

**INTRODUCTION
TO
MARINE RAILWAYS**

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MARINE RAILWAYS

A marine railway is a mechanical means of hoisting a ship out of the water along an inclined plane.

Lift capacities range from 100 to 6,000 tons.

Theoretically, even larger sizes are possible, but generally the floating dock becomes a more economical alternative.

Advantages of a marine railway:

- ∅ Low initial construction cost
- ∅ Fast operating
- ∅ The track slope can fit the natural slope of the shore in many cases. This eliminates or reduces dredging or bulk-heading requirements.
- ∅ Vessels can be transferred to and from the shore relatively easily.
- ∅ Vessels longer than the dock cradle can be docked by overhanging the bow and/or stern.



Disadvantages of a marine railway:

- ∅ The track is a fixed structure and cannot be moved easily. This makes it harder to sell, thus harder to finance.
- ∅ It is a mechanical system that requires periodic replacement of some moving parts (hauling chains, rollers, etc.)
- ∅ Underwater maintenance is required.
- ∅ The vessels can damage the track.

Marine Railway Design

The basic components of a marine railway dry dock consists of (Figure 1):

- ∅ Cradle
- ∅ Inclined track on a foundation
- ∅ Hauling chain
- ∅ Hauling machine

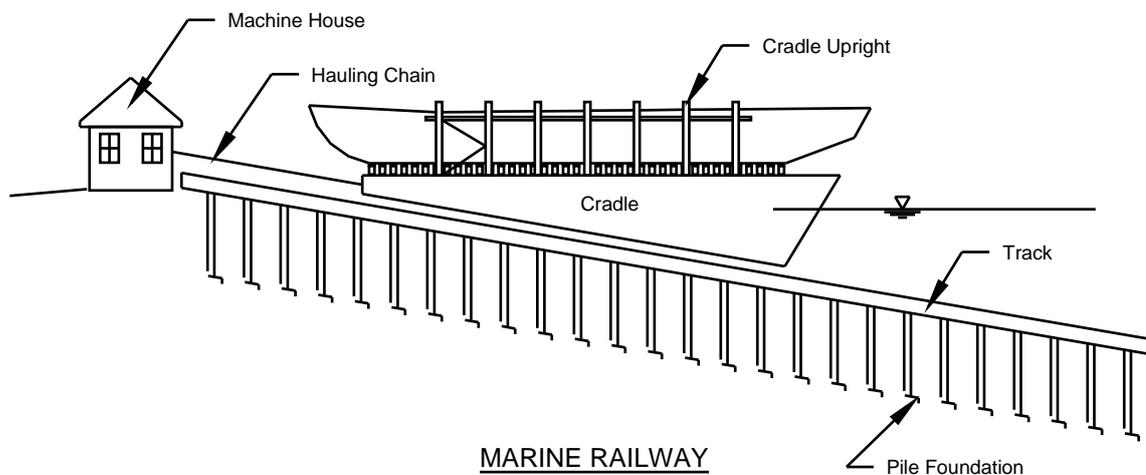


FIGURE 1

The cradle, which rolls on rollers or wheels, is lowered into the water along an inclined track until sufficient water over the cradle is achieved.

The ship is floated over the cradle and tied to the uprights. The cradle is hauled up the track and the vessel grounds onto the blocks.

After complete grounding on the keel blocks, the side blocks are brought to bear and the hauling continues until the cradle is full up.

Track Layout

Ideally, the slope of the track should be selected to fit the natural slope of the particular site to minimize dredging and yet provide the required drafts over the blocks for docking the vessel.

Realistically, trade-offs usually have to be made between the length and slope.

For example, a very shallow track may fit the topography very well but requires a long track thus more piles, more track beams, and longer hauling and backing chains. A steeper track will be shorter but the aft cradle build up is now taller, requiring longer and heavier columns, and the track must go even deeper to provide the same depth of water over the cradle deck.

The steeper track, not fitting the topography, may require dredging. Refer to Figure 2.

Other criteria to consider when laying out the track are: channel lines, pier-head lines, property lines, direction and speed of currents, etc.

For railways that required dredging to install the track it is probable that the dredged hole will fill with sediment overtime. Depending on the site this could happen very quickly. It is important to regularly inspect the rails for mud build up. Mud over the rails is a common reason for cradle derailment

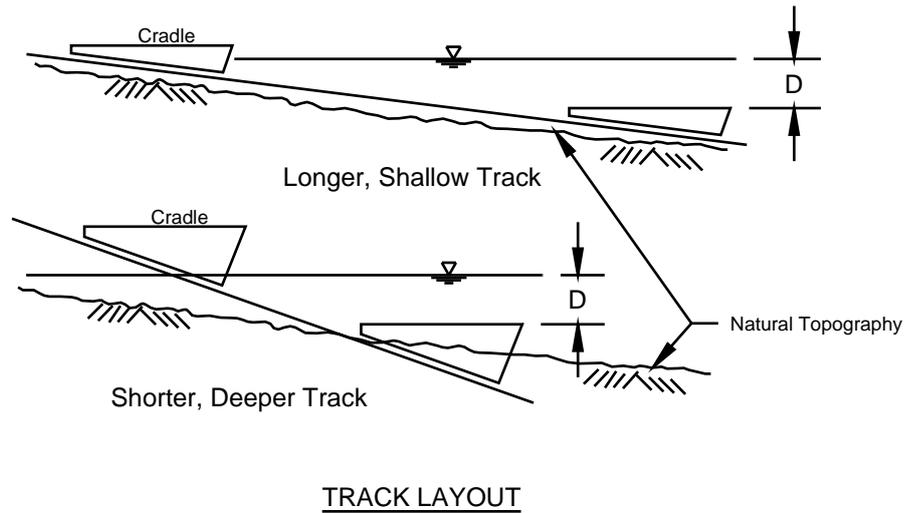


FIGURE 2

Sometimes the track will be laid out as an arc of a circle instead of a straight-line slope.

This provides 3 benefits:

1. The cradle deck can be horizontal in the full up position allowing vessel transfer to shore and easy access. As the cradle is lowered down the track, the aft end rotates downward, providing deeper water over the aft end of the dock. This puts the block line on a trim, which can more closely match the trim of the vessel being docked. This reduces grounding stability problems and knuckle loads. Refer to Figure 3.
2. The cradle build-up aft is less, so the track does not have to go as deep or far to get the same water over the deck.
3. As the cradle is hauled up the track, the actual incline of the track is getting less. Thus, less hauling power is required as the full weight of the vessel transfers from the water to the cradle.



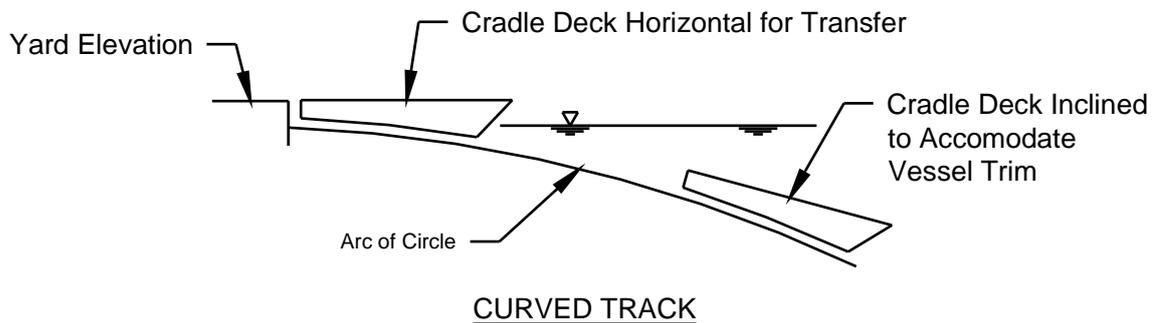


FIGURE 3

On tracks built with a curve it is important to realize that the angle of the dock's keel line to horizontal will constantly change as the cradle moves up or down the track. When docking a vessel (even one with no trim) you must determine at what point along the track the vessel will land first on the blocks. Then you must figure the angle of the keel line at that point along the track and compare the angle to the vessel's trim (the angle of the vessel's keel). The difference between the two slopes is the trim that must be removed for complete landing of the vessel. The trim removed is the value used in calculating landing stability and sue or skeg loading.

Changing tide levels will change at what point the vessel lands on the blocks and will change the angle of trim to be removed. Refer to Figure 4

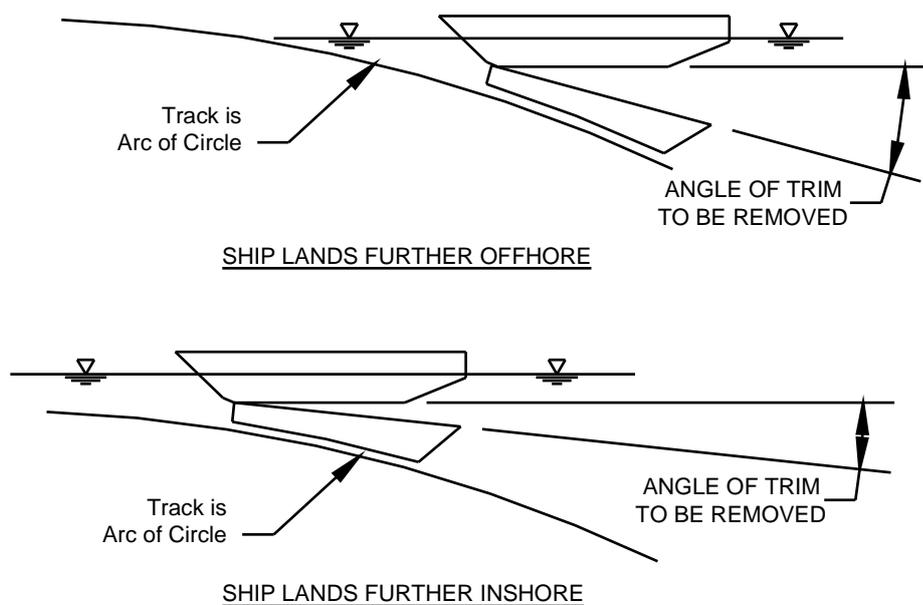


FIGURE 4

Track Foundation

The type of foundation for the marine railway is dependent on soil conditions and size of vessels being lifted.

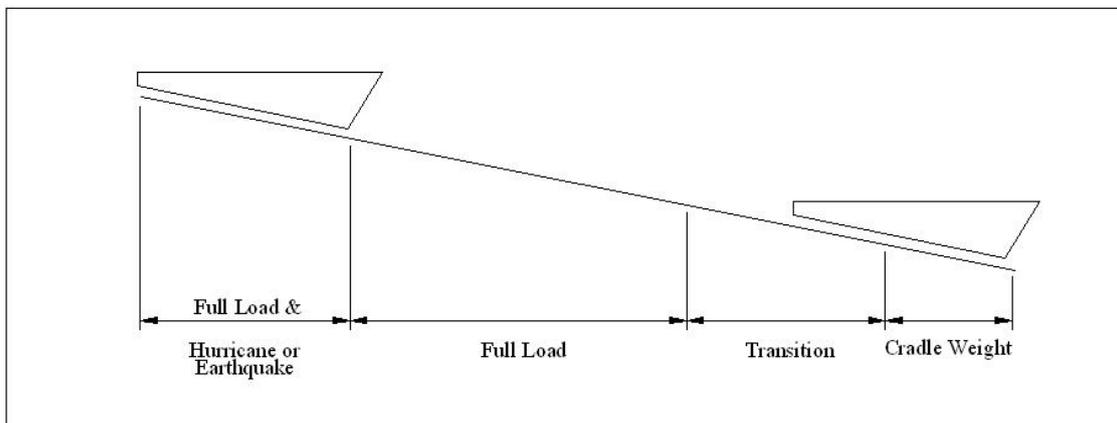
Typical marine railway foundations are:

- ∅ Railroad tie timber “sleepers” – for very light loads
- ∅ Concrete spread footings – light to moderate loads
- ∅ Timber piles – moderate to heavy loads
- ∅ Steel piles – heavy to very heavy loads
- ∅ Concrete piles – heavy to very heavy loads

The loading on the foundation varies throughout the length of the track. Refer to Figure 5. At the end of the track, only submerged weight of the cradle needs to be supported.

As the cradle moves inshore and the vessel begins to be lifted, its weight is gradually transferred onto the cradle.

At the point the ship's keel breaks water, its full weight is on the cradle and the remaining portion of the track and foundation must be designed for this condition.



TYPICAL VARIATIONS IN FOUNDATION LOADS

FIGURE 5

The foundation under the cradle in the full up condition should also be investigated for additional loads induced by hurricane winds or earthquakes with a capacity vessel aboard.

Most large railways are founded on piles. Steel, concrete or wooden piles can be used. Steel or wood are most frequently used offshore because they are easier to cut to exact grade underwater than concrete.

Concrete piles can be used above low water where they can be cast into the concrete track.

Piles are usually spaced between 3 to 8 feet.

Many railways use a single row of piles under each track. This eliminates the need for cap beams but requires strict tolerances when driving piles to insure the track falls directly over the line of piles.

To loosen the driving tolerances a little, a wide bonnet can be placed over the pile. This provides a wide shelf for the track to sit on.

If the pile is driven out of tolerance, a cap beam is installed to bridge across to the other line of piles.

Track Beams

The track can be constructed out of wood, steel, concrete or some combination.

The track should be designed for the same loading arrangement as the foundation.

Most large docks today have steel tracks for their offshore portion and concrete above the low waterline. This eliminates much of the steel in the tidal and splash zones where steel is quickly corroded.

Steel offshore sections can be fabricated on the shore (in the dry) in sections of 40 to 60 feet length. Then they can be lowered onto the pile bonnets and fastened. This eliminates much of the underwater assembly work.

Installation of the track offshore can be done by either lowering it using a crane or floating it into place.

Attached to the top of the track is the rail on which the cradle runs. The rail can be either a crane rail (for wheels) or a flat plate (for rollers).

It is recommended that a cushion be designed into the track/foundation system to help distribute any load concentrations.

This helps prevent overload to the rollers or wheel, piles, cradle columns etc.

On timber tracks, the timber is the cushion.

On steel tracks, a rubber pad placed between the pile and the bottom of the track beam is usually adequate.

On concrete tracks, a rubber pad between the rail plate and concrete is needed.

The pulling of the loaded cradle up the track creates a longitudinal friction force along the axis of the track beam. Refer to Figure 6.

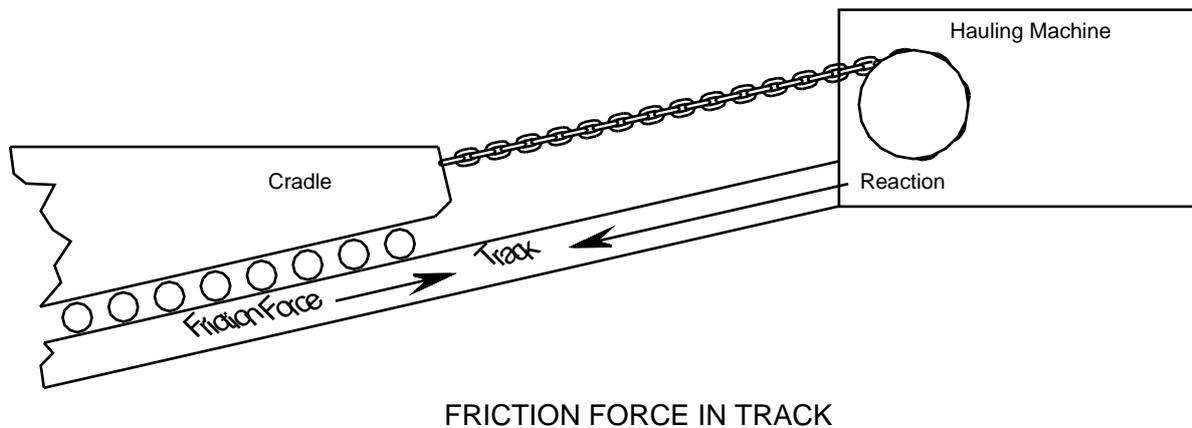


FIGURE 6

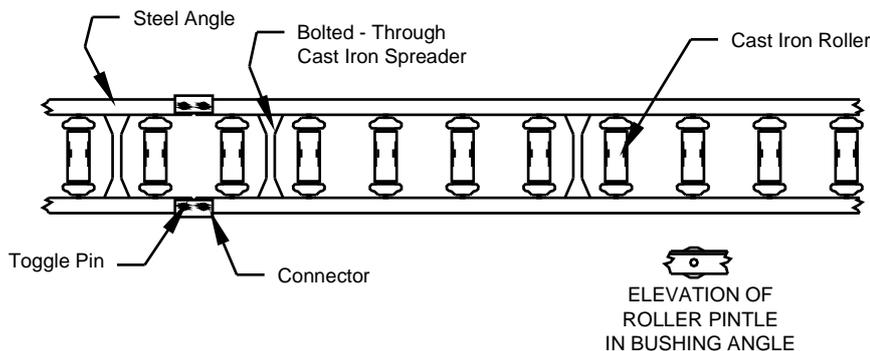
This force is equal to about 2% - 5% of the cradle plus ship weight, depending on the type of roller or wheel used and condition of the track.

To balance this frictional force, the track should be tied into the hauling machine foundation by struts at the head of the track. This eliminates the tendency to pull the track off the piles.

Rollers and Wheels

The marine railway cradle runs on a system of rollers or wheels.

Rollers are generally used for larger capacity railways because they cause less friction than wheels and they tend to distribute the load more evenly along the track since they are placed closer together. Refer to Figure 7.



TYPICAL ROLLER FRAME SECTION

FIGURE 7

The design load per foot value dictates roller width and spacing. Rollers are usually spaced 12 to 18 inches apart. Co-efficient of friction for rollers is 1-2%.

CRANDALL roller is good for about 1 kip/inch of tread width.

Minimum width = 6 inches

Maximum width = 14 inches

Some railways use wheels.

Disadvantages of using wheels are:

- ∅ Greater friction
- ∅ More expensive
- ∅ Cause higher point loads; requires stronger track beams and foundation

Cradle

The cradle is the platform that holds the vessel from the time it grounds out on the blocks. Refer to Figure 8.

The cradle must have strength and stability to support the ship and yet be flexible in longitudinal bending and torsion to accommodate any irregularities that may occur in the track's line and grade.

The gauge of the cradle runners must be wide enough to provide stability against overturning from wind, current and earthquakes.

As a general rule, the gauge of the marine railway should always be about half the beam of the widest vessel to be docked or about a third of the width of the cradle.

The cradle beams should be designed to take 100% of the rated load per foot times the beam spacing.

The load should be concentrated at the centerline of the beam.

The beams must also be designed for bilge block loads positioned outboard of the columns and bending due to line pull or fender impact on the uprights.

There is a column under each cradle beam at the runner. Each column should be designed for half the load on the cradle beam it supports plus any additional loading from hurricane or earthquake tipping forces.

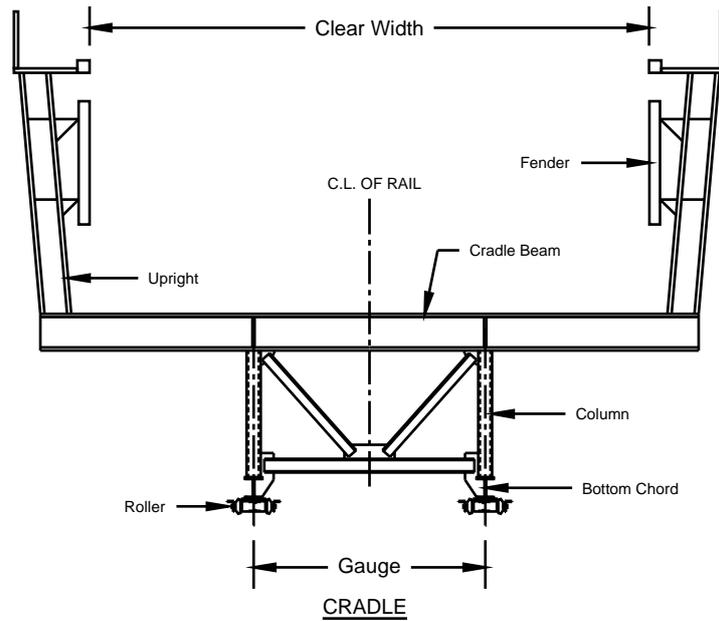


FIGURE 8

The upright columns support the docking platform, which is used by the dock crew for the line handling. They should be designed to resist the pull from the lines and fender impact from the vessel.

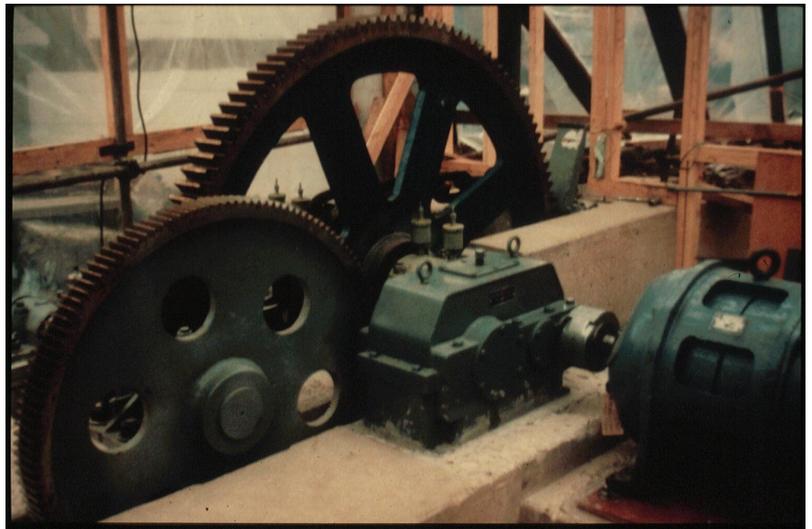
Hauling Machine

The hauling machine is a large capacity winch designed to pull the cradle with the capacity ship aboard.

The machine consists of an electric motor, which drives a speed reducer and a train of gears.

The gears turn the chain wheels, which drives the chain.

An automatic brake is provided to hold the cradle whenever power to the motor is interrupted.



The load on the winch (chain load) is a function of the cradle and vessel weight, the gradient (slope of track), and the friction in the system.

$$\text{Chain Load} = (W \times \text{Slope}) + (W \times C_f)$$

Where:

W = weight of cradle, ship & chains

Slope = 1/??

C_f = Coeff. Of friction

=> 0.02 – 0.04 for rollers

=> 0.03 - 0.05 for wheels

When investigating the stresses in the chain, the chain load should be increased by 10% to account for local stress due to chain bending on the wheel.

The required horsepower of the electric motor is a function of the pull on the chain times the speed of haul.

Experience has shown that a speed that raises the cradle 1 vertical foot per minute reduces the tendency of the cradle to surge.

Example:

For a slope of 1 in 20, the ideal hauling speed is 20-ft per minute.

Chain

Chain material and manufacturing have improved greatly over the years.

In order of their development:

- ∅ Wrought iron chain – Not as strong as steel, no longer available
- ∅ Cast iron chain – Stronger than wrought iron but could contain slag pockets and other imperfections that could cause failure
- ∅ Welded steel chain – Made from forged bars, does not have slag pockets
- ∅ Welded alloy steel chain – Very high strength, developed for the oilrig industry

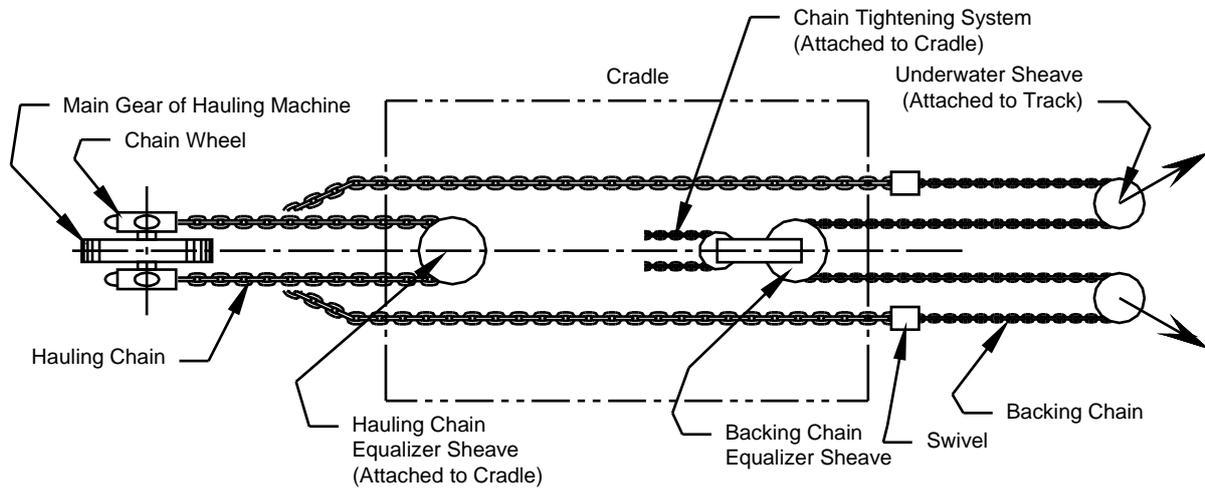
In addition to strength, marine railway hauling chain needs uniformity of link shape.

Links that are too small may bind on the chain wheel tooth and fail to engage properly.

Links that are too big will not seat right on the chain wheel, causing movement and snapping and possible overloading of the teeth.

Hauling chain is always arranged in an endless loop. Refer to Figure 9. This insures that the cradle can be backed down the track even if debris on the track prevents the cradle from moving by gravity.

The hauling chain is used for hauling the cradle up the slope and the backing chain pulls the cradle down the slope if gravity does not overcome friction.



TYPICAL TWO CHAIN REEVING DIAGRAM

FIGURE 9

For a multiple part chain system, all chains must be equalized. If they are not, small differences in chain dimensions would eventually loosen one or more chains, overloading others.

Before the chain goes over the chain wheel, it should be washed to remove sand and grit, which greatly increase wear. The chain should be oiled at the grips just prior to going around the wheel.

To support the chain and prevent it from eventually cutting through the track cross ties, chain slides are provided on each cross tie.

Wire Rope

In general, wire rope should NOT be used for hauling marine railway cradles.

Salt water tends to corrode wire rope quickly and there is no way of determining its strength once it has been in use, without removing it and testing.

Chain, on the other hand, can be measured in place and its strength can be calculated.

If wire rope is used,

“Synchrolift” recommends removing and full load testing the wire rope every 3 years.

“Marine Travel Lift” recommends replacing wire rope every 5 years, although in their case the wire rope does not go into the seawater. Child’s Engineering recommends testing and replacing wire ropes at least every 2 years when used in salt water.

MARINE RAILWAY INSPECTIONS

Dry docks are structures with sufficient dimensions and strength, to lift a vessel from the water. As with any structure in the marine environment, a dry dock will deteriorate over time, and gradually lose its ability to lift vessels. Periodic inspections of the dry dock insure the dock’s ability to lift ships of the certified capacity.

A material condition survey by an independent company experienced in the design of the particular dry dock should be conducted on a regular basis. This inspection establishes the certified lift capacity of the dry dock and highlights areas of the dock to be monitored in the interval between inspections. Intervals between inspections by the independent surveyor may vary between 1 and 5 years depending on the dock’s condition. The Dockmaster should conduct his own “in-house” inspections in this interval. (At least once a year but more frequently if problems are noticed.)

The intent of a marine railway inspection is to establish the “as-is” condition of the dock’s structural and mechanical components.

Inspection of a marine railway generally consists of:

- ∅ General structural survey of
 - Foundation (above & below water)
 - Track (above & below water)
 - Cradle
 - Blocking
- ∅ Line & Grade Survey
- ∅ Inspection of roller or wheel system
- ∅ Inspection of hauling machine
- ∅ Inspection of wire rope or chain system

Foundation Inspection

The foundation is usually buried and hard to inspect. However, buried structures deteriorated much more slowly than those exposed.

A foundation failure should be evident by tell-tale signs on the track and excavation of the foundation is usually not required if these signs are not present. Any exposed foundation members should be inspected as described below for the track. The track should then be inspected for external signs that the foundation may have failed. These signs include:

- ∅ An out of grade track

- ∅ Large gaps between the track & foundation
- ∅ Structural failure of the track beams

If these signs are found, the condition of the foundation should be investigated more thoroughly.

Track Inspection

A marine railway track can be constructed of steel, concrete, timber or some combination of these. The modes of deterioration will vary depending on the materials of construction.

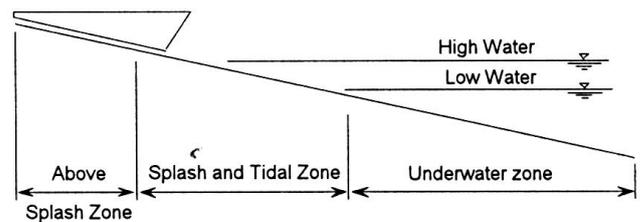
Also, a track has three different environmental zones which can affect materials in different ways. See Figure 10.

These Zones are:

Underwater Zone – The portion of track and foundation that remains submerged at all times.

Splash and Tidal Zone – The portion of track, foundation and cradle that get wet from tidal variations and wave splash. This is usually the zone of heaviest deterioration.

Above the Splash Zone – The portion of track, foundation, cradle and hauling house that is above the heavy splash from waves.



TYPICAL DETERIORATION ZONES

FIGURE 10

Concrete Track

A concrete track is generally used above low water only (in the tidal, splash and above the splash zones).

Most concrete structures contain steel reinforcement in the concrete. To gain maximum strength from the concrete, and steel combination, the steel is deliberately put as close to the surface of the concrete as possible.

Unfortunately, concrete is porous and will absorb water. In a marine environment, the saltwater will be absorbed by the concrete. If the water reaches the steel reinforcement, the steel will corrode. When steel corrodes, the volume of rust produced is about 8 times the volume of original steel. This expansion cracks the concrete cover and eventually “pops” it off, exposing the rebar.

The first signs of deterioration occur as a series of parallel cracks running in the direction of the reinforcement.

In the second stage, a cleavage plane forms at the level of reinforcement and rust staining occurs along the cracks. The concrete will sound hollow when tapped with a hammer, and the cover can easily be hammered off.

In the last stages, the cover has spalled off exposing the rebar. The concrete is usually sound below the level of the rebars.

Corrosion of the rebars is the most common cause of concrete deterioration although it is not the only cause. Other common causes of concrete deterioration are:

Pay particular attention to the splash and tidal zone as this is where corrosion, weathering, and impact from floating debris are generally greatest.

Anchor bolts that are embedded in the concrete to anchor rail plate or other fittings tend to corrode at the interface of the concrete and attached item. Corrosion is not always evident.

A concrete track should be inspected for:

- ∅ **Spalling** – Some spalling is OK but if spalling has progressed to undermine the rail plate or is exposing the rebar, it is time to repair. See Figure 11.
- ∅ **Major Cracking** – Indicates possible overload, foundation failure or impact damage.
- ∅ **Deteriorated Fastenings** – Rails can pull away from the concrete or become loose, a potential cause of derailment.

CAUSE	
Rebar corrosion	Cracks, Spalling Rust Stains
Poor construction	Cracks
Drying shrinkage	Cracks
Temperature Stresses	Cracks, Spalling
Absorption of moisture	Cracks
Chemical reactions	Cracks, Spalling Disintegration
Weathering	Spalling, Disint.
Erosion	Disintegration
Poor design	Cracks, Spalling Disintegration
Impact damage	Cracks, Spalling
Overload	Cracks, Spalling

CONCRETE FAILURE MODES

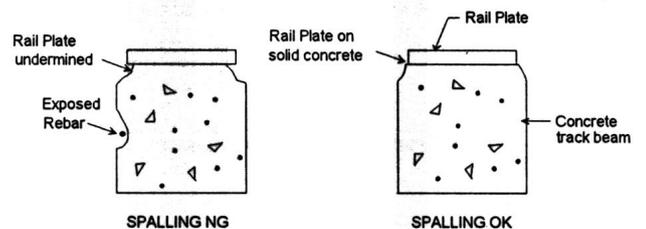


FIGURE 11

Steel Track

A steel track deteriorates at varying rates over its length. Some areas of the track may look fine while other areas have heavy corrosion.

In general, the area of worst corrosion is usually the splash and tidal zone.

During the inspection, the condition of steel structural members should be examined. Use a hammer to dislodge rust, as thickness of rust can be deceiving.

Note percentages of total area that are corroded.

Note corrosion using the following reference guide (in order of severity):

Light rust film – Light colored staining of steel

Moderate rust film – Light rust powder on steel

Heavy rust film – Heavy rust powder on steel

Rust Bubbles – Small bubbles of rust in isolated areas of plate that have most of its protective coating intact. Can vary from light, a few bubbles over a large area, to heavy, many bubbles almost touching each other.

Light Rust Scale – Thin sheet of rust formed on steel, sheet can be broken off in small pieces with hammer. Minor loss of metal thickness from original steel.

Moderate Rust Scale – Thicker sheets of rust formed on steel, sheets can be broken off in larger pieces with hammer. Moderate loss of metal thickness from original steel.

Heavy Rust Scale – Multiple, thick sheets of rust formed on steel, sheets may have pulled away from steel under their own weight, large sheets of rust can be peeled away with hand. Significant loss of metal thickness from original steel.

Knife Edged – Edge of flange or other member tapered down (by corrosion) to a thin, sharp edge.

Isolated Hole – Small hole in steel due to corrosion.

“Lace Curtain” Holes – Large number of small to medium size holes in plate creating a “lace curtain” (see through effect)

Complete Wastage – Large holes in plate or structural member with significant portion gone.

Use ultrasonic thickness measurements and/or calipers to physically measure thickness in areas of high corrosion.

The number and frequency of readings will vary as to the condition of the dock and purpose of inspection. Steel that still retains all of its protective coating or steel with many holes through it may require no readings because the condition is obvious. Steel that is questionable and due for repair may require many readings to establish the zones for replacement.

A steel track should be inspected for:

- Ø **Corroded steel** – as described above
- Ø **Rolled top flange** – Overloading or off-center loading of the rail plate may cause the top flange of the track to roll or bend about the web of the beam. (see figure 12)
- Ø **Missing rubber pads** – Some steel tracks on steel piles have rubber pads installed between the track and pile bonnets.

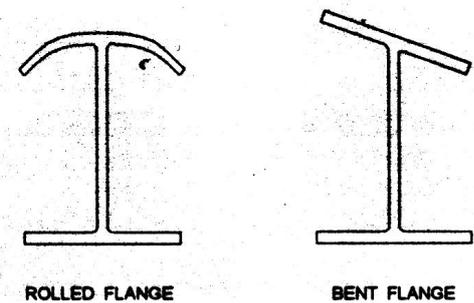


FIGURE 12

Wood Track

A wood track deteriorates in different ways in different zones of the track. Some areas of the track may look fine while other areas have heavy deterioration.

Inspect timber, for rot, marine borers and impact damage. Use a probe, core borer and/or hammer to test wood – Marine borers are not always evident from the surface. Determine the depth at which sound wood is found below punky surfaces.

Note the condition of track timber sheathing (if any). Remove sheathing in one or two areas to check condition of tar coating, sheathing felt and timber beneath.

Pay particular attention to the areas where the pile or other foundation supports the track. Look for excessive crushing.

A timber track should be inspected for:

- Ø **Rotted Timbers** – Usually found above the splash zone.
- Ø **Termites or Other Bugs** – Usually found above the splash zone.
- Ø **Marine Borers** – Borers are usually found in the tidal and underwater zones in salt water only. Two common types of marine borers are the wood gribble, or limnoria, and the teredo or shipworm. Limnoria damage is readily evident with a visual inspection as loss of material occurs on the outside of the timber. The teredo is a mullusk, although it looks like a worm. They bore a tiny hole into the wood when young. As the teredo grows, it tunnels along the grain of the wood. Detection of

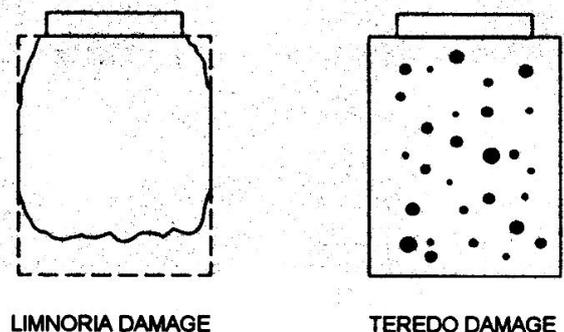


FIGURE 13

teredos is difficult because most of the damage occurs inside the timber. A member may be riddled with holes but look fine from the outside. See Figure 13.

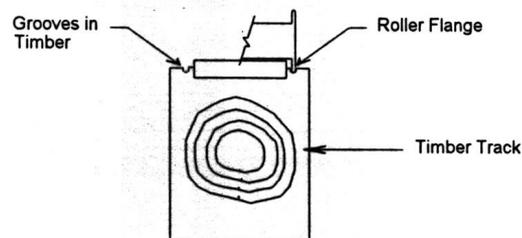


LIMNORIA DAMAGE



TOREDO DAMAGE

- Ø **Rail Plate Squeeze** – The rail plate sometimes squeezes into the wood reducing the height of the top of plate above the wood. The roller flanges can then contact the wood and will wear grooves in the wood on either side of the rail plate. See figure 14. The roller flanges contacting the wood can create considerable additional friction that the hauling system must overcome. This additional force could overload the hauling system. Also, roller flanges may tend to break more often.



RAIL PLATE SQUEEZE

FIGURE 14

All Types of Tracks

All types of tracks should be checked for the following:

- Ø **Ice damage** – check for damage by ice in the tidal zone. Damage may include bent or broken members, derailed roller frames, “jacking” of track up off of piles, or out of line or grade track.

- Ø **Impact damage** – Check for damage by floating debris in tidal zone. Check for damage by anchors, vessel impact in tidal zone or underwater zone. Damage may include bent or broken members, derailed roller frames, or out of line grade or track.
- Ø **Mud or Debris on Track** – Check for mud over the rail plate. Mud covering the track beams is OK as long as it does not cover the rail plates. (Mud will actually protect the track beams from deterioration). Mud on the track can cause the rollers to ride up on the mud and derail, possible causing a cradle derailment. If mud has built up greater than the level of the rollers, the cradle will have to push through this mud when backing down. This will add considerable force to the backing chain and underwater sheaves, possibly overloading them.
- Ø **Gaps between pile and track beam** – Gaps between pile and track beam indicate shims have fallen out, pile has sunk, or track has come up. Track grade should be checked and shims inserted to suit. There should be no gaps between pile and track or track will deflect when loaded cradle travels over this area.
- Ø **Chain slides** – Check for worn, loose, or missing chain slides.

All rail plates should be checked for the following, (see figure 13.2-6):

- Ø **Crown** – The rail plate should be flat across the top with a crown no greater than 3/16".
- Ø **Thickness** – The rail plate thickness should not be less than 3/4". Thin rail plate can curl up under weight and derail rollers and cradle. Thin rail plate can cause roller flanges to contact track beam.
- Ø **Wear** – Signs of wear along the sides of the plate, usually in the form of a "J" groove, may indicate poor track alignment or out of gage track.
- Ø **Fastenings** – Check to insure all rail plate fastenings are tight. Bolt heads can deteriorate (particularly in the tidal zone) and rail becomes loose. Loose rails can dislodge and derail rollers and cradle.

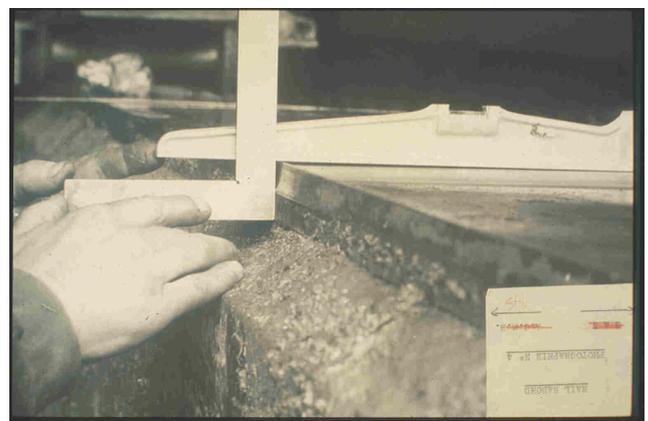
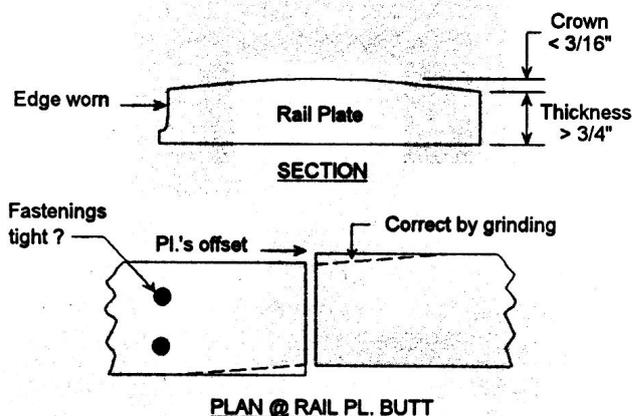


FIGURE 15

MEASURING RAIL PL. CROWN

- ∅ **Jogs or offsets** – Check for jogs or offsets in rail plate. A sudden change of thickness of rail plate (step up) will cause increase loading in roller at that point, possibly breaking the tread. If one plate is wider or offset such that plate sides are not in alignment, roller flanges can break when encountering this point. If jogs or offsets are found, plate should be ground down to provide a smooth transition.

Track Line and Grade

A detailed line and grade survey of the track (using surveyor's instruments) should be taken once every 5 years unless some unusual incident has occurred (overload, ship impact, derailment) or the dock's behavior indicates a problem.

Procedures for performing a line and grade survey are beyond the scope of this manual.

There are signs that can be looked for, however, that may indicate problems with the line and/or grade of the track.

Some of these signs are:

- ∅ As the cradle deck enters the water, both ends of each deck beam go under at the same time. If not, one side of the track may be lower than the other. (Or one side of the deck beam may be bent, but this can be checked with the cradle full up.)
- ∅ If blocks at the forward end of the cradle go underwater before the aft end it may be an indication of a low spot in the track. (blocks must be built level with no curvature in track.)
- ∅ When hauling a vessel, if the blocks pull away from the ship and then return in one area as the cradle passes over, there is a possibility of a low or high spot in the track at that location.
- ∅ Excessive wear in the roller flanges or many broken roller flanges may indicate a problem with line or gauge.
- ∅ Wear on the sides of the rail plate in one area (see figure 13.2-6) may indicate a problem with line or gauge.
- ∅ Many roller treads breaking in one spot may indicate a high spot.

Roller System

Due to friction, the roller frames tend to slip a little bit down the track during each cradle operation. Thus, after the cradle has been lowered and raised, the roller frames will not have returned to their original positions and will be slightly down the track (offshore). This distance,

the “slip”, gets greater with each cradle movement. When the rollers have slipped the distance of one roller frame, the frame farthest offshore should be disconnected and brought to the forward end of the roller train. This recycling helps to even out roller wear. (You must insure there are enough rollers beyond the end of the cradle to allow for maximum cradle submergence without overrunning the last roller.)

Roller should be checked for wear as follows:

- ∅ Are roller treads worn concave across their treads? Difference in roller diameter should not exceed 3/16”.
- ∅ Are roller treads worn excessively? Rollers can have a groove between the tread and flanges. When the tread has worn down to eliminate this groove, the roller should be replaced.
- ∅ Are roller treads broken? Note location of broken treads in roller train to assist in determining where the problem is.
- ∅ Are roller flanges worn or broken? Note location of broken flanges in roller train to assist in determining where the problem is.
- ∅ Are roller pintle worn? If the diameter of the bushing hole is more than 1/2” greater than the pintle diameter, the roller may become skewed on the rail which can accelerate wear and break roller flanges.



BROKEN ROLLER FLANGES

Bushings should be checked for wear as follows:

- ∅ Are bushings tight in roller frame angles?
- ∅ Are the bushing holes worn excessively? If the diameter of the bushing hole is more than 1/2” greater than the pintle diameter, the roller may become skewed on the rail which can accelerate wear and break roller flanges.

Roller frames should be checked for straightness, corrosion, and to insure they are properly connected.

Cradle Inspection

Look for corroded or rotted structural members, particularly at the waterline.

Look for cracked or buckled members particularly the cradle columns where they attach to the top and bottom of chords of the runners.

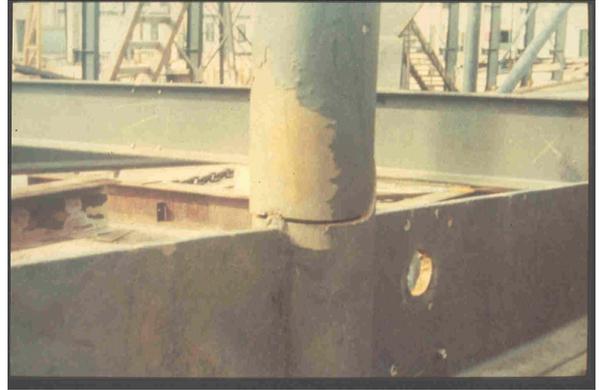
Check cradle shoe plate for wear and crowning in the same manner as the track rail plates.

Check the cradle bottom chord for rolled or bent flanges (steel cradle) or rail plate squeeze (timber cradle) in the same manner as the track beams.

Look for bent or sagging cradle deck beams.

Check cradle deck for broken or rotted planks and joists.

Look for bent, buckled, damaged or corroded upright beams and catwalk structure.



CRACKED CRADLE COLUMN

Hauling Machine

The hauling machine consists of an electric motor with automatic brake, speed reducer, series of open gearing, chain wheel and chain.

The electric motor, brake, and speed reducer should be maintained per manufacturer's instructions.

Use Texaco Crator compound No. 2 on the open gears. Apply it hot so it flows into the gears.

Check the gears for wear and fit of the teeth. Too much slop increases tooth load and could cause tooth failure.

Check the bearings for overheating during the operation. Excessively worn or out of align bearings will heat up.

If the machine has a stop pawl, be sure the limit switch is working. The machine should not back down with the pawl engaged,

The brake should be adjusted to stop machine 2 to 3 seconds after power is cut.

Chain System

Refer to Figure 16 for chain system components.

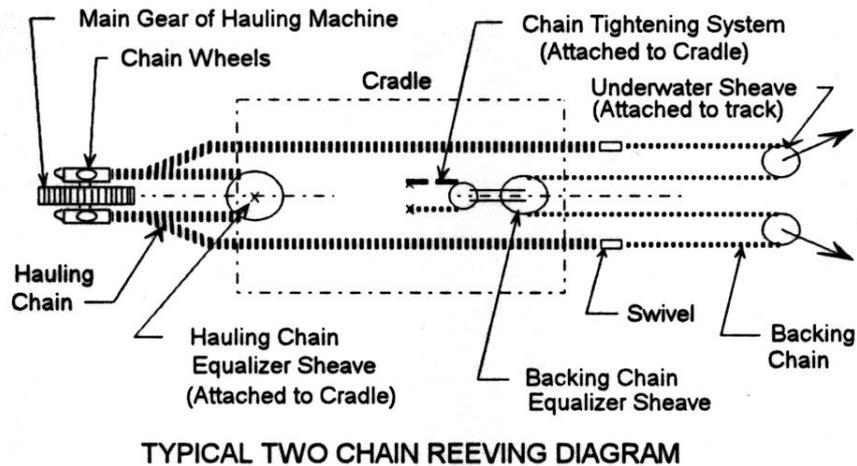
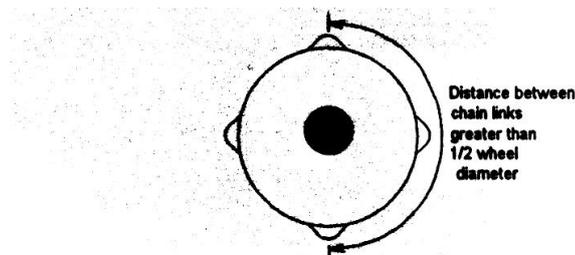


FIGURE 16

The fit of the chain over the chain wheel should be observed during an operation. As the chain and wheel wear, the chain becomes longer between links and the wheel's diameter becomes smaller, so the chain no longer fits properly on the wheel. See Figure 17.



When this occurs, the chain may make a snapping noise as it passes over the wheel. This can be corrected by padding the chain wheel to increase its effective diameter. Careful measurements of the chain AND wheel are required!

The chain should be kept properly tensioned. It should come off the underside of the chainwheel fairly taught, without dragging in the first bay between the machine house and first crosstie. See figure 18.

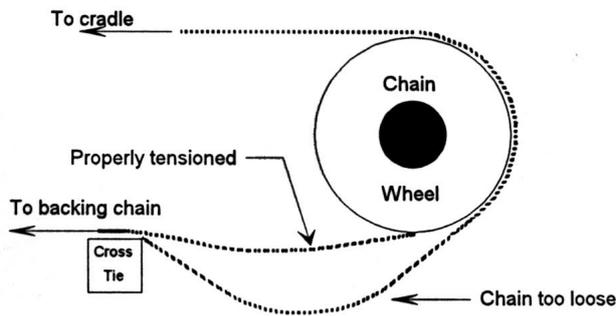


FIGURE 18



CHAIN TOO LOOSE

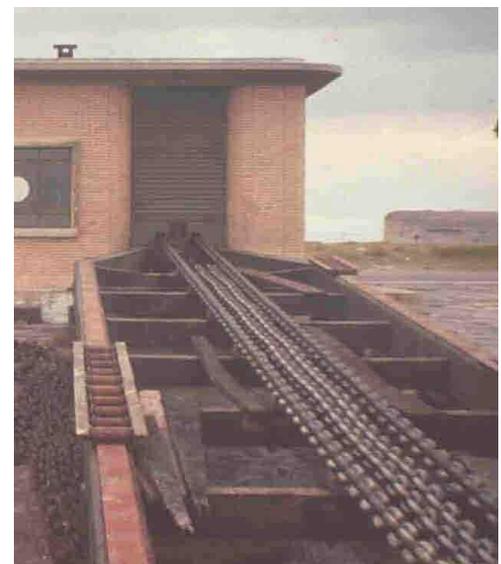
The hauling chain should not have any twist in it between the chain wheel and the point it is attached to the cradle (hauling connection).

Check the equalizer sheave, sheave case and pin for wear. Check the equalizer pin to be sure it is fully engaged and the retaining device is still working.

Check the underwater sheave, sheave case and pin for wear. Also examine the tie bars and connection to track.

The swivel and hauling shackle should be greased twice a year.

About every five years (more frequently for older docks), the hauling chain should be fully gaged and the capacity recalculated based on condition.



CHAIN PROPERLY TENSIONED

Measure the grips (double wire diameter) and link sides for wear. The capacity of the railway should be reduced to account for any loss of wire diameter of the hauling chain.

Measure the distance between 5 link lengths to determine chain stretch.

The backing chain should be inspected for wear and elongation due to overload.