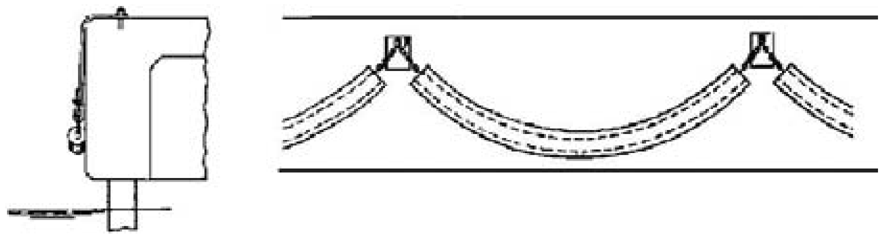
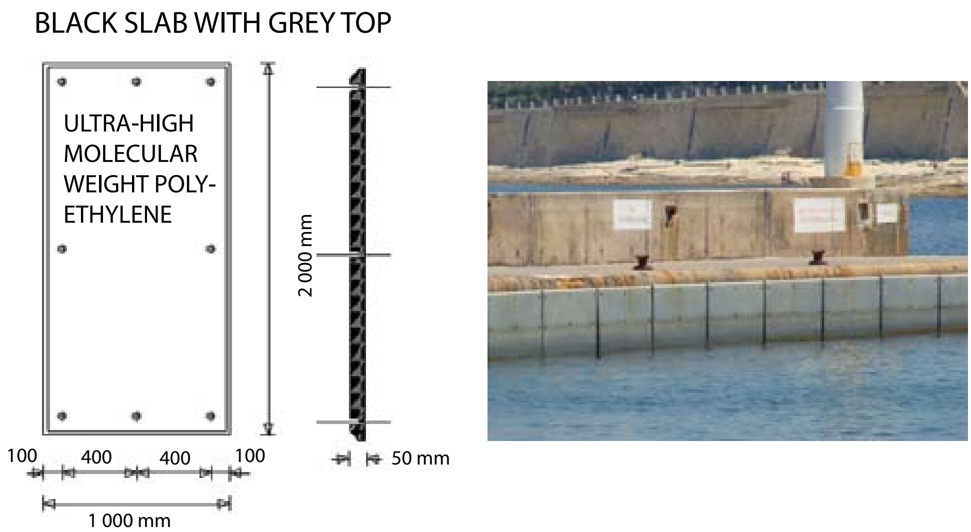


FIGURE 8
**Sliding slab fenders**

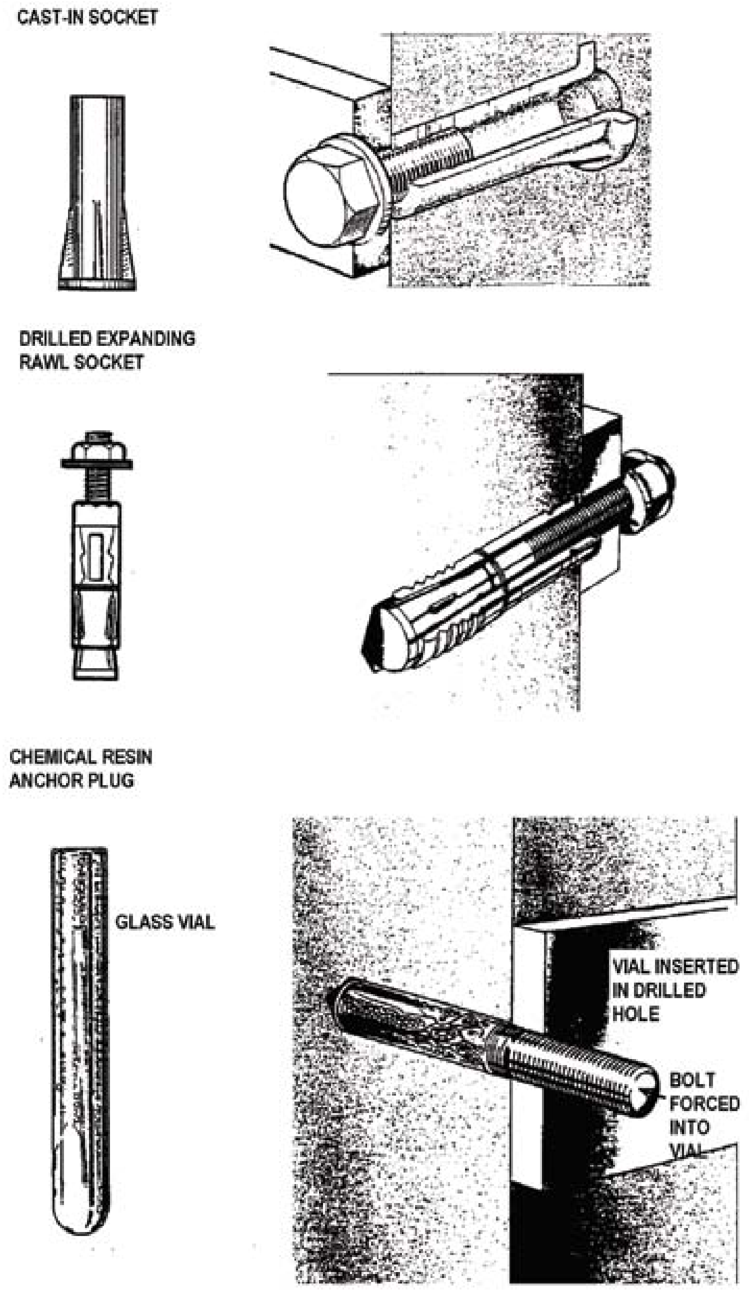



## 10.1.3 Anchor bolts

Most fittings are anchored into the concrete with bolts. Anchor bolts may consist of permanent bolts embedded in concrete (which cannot be removed) or fixed bolts (which may be undone at a later stage). Figure 9 illustrates the standard type of fixings generally used, both during construction and post-construction.

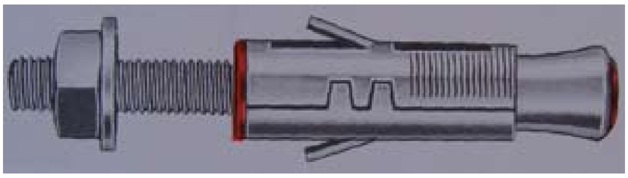
Figure 9 illustrates the cast-in plug, the expanding rawl socket and the chemical resin anchor plug, respectively. The cast-in plug (steel or high-density polyethylene [HDPE]) is generally included in the cast during concreting by a bolt passing through the formwork. The rawl socket is placed inside a hole predrilled in the concrete. The chemical resin plug is a glass vial with a polyester compound. It is inserted into a predrilled hole and a bolt pushed through it, rupturing the vial and setting off the chemical reaction to cement the plug.

FIGURE 9
**Anchor bolts**




Typical characteristics of drilled expanding rawl sockets are shown in Figure 10. The pull-out values of the sockets in this figure refer to a base concrete strength of 30 N/mm$^2$ and tightening torques as specified by the manufacturer. No factor of safety included.

FIGURE 10
**Typical pull-out strengths of expanding rawl sockets (courtesy Fischer)**



| Diameter of bolt (mm) | Diameter of hole for socket (mm) | Depth of hole or socket length (mm) | Typical pull-out strength (kg) |
|---|---|---|---|
| 6 | 12 | 60 | 1 600 |
| 8 | 15 | 70 | 1 800 |
| 10 | 18 | 80 | 2 370 |
| 12 | 22 | 100 | 3 520 |
| 16 | 29 | 130 | 7 360 |
| 20 | 36 | 170 | 9 830 |
| 24 | 42 | 210 | 15 050 |

FIGURE 11
**Typical pull-out strengths of polyester resin plugs (courtesy Wurth)**


| Diameter of stainless steel bolt (mm) | Diameter of hole for glass vial (mm) | Depth of hole or length of vial (mm) | Typical pull-out strength (kg) |
|---|---|---|---|
| 6 | 10 | 80 | 2 300 |
| 10 | 12 | 90 | 3 470 |
| 12 | 14 | 110 | 5 500 |
| 16 | 18 | 125 | 9 700 |
| 20 | 24 | 145 | 12 600 |
| 24 | 28 | 180 | 20 800 |

Typical characteristics of chemical resin sockets are shown in Figure 11.

The pull-out values of the chemical plugs in the above table are breakout values without a factor of safety and refer to a base concrete strength of 30 N/mm$^2$. The setting time at an ambient temperature of 20 °C is 30 minutes; at 15 °C the setting time is 60 minutes.

## 10.2 BOLLARDS

Vessels require bollards to moor alongside a quay; bollards may also be replaced with mooring rings for small- to medium-sized vessels. Mooring rings offer the following advantages over the more conventional bollards:

- they are cheaper than bollards;
- they keep the quay free of mooring lines; and
- mooring lines do not chafe on the cope edge.

Ideally, mooring rings should be set in the concrete cope during construction as illustrated in Figure 12. Mooring rings may be cast proud of the cope line (not suitable for harbours with appreciable tidal variations) or recessed into the cope (suitable for areas with tidal variations).

For medium to large vessels, the mooring rings should be manufactured to specific standards regarding pull-out strength, as illustrated in Figure 13.

FIGURE 12
**Artisanal mooring ring (0.5 tonnes)**

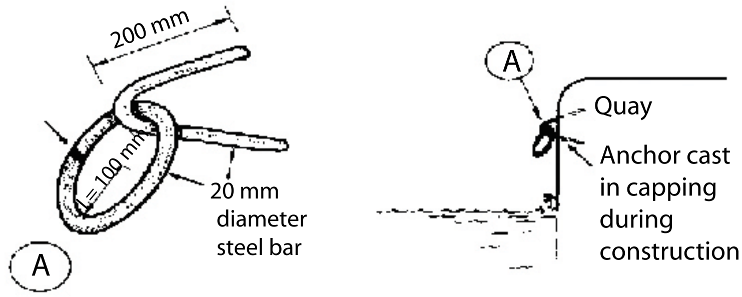
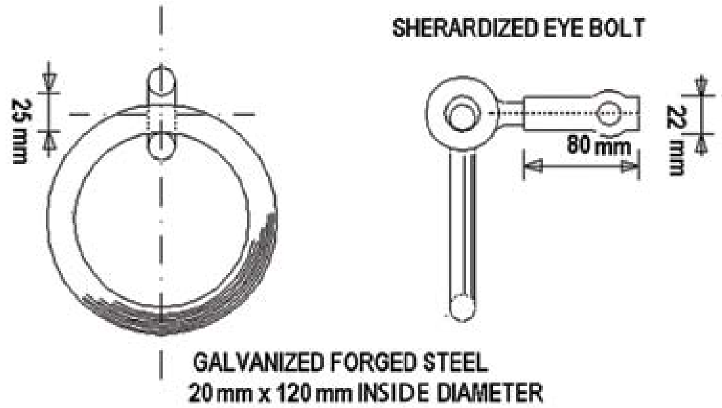



FIGURE 13
**Heavy-duty mooring ring (1 to 2 tonnes)**




Mooring rings should be installed every 2.50 metres or less. In areas where sea swell is predominant, vessel surge often leads to failure of the eye bolts by fatigue and proper vertical bollards should be considered.

Berths which are heavily used by large vessels and where swell is predominant should be equipped with proper bollards or a combination of bollards and mooring rings. Bollards may be constructed from welded pipe sections or purchased in cast iron, Figure 14. Figure 15 presents an illustration of 5- and 10-tonne pipe bollards and Figure 16 of mushroom bollards.

FIGURE 14
**Artisanal pipe bollards**

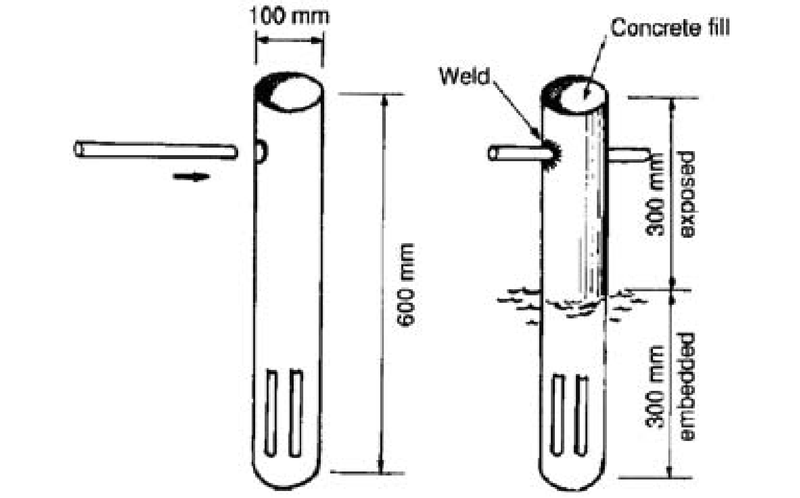



FIGURE 15
**5-tonne and 10-tonne pipe bollards**

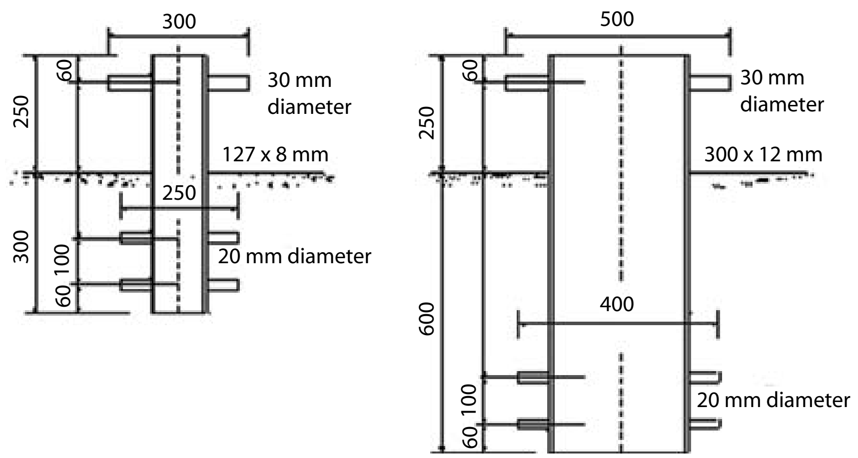
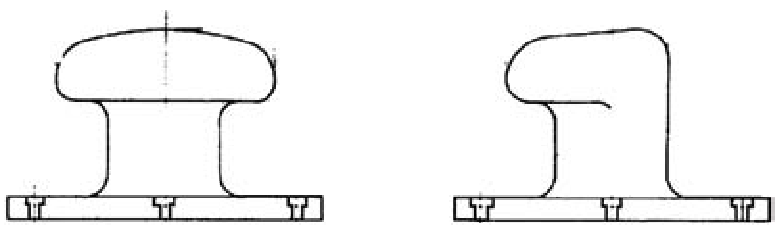



FIGURE 16
**25- to 50-tonne cast iron mushroom bollards, also produced in the 1- to 5-tonne range for small vessels**



## 10.3 CHAINS

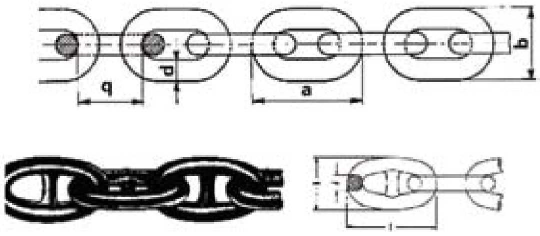
Mooring chain is manufactured from four different internationally accepted qualities of steel, designated grade 2, grade 3, oil rig quality (ORQ) and grade 4. Chain of grades 2, 3 and 4 is manufactured to Classification Societies Specification, like Lloyd's Register, and ORQ chain is based on the American Petroleum Institute's specification. Grade 1 chain is no longer manufactured. Grade 2 chain is the lowest quality chain

manufactured. Grade 3 chain is the most common grade used in marine construction and is only marginally more expensive than grade 2. Grade 2 chain is significantly heavier than a grade 3 chain for a comparable breaking load.

Chain is manufactured in lengths of 27.5 metres, also known as shots. Chain can be ordered with or without inserted studs (studless). In order to maintain the same strength, the diameter of studless chains (i.e. open links) needs to be 20 percent greater than that of stud link chains.

Chain fittings to connect lengths of each or other items, such as anchors or buoys, are illustrated in Figure 18.

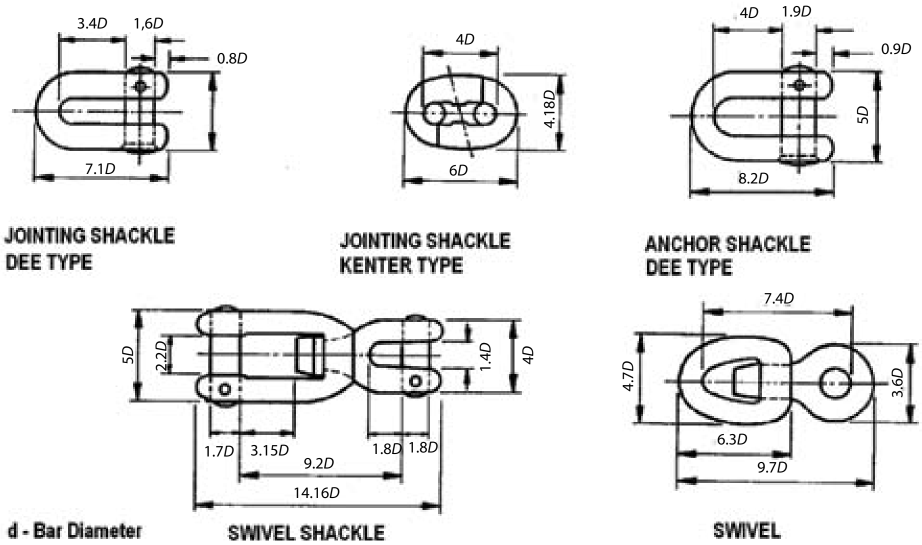
FIGURE 17
**Studless chain (top) and stud link chain (lower)**



**Typical characteristics of studless chain**

| Diameter d (mm) | a (mm) | b (mm) | q (mm) | Breaking load | Weight |
|---|---|---|---|---|---|
| 5 | 28 | 17 | 18 | 0.9 tonnes | 0.52 kg/m |
| 6 | 33 | 20 | 21 | 1.30 | 0.74 |
| 8 | 44 | 27 | 28 | 2.30 | 1.33 |
| 10 | 55 | 34 | 35 | 3.60 | 2.08 |
| 12.5 | 69 | 43 | 44 | 5.50 | 3.25 |
| 14.5 | 80 | 49 | 51 | 7.50 | 4.37 |
| 16 | 88 | 54 | 56 | 9.10 | 5.32 |
| 17.5 | 96 | 60 | 61 | 10.90 | 6.36 |
| 20.5 | 113 | 70 | 72 | 14.90 | 8.77 |
| 22 | 121 | 75 | 77 | 17.20 | 10.00 |
| 24 | 132 | 81 | 84 | 20.40 | 11.90 |

FIGURE 18
**Standard chain fittings**



## 10.4 ACCESS LADDERS

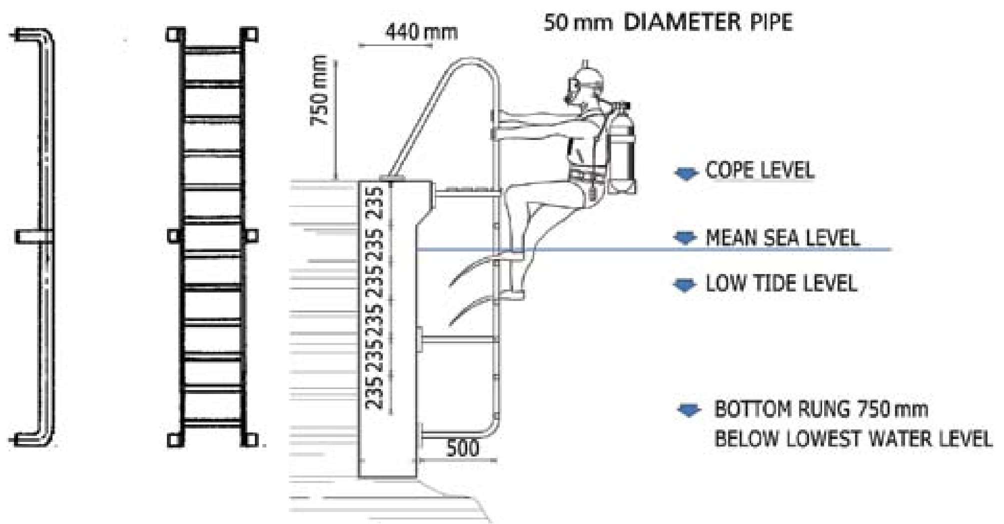
Where required, access ladders should be provided for pedestrian access to the quay from a rowing boat, small fishing vessel or vessel tender, especially inside harbours with a large tidal variation. Figure 19 shows a typical ladder made from welded steel, which should be recessed inside the cope line to prevent it from being damaged by moored vessels. Each ladder point should also be equipped with two mooring rings, one on either side of the ladder, to enable rowing boats or canoes to be moored from inside the vessel.

Maintenance (scrubbing) and underwater inspections (sacrificial anodes) of vessels are very often carried out by divers offering such services. It is hence useful to also install a diver's exit ladder to enable fully-kitted divers to exit the water safely. Such ladders should also be recessed inside the cope. If this is not possible, then they should be tucked away in a quite corner away from vessel movements.

The stringers (the vertical members) should be 180 mm wide x 20 mm thick in mild steel. The length should be equal to the height of the cope from lowest tide level. The rungs should be made from 30 mm diameter steel bars welded to the stringers at 300 mm intervals. The width of the ladder from stringer to stringer should be at least 500 mm. Mild steel cleats should be provided at both ends. If the ladder is longer than 3 metres, intermediate cleats are also required. The whole ladder assembly should be heavily galvanized just prior to placing, i.e. when all surface work on the ladder (welding and drilling) has been terminated.

Access ladders are also produced in 40 mm diameter stainless steel pipe, polyester resin (PE) and HDPE.

FIGURE 19
**Simple access ladder (left) and a diver's exit ladder (right)**




## 10.5 HYDRANTS

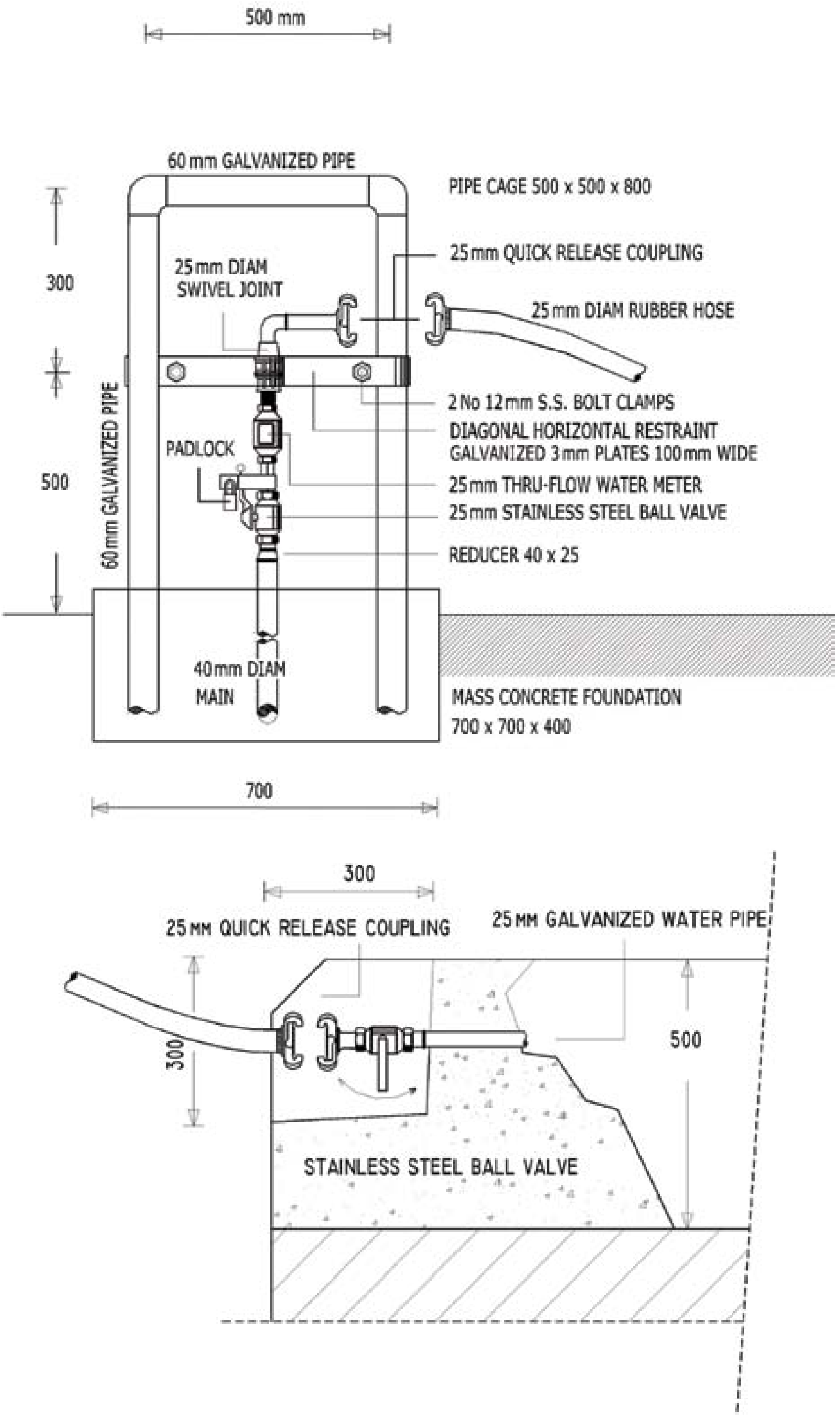
Water hydrants should be provided at the quay side for the hosing down of boxed fish, vessel decks, equipment, etc. The hydrants may be freshwater or seawater, depending on the local water supply conditions. Freshwater hydrants should supply drinking-quality water whereas the seawater hydrants should supply clean seawater drawn from a borehole outside the port basin area. Harbour basin water should never be used on-board moored vessels.

All seawater systems should be separate from freshwater systems and the pipework clearly marked and colour coded. All pipework for both systems should be in HDPE

plastic and all fittings (swivel joints, quick-release couplings, ball valves, hydrants) suitable for seawater operating conditions and made from HDPE with stainless steel or bronze components. All exposed HDPE plastic should be resistant to ultraviolet.

Figure 20 top, shows an above-ground hydrant. Above-ground hydrants should not be placed too close to the cope line as this would interfere with mooring and unloading

FIGURE 20
**Above-ground hydrant (top) and quay-side hydrant (bottom)**



operations. This type of hydrant consists of a strong square cage in 60 mm diameter galvanized pipe (not welded) embedded in a concrete foundation block. The standpipe is fixed but can rotate through 360° by means of a swivel joint attached to the ball valve. The end terminates in a quick-release coupling to which various hoses may be attached (shipboard hose, market hose, auction hall hose, etc.) for hose-down operations. The supply may be metered. Figure 20, bottom, shows a simple quay-side hydrant suitable for small harbours serving small artisanal vessels. In this case, the hydrant is placed at the edge of the quay inside a small recess. A quick-release coupling engages directly to the ball valve. The flexible hoses leading from the hydrants to the various work areas should be sturdy enough to withstand abrasion and direct sunlight. Plastic garden-hose types are not suitable on both counts. Although more expensive, reinforced rubber hoses should be used as these last much longer and are unlikely to split open as plastic ones do.

## 10.6 CAPSTANS AND WINCHES

Mechanical winches are required in ports and landing areas to haul vessels out of the water, whether on to a simple beach or up on a slipway.

### 10.6.1 Artisanal winching systems

In areas where vehicles have easy access to the beach area, a four-wheel drive vehicle or agricultural tractor plus a length of rope passed through a snatch block tied to a tree is the easiest and most economical way to haul a vessel on to the beach, Figure 21.

If the beach is in a remote area or not accessible to vehicles, artisanal capstans should be installed. These range from the very simple type, Figure 22 left, to the more advanced type constructed from steel sections welded together, Figure 22 right. The simple type depends on its own self weight (normally a concrete block) for stability, whereas the

FIGURE 21
**Beach accessible to vehicles**

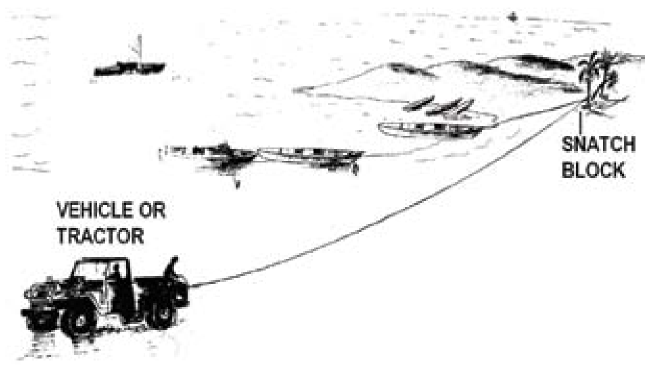
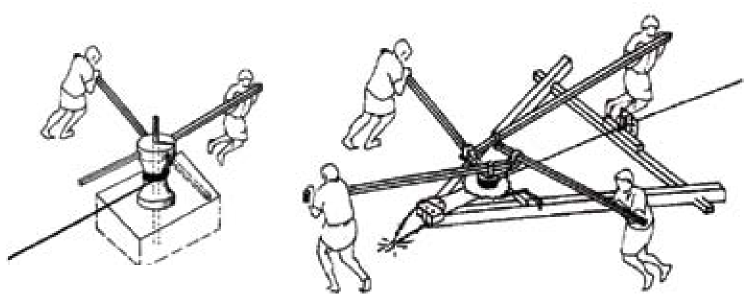


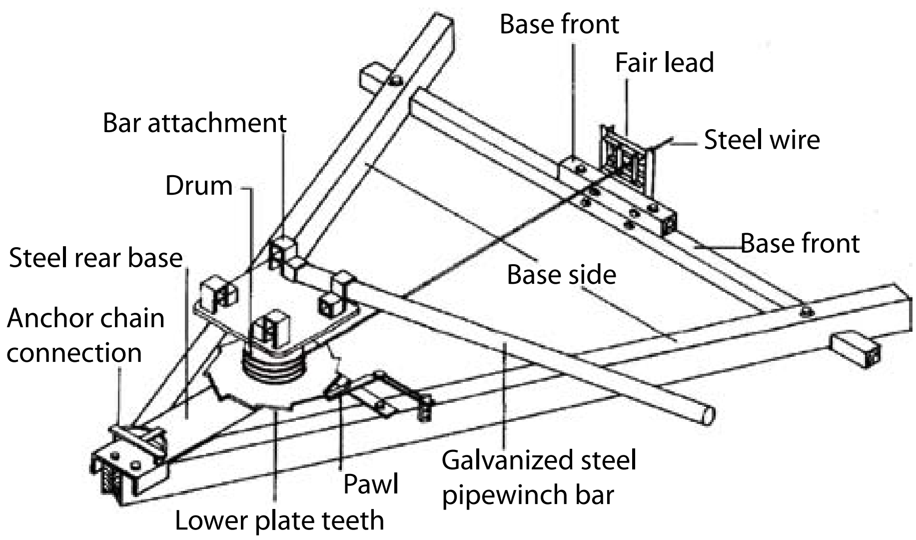

FIGURE 22
**Simple winch (left) and a workshop-manufactured frame capstan**



advanced frame capstan is very light (can be moved from one area to another) but digs itself into the sand and may be anchored by pegs.

The simple capstan may be constructed from locally available materials, such as oil drums, large diameter tree trunks, oars and concrete. Frame capstans, on the other hand, should be constructed in a proper workshop equipped with welding and cutting equipment. Figure 23 illustrates the technical details of the frame capstan.

FIGURE 23
**Technical details of a frame capstan**




## 10.6.2 Mechanized winching systems

Mechanical winches generally consist of a horizontal drum coupled to a set of reduction gears via a powered drive (Figure 24). The type of power drive is entirely dependent on the availability of electricity at the site of the slipway. Electric and hydraulic motors are the preferred systems as they are generally low in maintenance (Figure 25); diesel or petrol require considerably more maintenance and stocks of spare parts. The winch comes with a sturdy mounting which should be bolted to a concrete foundation block according to the manufacturer's instructions.

FIGURE 24
**Mechanical winches**

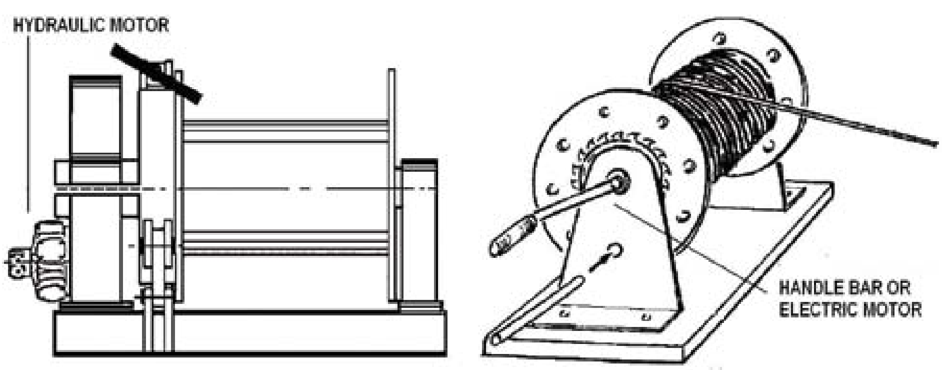


FIGURE 25
**Electric-powered 10-tonne pull winch awaiting installation**

**Typical characteristics of heavy-duty hydraulic winches**

| Pull (tonnes) | Low speed (metres/minute) | High speed (metres/minute) | Rope size (mm) | Rope length (metres) | Weight (kilograms) |
|---|---|---|---|---|---|
| 9.0 | 21 | 42 | 24 | 200 | 2 000 |
| 11.5 | 21 | 42 | 28 | 220 | 2 300 |
| 14.0 | 21 | 42 | 28 | 220 | 2 400 |
| 18.0 | 21 | 42 | 32 | 280 | 3 200 |

## 10.7 TROLLEYS

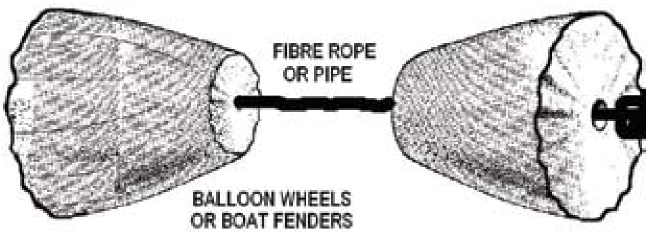
Beached vessels can be pulled straight up a beach by a strong winch with the keel sliding directly on the sand. The pulling power required can however be drastically reduced by using rollers under the vessel's keel to reduce the friction of the keel on the sand and the abrasion on the paint finish. Large vessels on slipways require a cradle or trolley and cannot be hauled up on their keel.

### 10.7.1 Rollers

The simplest type of artisanal roller is a section of tree trunk. However, the larger the diameter of the roller, the less effort is required to move a vessel on sand. To overcome this problem, balloon wheels in rigid plastic are now available, Figure 26.

The wheels can be attached by a rope or by a rigid pipe to form a cradle as shown in the figure.

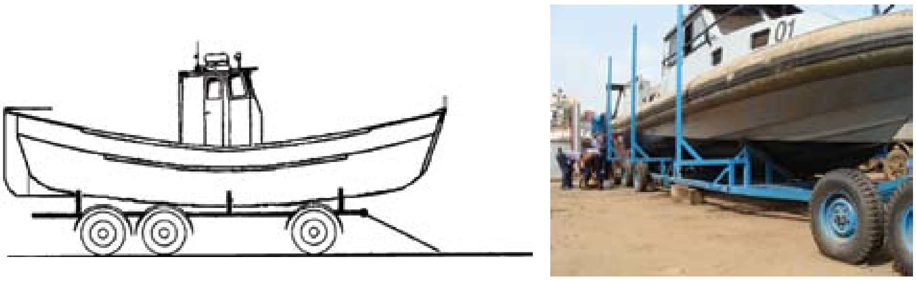
FIGURE 26
**Balloon wheel rollers**




### 10.7.2 Trailers

Boat trailers able to travel on a paved road are normally used for vessels of intermediate size up to a length of around 20 metres. Trailers may be purpose built or converted from old truck chassis. Figure 27 illustrates a fisheries patrol vessel on a custom-built trailer. A major problem with trailers is the corrosion of the wheel axle bearings and it is not uncommon for trailers to lose wheels during long road journeys.

FIGURE 27
**Rubber-tyred boat trailers**



### 10.7.3 Steel cradles

The boat cradle or trolley, illustrated in Figure 28, consists of a frame made up from steel channels, typically 300 mm high, welded back-to-back with cast-steel wheels fixed in between. On top of this frame sits another frame, rendered horizontal by means of spliced channels. On top of this horizontal frame sit the sliding racks which slide inwards and outwards to adjust to the vessel's dimensions.

FIGURE 28
**Steel cradles**

Timber keel blocks are bolted to the horizontal frame to permit the vessel's keel to come to rest in contact with timber. The typical length of the lower frame may be up to 25 metres and the width varies with the local vessel sizes. The wheel axles should not be placed more than 2 metres apart. The rear end of the lower frame should be provided with a pawl and rack arrangement in order to stop the cradle running back into the water should the hauling wire rope break during a slipping operation. The wire rope should be attached to the cradle via an appropriate shackle connected to a bolted anchor point on the lower frame. Depending on the size and weight of vessels to be serviced, the cradle wheels may be in steel or UHMW polyethylene. With vessels not heavier than 5 tonnes, solid plastic wheels running on a smooth concrete surface may be used. For heavier vessels, steel bogies running on steel rails anchored to concrete beams should be used.

## 10.8 ROPES

Both wire and fibre ropes are utilized around a fishing port. Wire ropes are normally used on slipways and on hauling drums aboard trawlers whereas fibre rope is used to moor vessels.

### 10.8.1 Wire rope

Wire ropes generally consist of a number of bundles made up of individual steel strands of differing diameters and bundled together to form a thick rope. The central core may consist either of an oil-impregnated fibre or more steel strands or a mixture of both.

Winches generally require what is known as a 216 + 1 wire rope (rope diameters up to 26 mm) or a 216 + 49 wire rope (rope diameters from 28 mm to 40 mm and used on most powered winches). A 216 + 1 wire rope consists of 6 bundles of strands + 1 fabric core; each bundle, in turn, consists of 37 strands of steel of varying diameters, which together form a very compact cross-section. A 216 + 49 wire rope consists of 6 bundles of strands + 1 central bundle; each bundle consisting of 36 strands of steel of varying diameters; the central bundle is made up of 49 strands. Wire ropes meant for use in a slipway should be made of galvanized steel strands.

Wire rope is very expensive and requires good care in handling and maintenance. The correct size of the rope must be used when ordering attachments such as pulleys and Figure 29 illustrates the correct way to measure rope diameter.

A new wire rope should be unreeled from an idle spool holder as shown in Figure 30. It should never be unwound from a static spool.

To ensure that the wire rope spools on to the drum without chafing, the distance of the winch drum from the first static pulley should be such that the subtended angle at the pulley does not exceed 2° as shown in Figure 31.

FIGURE 29
**Measuring the diameter of a wire rope**

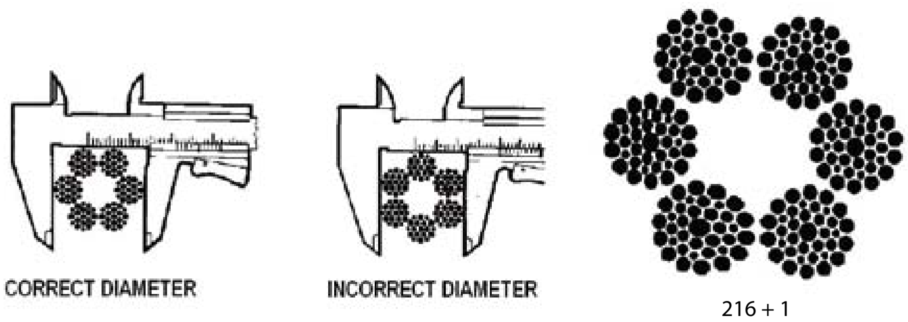



FIGURE 30
**Unwinding a reel of wire rope**

To ensure maximum durability, the minimum diameter of a winch drum or pulley should not be less than 25 times the diameter of the wire rope as measured in Figure 29 (that is, a 28 mm rope should not be wound round a drum or pulley with a diameter less than 25 x 28 = 700 mm). To use a drum that is, for example, half the recommended size (say, only 12.5 times the diameter of the rope), the rope should be subjected to only 80 percent of its recommended maximum load. Wire rope should never be allowed to scrape the ground or chafe over metallic objects, such as rails or metallic sleepers; timber sleepers or rollers should always be placed under wire ropes.

Wire rope should never be threaded through shackles without thimbles and the thimble size should be adequate for the rope diameter, Figure 32.

Figures 33A and 33B show unseated strands resulting from wire ropes being twisted or warped by pulleys that are too small.

Figure 33C shows kinks in a wire rope developed by abrupt loads or jerks. Figure 33D shows the result of a rope that was overloaded and Figures 33E and 33F wire ropes that were bent around very small diameters such as shackles.

FIGURE 31
**The minimum winching distance**

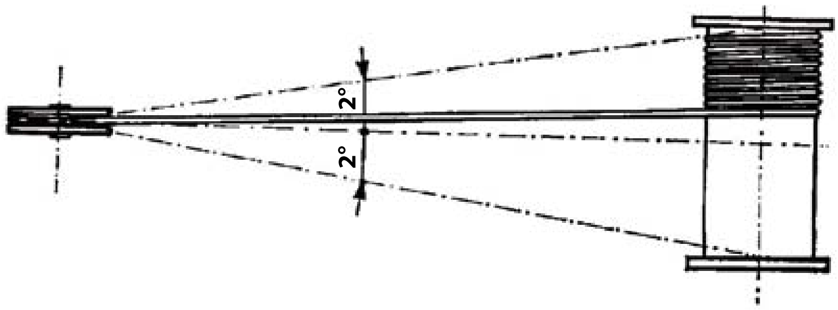



FIGURE 32
**Correct use of thimbles**

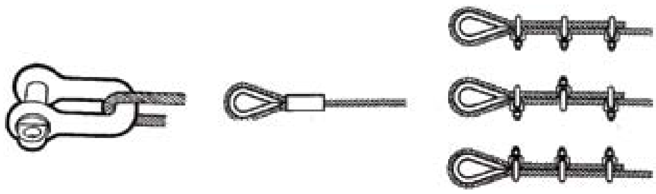
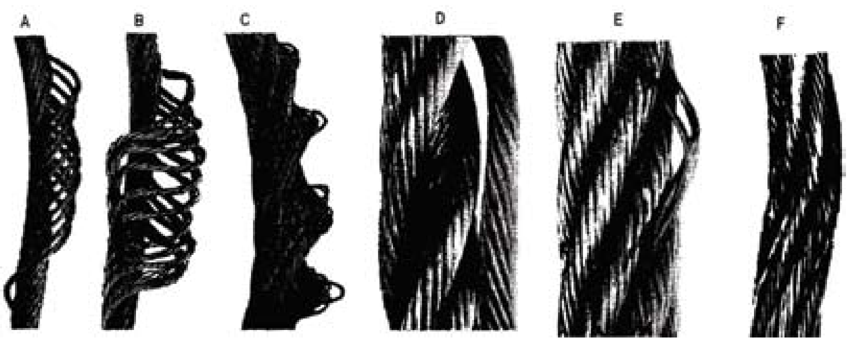


FIGURE 33
**Damaged wire rope**



Corroded ropes should be replaced immediately as should wire ropes showing definite signs of fatigue, such as broken strands, pulled strands, uneven wear, strongly visible kinks.

Wire ropes are supplied with specific strength characteristics, the most important of which is the safe working load, or SWL. The safe working load is the maximum load that the wire rope can carry without damage to the steel fibres divided by a factor of safety. The factor of safety for wire ropes ranges between 5 and 8 and depends on a number of factors, such as the equipment using it (winch, crane, elevator) and the country's national health and safety code requirements (Table 1).

The typical equivalent SWL for a 216 + 1 wire rope is much smaller than that for 216 + 49 shown in the above table; this means that for the same load requirements, using a 216 + 1 wire rope implies using a thicker rope, which in turn means using a larger diameter pulley, drums and fittings in general.

TABLE 1
**Typical safe working load for a 216 + 49 wire rope**

| Diameter (mm) | Safe working load (tonnes) | Weight (kg/metre) |
|---|---|---|
| 20 | 6.80 | 1.68 |
| 22 | 8.20 | 2.05 |
| 24 | 9.40 | 2.40 |
| 26 | 11.20 | 2.83 |
| 28 | 13.0 | 3.28 |
| 30 | 15.0 | 3.75 |
| 32 | 16.40 | 4.25 |

### 10.8.2 Fibre rope

Fibre ropes come in a vast range of materials each with differing mechanical characteristics (Table 2). The materials available are nylon, polyester, polypropylene and polyethylene.

Nylon rope is very elastic and when under load it stores considerable energy. This characteristic makes it ideal for use as springs in mooring lines in the presence of ocean swell, avoiding jerking, and sudden loads on the bollards or mooring rings.

Polypropylene rope is not elastic and is not affected by seawater. Polyethylene rope has very good abrasion and does not absorb water. It is not as strong as polypropylene.

Polyester rope displays excellent fatigue life and has a low water absorption rate. Polyester rope is moderately elastic.

TABLE 2
**Characteristics of commonly used fibres**

| Property | Nylon | Polyester | Polypropylene | Polyethylene |
|---|---|---|---|---|
| Specific gravity | 1.14 | 1.38 | 0.91 | 0.95 |
| Floats | No | No | Yes | Yes |
| Continuous fibres | Common | Common | Not available | Common |
| Short fibres | Not common | Not common | Not available | Not common |
| Monofilament | Not common | Not common | Common | Not common |
| Combustion | Melts and forms yellow droplets | Melts and burns bright | Melts and burns pale blue | Melts and burns pale blue |
| Colour of smoke | White | Black | White | White |
| Smell | Fishy | Oily | Candle wax | |
| Residue | Yellow droplets | Black droplets | Solid droplets | Brown droplets |

Table 3 presents the breaking strengths generally quoted as the minimum strength of the rope, excluding any factors of safety that may be applicable locally.

TABLE 3
**Typical breaking strengths of some sizes of rope**

| Material | Diameter (mm) | Weight (kg/100 metre) | Breaking strength (kg) |
|---|---|---|---|
| Polyethylene monofilament | 24 | 27.40 | 6 100 |
| Polypropylene split fibre | 24 | 26.0 | 7 600 |
| Nylon | 24 | 37.50 | 12 000 |
| Polyethylene monofilament | 28 | 37.30 | 8 030 |
| Polypropylene split fibre | 28 | 35.50 | 10 100 |
| Nylon | 28 | 51.0 | 15 800 |
| Polyethylene monofilament | 32 | 48.70 | 10 400 |
| Polypropylene split fibre | 32 | 46.0 | 12 800 |
| Nylon | 32 | 66.50 | 20 000 |

## 10.8.3 Fibre slings

With the advent of the mobile gantry, fibre slings are widely used in most boatyards (Figure 34 and Table 4).

FIGURE 34
**Fibre slings**

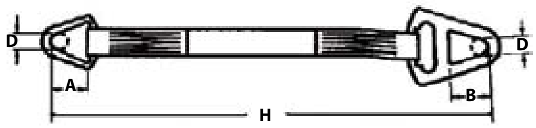




TABLE 4
**Typical characteristics of fibre slings**

| Material | Width (mm) | Safe working load (factor of safety of 6) (kg) |
|---|---|---|
| Polyamide | 50 | 1 080 |
| Polyamide | 100 | 2 000 |
| Polyamide | 150 | 2 600 |
| Polyamide | 225 | 3 600 |
| Polyester | 50 | 720 |
| Polyester | 100 | 1 440 |
| Polyester | 150 | 1 800 |
| Polyester | 200 | 2 160 |

## 10.9 ROPE AND CHAIN FITTINGS

### 10.9.1 Sheaves and snatch blocks

Sheaves (or pulley blocks with two to four pulleys inside the same block) and snatch blocks are required to increase the pull from a winch to cover a whole range of vessel sizes (Figure 35). A small 5-tonne vessel may be hauled directly on a 10-tonne pull winch, but a 100-tonne vessel (which may need a 20-tonne pull) has to be hauled through a system of sheaves if the winch cannot produce more than 10 tonnes of pull.

Utilizing the appropriate wire rope diameter, ropes should seat properly in a pulley as shown in Figure 36 below. The throat diameter D of the pulley should correspond to the rope diameter as measured in Figure 29.

FIGURE 35
**Snatch block (left) and a sheave (right)**

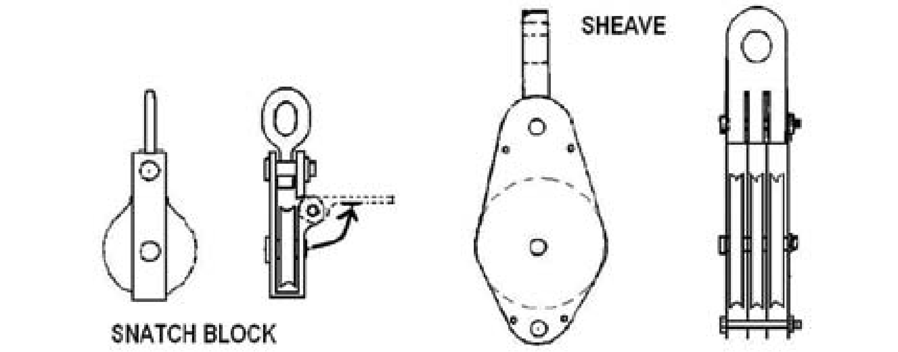



FIGURE 36
**Throat diameter of pulley**

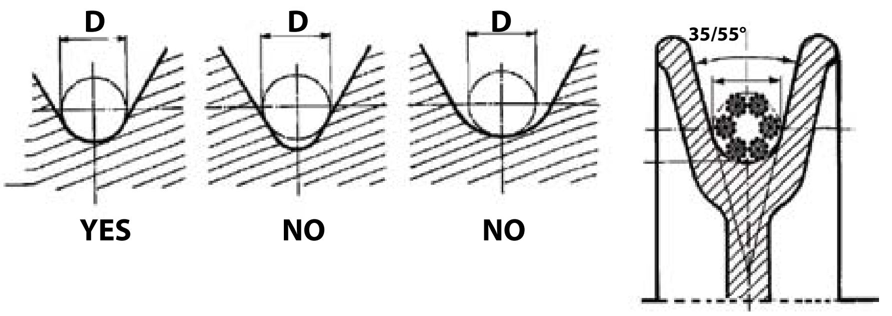



FIGURE 37
**One winch serving more than one slipway**

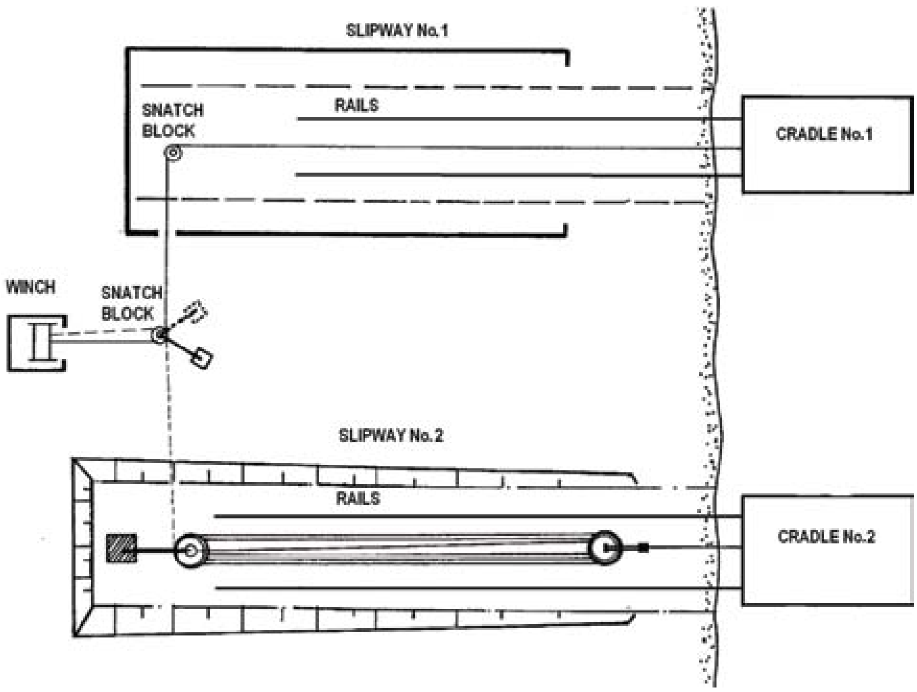


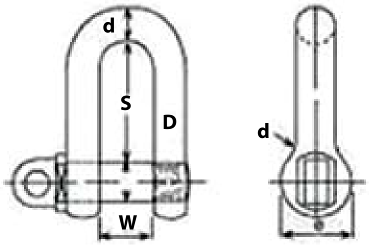
Figure 37 illustrates how a maintenance yard may be organized around a single winch. The yard may have a covered work area and an open work area. The wire rope from the winch may be rerouted to either area by a snatch block anchored to a mass concrete block. Sheaves and snatch blocks are usually anchored to blocks of concrete using lengths of heavy chain coupled to embedded shackles. When light vessels are handled, a single direct rope may suffice as shown on slipway No. 1. A 3-pulley sheave will multiply the pull from the winch by a factor of 6, allowing heavier vessels to be hauled out of the water. In some cases (especially when timber cradles are equipped with skids instead of wheels), slipways may also be equipped with a single pulley at the far end of the slipway, under water, to pull the cradles back into the water.

### 10.9.2 Shackles

Shackles are multipurpose connections used to connect all kinds of rope and chain to other fixtures, Figures 38 and 39.

FIGURE 38
**Commercially available Dee shackles**

Dee shackles

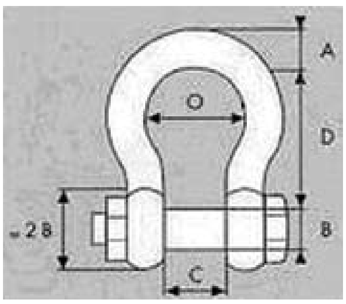



Higher tensile steel shackles to BS3032:1958 tested

**Small Dee**

| SWL (tonnes) | d (inches) | D (inches) | W (inches) | S (inches) | e (inches) | Weight each (kg) |
|---|---|---|---|---|---|---|
| 0.30 | 1/4 | 3/8 | 3/8 | 7/8 | 3/4 | 0.06 |
| 0.60 | 3/8 | 1/2 | 5/8 | 1.3/8 | 1 | 0.15 |
| 1.00 | 1/2 | 5/8 | 7/8 | 1.7/8 | 1.1/4 | 0.33 |
| 1.75 | 5/8 | 3/4 | 1 | 2.1/4 | 1.1/2 | 0.61 |
| 2.50 | 3/4 | 7/8 | 1.1/4 | 2.3/4 | 1.3/4 | 0.93 |
| 3.50 | 7/8 | 1 | 1.3/8 | 3.1/4 | 2 | 1.80 |
| 4.50 | 1 | 1.1/8 | 1.1/2 | 3.5/8 | 2.1/4 | 2.15 |
| 5.50 | 1.1/8 | 1.1/4 | 1.3/4 | 4.1/8 | 2.1/2 | 3.02 |
| 7.00 | 1.1/4 | 1.3/8 | 1.7/8 | 4.1/2 | 2.3/4 | 4.20 |
| 8.00 | 1.3/8 | 1.1/2 | 2.1/8 | 5 | 3 | 5.34 |
| 10.75 | 1.1/2 | 1.3/4 | 2.3/8 | 5.1/2 | 3.1/2 | 8.36 |
| 13.00 | 1.5/8 | 1.7/8 | 2.1/2 | 5.7/8 | 3.3/4 | 9.35 |
| 14.75 | 1.3/4 | 2 | 2.3/4 | 6.3/8 | 4 | 12.39 |
| 16.75 | 1.7/8 | 2.1/8 | 2.7/8 | 6.3/4 | 4.1/4 | 15.30 |
| 19.00 | 2 | 2.1/4 | 3 | 7.1/4 | 4.1/2 | 18.40 |
| 20.00 | 2.1/8 | 2.3/8 | 3.1/4 | 7.3/4 | 4.3/4 | 23.60 |

FIGURE 39
**Commercially available Crosby shackles**




| SWL TON | A mm | B mm | C mm | D mm | O mm | W KG |
|---|---|---|---|---|---|---|
| 2 | 13 | 16 | 22 | 51 | 32 | 0.44 |
| 3.25 | 16 | 19 | 27 | 64 | 43 | 0.79 |
| 4.75 | 19 | 22 | 31 | 76 | 51 | 1.26 |
| 6.5 | 22 | 25 | 36 | 83 | 58 | 1.88 |
| 8.5 | 25 | 28 | 43 | 95 | 68 | 2.79 |
| 9.5 | 28 | 32 | 47 | 108 | 75 | 3.8 |
| 12 | 32 | 35 | 51 | 115 | 83 | 5.26 |
| 13.5 | 35 | 38 | 57 | 133 | 92 | 7.0 |
| 17 | 38 | 42 | 60 | 146 | 99 | 8.8 |

## 10.10 LANTERNS AND MARKER BUOYS

### 10.10.1 Lanterns

On almost all coasts, landmarks and off-lying hazards are illuminated at night. These lights may be divided into three broad groups:

- landfall lights, including lighthouses, which are invariably very powerful and are usually clearly visible from a great distance;
- position lights, generally less powerful, their primary function being to indicate the position of a harbour mouth; and
- lighted aids to navigation, including light buoys that mark offshore shoals, rocks or navigable channels. Channel marker buoys come in two different shapes and colours for use during daylight.

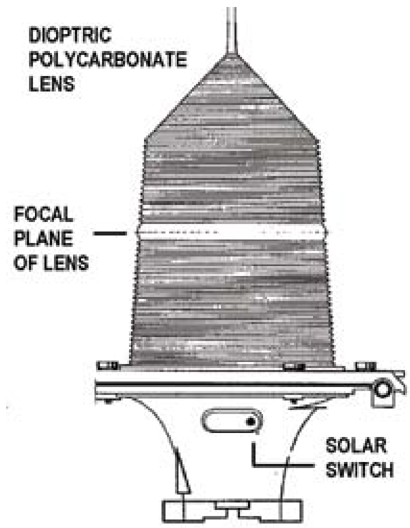
All lights, buoys and signs should conform to the specifications contained in the laws of harbours and pilotage of the country concerned. Lights or beacons are distinguishable from each other by their character, colour and period.

Character: A light can be fixed, flashing or occulting (occulting lights are steady lights which are eclipsed or blanked-out at regular intervals). Light buoys nearly always carry flashing or occulting lights to distinguish them from the lights of moored vessels.

Colour: Lights should normally be white unless they are for a specific purpose. Position lights are usually red (port or left side) and green (starboard or right side).

Period: The period of a light is the interval between the beginning of one phase and the beginning of the next one. In a simple flashing light, the period is the length of time between one flash and the next; in a group flashing system, it is the interval between the beginning of one complete phase of flashes and the beginning of the next.

FIGURE 40
**Basic marine lantern**



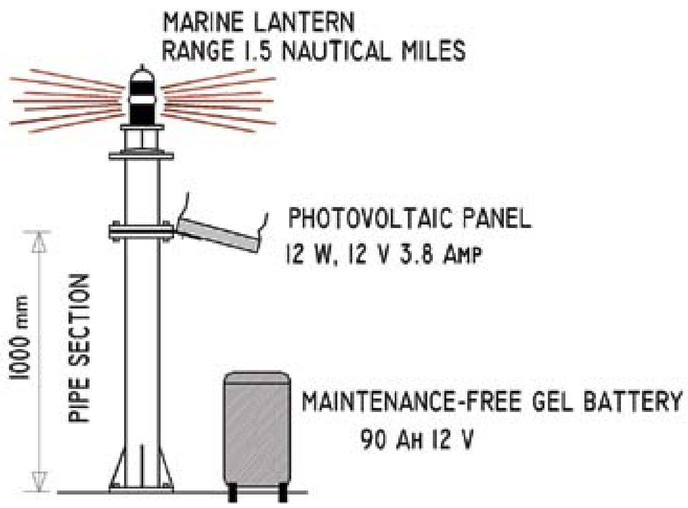

Before any lights are installed, the appropriate agency (maritime authority or coast guard) should be consulted so that current sea charts of the area may be updated. Figure 40 illustrates the basic type of lantern currently in use. It consists of a sturdy plastic housing in HDPE, an automatic lamp changer which automatically replaces burnt lamps from the lens' focal plane, a solar switch, and holes for bolting the lantern to a structure. When a lamp burns out, a motor relay is closed and a small electric motor is set in motion actuating the lamp changer. As soon as the new lamp is in position, the current again flows into this lamp and the motor relay deactivates.

Solar switches are generally incorporated into the body to activate the lanterns at sunset. At dusk, the solar switch switches the lantern off to conserve power. The power required for position lights is measured in candles and Table 5 illustrates typical ranges for various candle powers. Figure 41 illustrates the typical installation for a position beacon.

TABLE 5
**Typical ranges of marine lanterns**

| Power of lantern (Candles) | Range limpid condition (Nautical miles) | Range light mist (Nautical miles) |
|---|---|---|
| 0.40 | 1.0 | 0.50 |
| 1.05 | 1.5 | 1.0 |
| 1.95 | 2.0 | 1.5 |
| 3.45 | 2.5 | 1.5 |
| 5.34 | 3.0 | 1.5 |
| 8.20 | 3.50 | 2.0 |
| 11.50 | 4.0 | 2.5 |
| 13.70 | 4.25 | 2.5 |
| 16.20 | 4.50 | 2.5 |
| 19.0 | 4.75 | 2.5 |
| 21.85 | 5.0 | 2.5 |

FIGURE 41
**Typical installation for a position beacon**




Current lanterns use state-of-the-art, high flux, light-emitting diode (LED) units. The LEDs are mounted in a cluster to approximate a marine signal lamp located at the focal point of the lens. The life expectancy of a single LED cluster is in excess of 100 000 hours depending on the current, rendering the old lamp changer units obsolete. Many of the existing lanterns can be retrofitted with LED units.

### 10.10.2 Buoys

Buoys can be lighted or unlighted and used for daylight purposes only as in the case of channel markers. Nun buoys, Figure 42a, are unlighted with a conical top projecting above the water and are generally positioned on the starboard side (right) of an access channel when entering a harbour. They are normally painted red and numbered with even numbers. Can buoys, Figure 42b, are unlighted with a flat top projecting above the water and are generally positioned on the port side (left) of an access channel when entering a harbour. They are normally painted green or black and numbered with odd numbers.

Spar buoys, Figure 42c, are unlighted long thin masts generally placed inside channels where high velocity currents or tidal streams are present. Spherical buoys, Figure 42d, have a domed top projecting above the water line and are generally used to mark special positions in the channel, such as shoals or wrecks. They may be lighted and the colour usually depends on their use.

Currently, buoys are made almost exclusively from plastic materials (HDPE or polyester skin-filled with polyurethane foam) to better resist the effects of corrosion, Figure 43, left.

Buoys are generally anchored to the sea bed via a suitable chain connected to a proper anchor or heavy concrete block. Figure 43 shows a typical anchoring arrangement for a small buoy in 6 meters of water. A 32 mm diameter bottom chain anchored to a concrete block is joined to a 22 mm rising chain connected to the buoys anchor pin via two swivel joints. The bottom chain should be at least three times the depth of the water plus any variation in tide level. All fittings should be in the appropriate grade of steel.

FIGURE 42
**Unlit buoys**

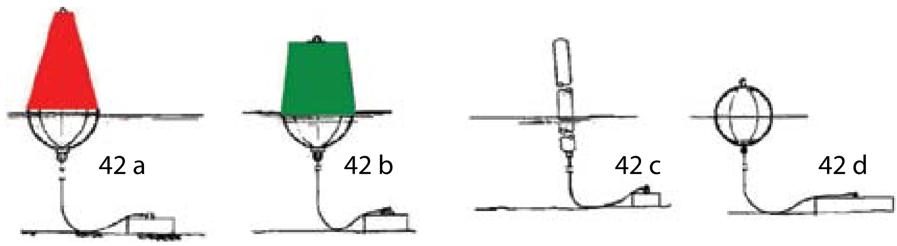
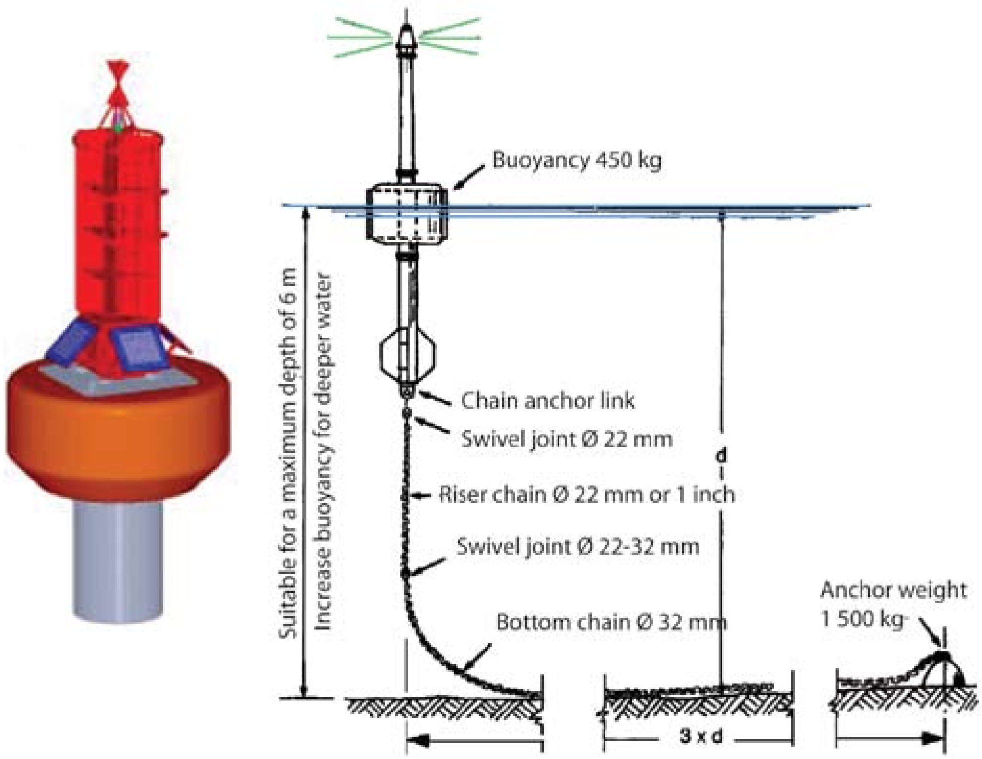



FIGURE 43
**Buoy in polyurethane (left) and mooring assembly (right)**



## 10.11 FISHERIES EQUIPMENT

### 10.11.1 Fish boxes

Proper fish boxes are required for the packaging of fish in a fish hall for onward transport. The basic requirements for a fish box are sturdiness, stackability and ease of cleanliness; the box must be sturdy to avoid damage to the fish, it must also be stackable without damaging the fish in the underlying box, and it must be made of a material which does not harbour bacteria and is easy to clean.

There are many types of boxes available, both improvised versions from other uses and custom-made for the fisheries industry. Fish boxes must be perforated to drain melt water away.

Figure 44 shows a very lightweight box made of polystyrene and meant only for the transport of fish by air. This box is very fragile and is meant for single use only (polystyrene is not impermeable and may harbour bacteria if the same box is used repeatedly). Polystyrene boxes need large storage areas because unlike other types they are not nestable. They are also not recyclable and are cause for concern when discarded into the environment, Figure 44 right.

Timber crates, Figure 45, make good fish boxes if no other means are available. They are cheap to make and may be recycled as fuelwood; they stack five or six high and, like the polystyrene boxes, they are not nestable and take up a lot of storage space. They are ideal for single species, such as sardines or anchovies, but repeated use of the same box may prove unhygienic as timber absorbs blood very easily.

FIGURE 44
**Single-use polystyrene boxes**

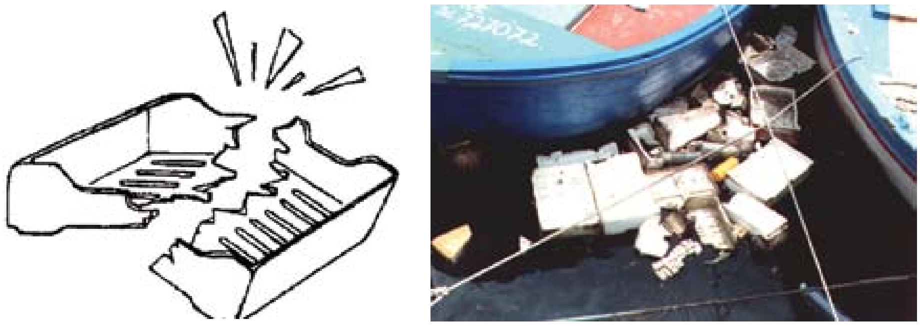


FIGURE 45
**Wooden crate**

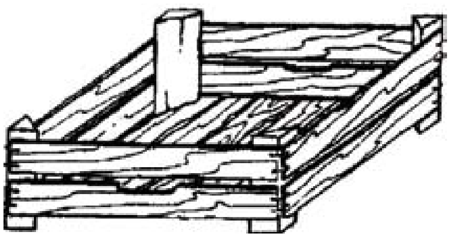


FIGURE 46
**Plastic boxes and tubs**

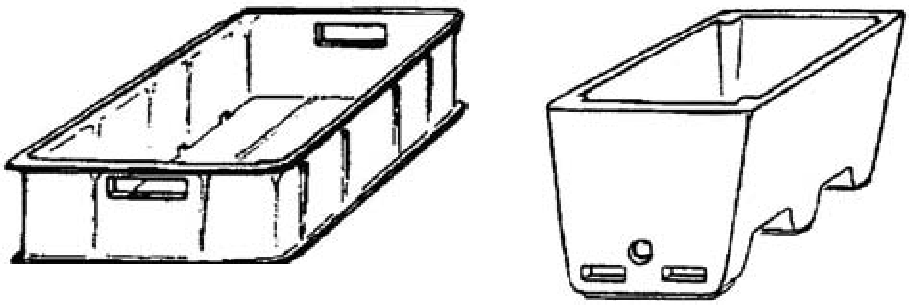
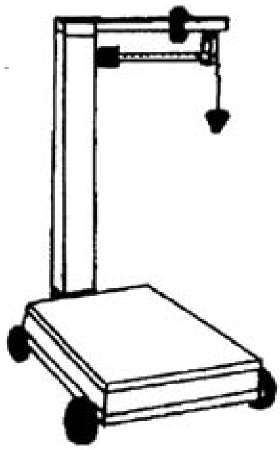


Figure 46 illustrates fish boxes and tubs in HDPE. They are produced specifically for fish and come in a number of sizes ranging from 100 to 1 000 litres. HDPE also comes in a number of colours making it easier to keep track of ownership. These boxes are all nestable when empty and by turning them backward front when full they stack without damaging the fish. They are easy to clean and disinfect. HDPE boxes are expensive in capital outlay but their initial cost is outweighed by their long lifetime.

### 10.11.2 Scales

Weighing scales should be heavy duty, platform-type scales with a tare adjustment to compensate for the weight of the fish boxes (Figure 47). Scales should be made of stainless steel and kept in clean operating conditions at all times. They should be graduated in 100-gram increments and capable of weighing loads up to 200 to 300 kilograms. Electronic load-cell digital scales are also available but purely mechanical units are recommended for most outdoor situations.

FIGURE 47
**Platform scales**



### 10.11.3 Trolleys and forklifts

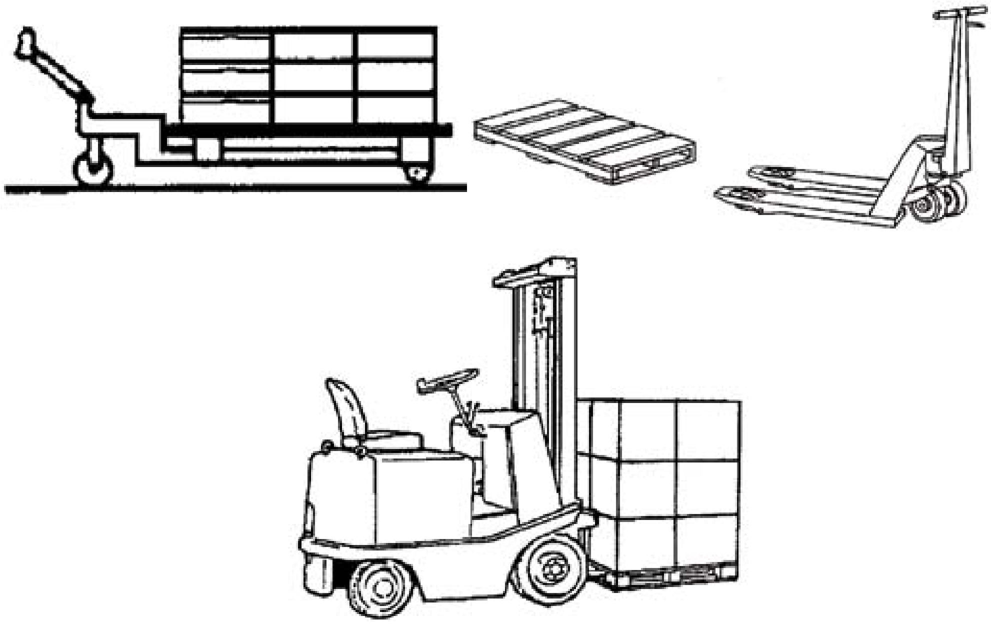
Depending on the size of the landed catch and the number of daily sortings, the speed with which fish boxes have to be transported between the quay and the sorting area is governed by the means of transportation. Boxes may be moved on manual trolleys, on pallets or by forklift (Figure 48).

The normal platform trolley is still the mainstay of many fishing ports and halls. The trolley should be steerable and built from stainless steel and have large diameter rubber wheels. Small diameter metal wheels should be avoided as these may cause damage to the paving and gutter drains. Only electric powered forklifts are suitable for use inside a fish hall. Diesel, petrol, kerosene or gas-powered forklifts should not be permitted to enter the building.

### 10.11.4 Sorting tables

Rinsing and sorting tables should be made of stainless steel. However, concrete or masonry tables built from locally available materials may also suffice in remote areas provided that the workmanship is of a good standard.

FIGURE 48
**Forklift and platform trolley**



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