Anchor loss - technical and operational challenges and recommendations

DNV GL, Gard and The Swedish Club

March 2016
Anchor loss – prevention - Content

- Background
- Technical issues and recommendations
- Operational issues and recommendations
- Legal notice
Why focus on anchor loss - lost per year?

Anchors lost per 100 ship year since 2007

- DNV GL has observed a relatively high number of anchor losses with 8-10 anchors lost per 1000 ships per year and a negative trend in 2014/2015.
Anchor losses per ship type

Anchors lost per 100 ship year & ship type
- Tanker for oil and Passenger Ships more exposed
- Reflecting the ship type trading pattern?

Anchor losses per 100 ship-year and ship type

- Loss per 100 Shipyear DNV Fleet 2010-2015
Costs involved with loss of anchors

- Direct cost to replace lost anchor and chain
- Gard has seen increasing costs related to recovering lost anchors amounting up to USD 50 000
- Delays and off-hire
- Cost due to grounding / collision / damage to subsea equipment etc.

Lost chain picked up by another ship
Consequences of anchor loss/dragging of anchor

Example of follow up events from dragging anchor:

- Ship anchored in bad weather during night time
  - Wind force 8-9
  - Waves 4,5m Hs
- Ship dragged anchor and grounded
- Consequence of damage:
  - 250 tons HF oil spilled
  - Polluting 37 protected areas of 120 km coastline
  - Cost of salvage 70 mill. USD
  - Out of service for 10 months
- Captain and 3\textsuperscript{rd} mate sentenced to jail

Vessel grounded due to dragging of anchor
Anchor losses technical issues

Technical issues

Anchor loss due to failure of:
- D-Shackle
- Swivels
- Chain
- Kenter shackles

Anchor and chain lost due to technical failure of:
- Windlass motor
- Windlass brakes
- Chain stoppers

Loss of anchor vs. loss of anchor and chain

DNV GL Fleet 2010-2015
Anchor losses due to operational issues

Operational issues:
- Dropping of anchor
- Use of brake
- Heaving the anchor
- Securing the anchor
- Anchor watch
- Lack of attention to bad weather

Events causing loss of anchor/chain

Source: The Swedish Club
When are anchors lost?

1. During normal anchoring in port anchorages.
   1. When vessel has too much speed during anchoring.
   2. When dropped without control by the brake
   3. When dropping anchor in too deep water
   4. When dragging. (Sometimes this may also cause damage to cables and pipelines and cause collisions)
2. When clutch disengages accidentally during anchoring operations
3. When anchor is stuck or fouled
4. When the hydraulic motor is engaged and the chain is pulled out by the vessel’s movements
5. Breakdown of windlass motor and the anchor and chain needs to be cut
6. On voyage, if the chain not properly secured
7. In connection with emergency anchoring to avoid grounding & collisions
What are the design loads for anchor, anchor chain and windlass?

- Wind speed?
- Strength of current?
- Wave height?
- Water depth?
The selection of anchor equipment is based on the Equipment Number EN defined as follows:

\[ EN = \Delta^{2/3} + 2.0hB + \frac{A}{10} \]

where:
- \( \Delta \) = moulded displacements [t], to the summer load waterline
- \( B \) = moulded breadth [m]
- \( h \) = effective height [m], from the summer load waterline to the top of the uppermost house
- \( A \) = area \([m^2]\) in profile view, of the hull, superstructures, and houses above the summer load waterline

\( \Delta^{2/3} \) represents the current forces

\( 2.0hB + \frac{A}{10} \) represents the wind force
Regulatory framework – IACS UR A1 (Unified Requirement)

- Class Rules based on IACS UR A1 – Anchoring equipment:
  - Designed for temporary mooring in harbour or sheltered area
  - Current velocity: max 2.5 m/s
  - Wind velocity: max 25 m/s
  - No waves

- Equivalent condition including wave loads:
  - Current velocity: max 1.5 m/sec
  - Wind velocity: max 11 m/sec
  - Significant wave height max 2 m

- Length of paid out chain
  - Scope of cable of 6-10
  - Good holding ground

Polluted coast line as result of anchor dragging
Windlass design load

- **Anchor winch motor** performance:
  - Minimum lifting capacity of 3 lengths of chain, i.e. 82.5m and the anchor

- **Windlass brakes** design load:
  - 45% of chain breaking load when a chain stopper is installed
  - 80% of chain breaking load when no chain stopper is installed
Anchor chain – conventional arrangement

Conventional connection between anchor and chain
**Alternative solution to attach anchor to chain**

1. Anchor shank
2. D-shackle
3. Swivel
4. Open link
5. Enlarged link
6. Kenter shackle
7. Anchor shackle (Crown shackle)
Class involvement with inspection of anchor and anchor chain

Class inspections:

- All materials to be certified by class
- Anchor windlass to be certified
- 5-yearly inspection intervals
- Thickness measurements from 10 years
- “Guidance for anchoring equipment in service” – IACS Recommendation 79
- Anchoring is a class matter not covered by IMO conventions

Technical issues
Anchor chain typical failures and focus areas

1. Anchor
2. Connection anchor to chain
3. Swivel
4. Anchor chain
5. Chain stopper
6. Windlass
7. Securing in hawse pipe
1. Anchor terminology and critical parts

- The crown shackle is made of forged steel. The bolt is forged in place.
- The anchor shank, flukes and crown plate is normally of cast steel.
- A solid crown pin or pivot of forged steel linking shank to crown.
- Class Societies have rules for the testing of anchors at the manufacturer.
- Certificates to be kept on-board.
1. Anchor types

Some typical anchor types:

- Spek, Baldt and Hall anchors hold basically by their mass
- The AC-14 is a high holding power and can be reduced in weight, by class rules.

Conventional Anchor types
1. Anchor – typical defects

- Anchor crown (and anchor shank) may be damaged during the dropping of an anchor if hitting rock
- Excessive wear of the anchor crown pin, and material defects in the anchor flukes and anchor shank
- Anchor shackle bent and bolt loose
  - Anchor shackle bolt is normally forged in place while D-shackle bolts are secured with a tapered pin
  - Bent shanks can be straightened according to class approved procedure
- Flukes may break off if stuck in-between rocks during pulling
1. Anchor defects

- Anchor shank is of cast steel and the material properties are critical
- Tests of material are carried out to obtain Class Certificate.
- Several anchors have been lost due to breakage of metal
  - Problem is assumed to be linked to insufficient annealing at manufacturer
  - Test pieces may be sufficiently annealed due to smaller mass than main object, and may have given good results during testing
  - Poor annealing may thus not be detected.
- Dropping of anchor at height at rocky bottom increase the risk for such failures
1. Second hand anchors

- Second hand anchors can be used, but must be in good condition, compatible with the ship and certified by class.

- Keeping a spare anchor can save a lot of time and money in case of an anchor loss.

- Class may re-certify second hand anchors based on visual survey, MPI, weighing and proof load testing.

Two anchors of the same ship are of different types, hence one is a second hand anchor.

Class approved anchors to be used.
2. D-shackle

- This shackle connects the chain to the anchor ring.
- Detached taper pin of the D-shackle is a common reason for loss of anchors.
- Pin and hole must be manufactured for a perfect match.
- Pin must be secured by hammering-in a lead pellet. If lead is melted and poured in, it will shrink when cooled and may not jam the pin.

Remember to check the taper pin on opposite side!

D-link bolt almost lost due to missing securing pin

Sketch of securing of D-link bolt by tapered pin
2. How to prevent detachment of D-shackle?

- Proper securing of the bolt by good fit between the securing pin and the D-shackle – securing by hammering in the lead pellet
- The bolt may be further secured by a washer plate and this is subject to Class approval
- Frequent inspections of securing of the D-shackle bolt
- Tight securing of the anchor in the hawse pipe during voyage to avoid excessive vibrations

Anchor lost and D-Link securing bolt loose

Additional securing of the D-Link securing bolt by a welded washer plate
3. Swivel

- Purpose of swivel is to avoid anchor chain twisting/shortening if vessel swinging around while at anchor
- There has been reported some cases where the swivel has detached due to excessive wear and tear
- Swivel is often not measured when ranged in dry dock
- If the slack between the eyelet axle pin and the link is more than 5% of the diameter the swivel should be replaced
- If chain needs to be renewed, renew also the fore-runner, swivel included

![Anchor lost due to detached eyelet axle pin](image1.png)

![IACS Recommendation 79 maximum wear of the axle pin](image2.png)
4. The anchor chain

- Thickness reduction due to wear and tear of the anchor chain must be carefully monitored.
- The maximum allowable reduction of chain diameter is 12%.
- If the chain is close to the limit special precaution is recommended to avoid excessive loads on chain.
- It is recommended to measure the chain also at dry-dockings for intermediate survey.
- Chain lengths with dislocated or missing studs should in general be replaced.
- Do not purchase second hand chain without class certificates.
- Be aware of fake certificates.
4. The anchor chain

- The studs which are there to keep the shape of the anchor links may come loose or fall out
  - If a stud is missing, the strength of the chain may be reduced by some 30%
  - Until this is rectified proper care must be exercised to avoid use in heavy weather

- Chain with loose / detached studs are recommended to be replaced

- Re-conditioning of chain with loose studs in certified workshops in accordance with a Class approved welding procedure including suitable heat treatment may be an alternative

- Un-authorized welding like seen on the lower right side is not allowed!
4. Kenter shackle

- Used to connect the chain lengths of 27.5 meters
- The Kenter shackle will normally not come apart provided the taper pin is properly fitted and sealed by a lead pellet
- Proper assembly of the Kenter shackle is essential
- When old chain is renewed it’s recommended to change the Kenter shackle as well
5. Chain stoppers

- Strong chain stoppers are installed between windlass and hawse pipe and are designed to absorb the pull of the chain
- Chain stoppers are to be engaged while at anchorage and during voyages
- The chain stopper is designed for 80% of breaking strength of chain

Conventional chain stopper arrangement

Guillotine bar broken
5. Chain stopper issues

- Guillotine bar or pawl may not fit
- Guillotine bar hinge pin may be heavily wasted and come loose
- Hinge pins and securing pins are often bent, reduced by corrosion or even missing
- Proper inspection and maintenance is needed
6. Anchor windlass

- Minimum lifting capacity for the anchor windlass is three lengths of chain (82.5m) and anchor submerged.
- The brake must be able to hold 45% of breaking strength of chain (80% if no chain stopper).
- Many incidents with loss of anchor and chain due to anchoring in deeper waters often combined with excessive sea loads (waves).
- Fatal accidents reported due to explosion of hydraulic motor due to rendering of the chain cable during hoisting operations in heavy weather.
6. Windlass brakes

- The windlass brake is essential to control the pay-out of the chain
- The conventional design is with brake bands but there are also disc brake systems
- Corrosion of the drum and wear of the brake band lining reduce the brake capacity
- It is essential that the tension of the brakes is adjusted and liners replaced as per makers instructions
- Alternate use of port and starboard anchors reduce risk for excessive corrosion / wear on one windlass
- Brake holding test is recommended at regular intervals
6. Windlass with high pressure hydraulic motors

- Fatal accidents have been reported with explosion of hydraulic motors due to rendering of the chain during heavy weather.

Pay attention to:
- Pressure relief valves
- Cleanliness of hydraulic oil
- Corrosion on the housing
- Protection cover could be considered to reduce risk for flying debris.

7. Chain cable tensioners

- Chain cable tensioners are installed for the purpose of avoiding slamming of the anchor in the hawse pipe.
- Tensioners of whatever type may be damaged and worn and should not be trusted alone to hold a stowed anchor at sea.
- Excessive vibrations of the anchors may cause loosening of securing pins in anchor shackles.
- Broken claws, hooks etc. of cable tensioners should not be repaired by welding, but renewed.
Operational issues
Operational recommendations

1. Preparing for anchorage
2. Dropping of anchor
3. At anchorage
4. Heaving the anchor
5. Preparing for voyage

Ship at anchorage

Ungraded

Lowering by the windlass
1. Preparing for anchorage

- Suitable anchoring location considering:
  - Traffic and congestion in the area & backup option
    - Have a plan b
  - The water depth
    - Windlass may not be able to recover more than three lengths of anchor chain (82.5m)
  - Safe distance to underwater cables and pipelines

- Master and Chief need to discuss if there is planned overhaul of machinery or essential equipment for ship navigation

- Nature of the sea bed & holding power
  - Clay gives best holding power but “sucking effect” to be considered for prolonged anchorage
  - Shingle and sand may have good holding power
  - Pebbles and cobbles have low holding power
  - Rocky bottoms and slopes are poor anchoring grounds where the anchor may be stuck

Anchoring in congested waters needs proper planning
1. Preparing for anchorage

- Take into account available port specific information
  - Pilot books
  - “Guide to Port Entry”
  - Large scale charts
  - ECDIS
- Weather forecast for the anchoring period
- Pre anchoring brief with all involved parties, where all possible risks are evaluated
2. Dropping the anchor

Three ways of lowering the anchor:
Vessel speed close to zero over ground

- **Let go of anchor**
  - Anchor being let go from the hawse pipe or from sea level
  - Suitable for shallow waters (up to 20-25m) with soft sea beds

- **Lowering by the windlass and let go controlled by brake**
  - The anchor is lowered by the windlass until 10-15 meters from bottom and then let go controlled by the brakes
  - Suitable for depth range 25 to 50 meter and for hard and rocky bottom where impact may damage the anchor
2. Dropping the anchor cont.

- **Lowering down by the windlass to bottom**
  - Anchor chain is lowered by the windlass motor to the bottom
  - Suitable for depths more than 50 meters and when the sea bed is rocky

- **Length of laid out anchor chain**
  - If the anchor is “walked out” by the ship engine it is essential that the astern speed is not exceeding the speed of the anchor winch Normally max 0.3 knots
  - In order to ensure maximum holding power of the anchor, the chain on the seabed needs to be horizontal
  - Class guidance to ensure this is a scope of 6-10
3. At anchorage

- Define the limiting wave / wind exposure based on the current at the location
- Monitor the weather forecast
  - In case heavy weather approaching, leave the anchorage in time
- When the anchor has been laid out, the chain stopper should be engaged and gear disconnected from the motor.
- Use all navigational equipment to ensure that the vessel is not dragging
- If vessel stays at anchor for a long time and current and wind swing the vessel, heave the anchor to avoid knotting the chain and fouling the anchor with own chain

Class rule environmental conditions:
- Current 2.5 m/sec
- Wind 25 m/sec
- No waves

Alternative environmental conditions:
- Current 1.5 m/sec
- Wind 11 m/sec
- Significant wave height 2 m
4. Heaving the anchor

- **Leave anchorage in time!**
  - Heaving anchors up in strong wind and high seas is extremely challenging
  - Mistakes can easily lead to grounding or collision
- Minimize the tension in the chain keep the chain as vertical as possible
- In windy weather conditions or strong current the rudder and engine must be fine tuned to prevent too high tension in the chain and overload of the windlass motor
- Close communication between bridge and anchor watch on deck is essential

Proper attention to weather forecast is essential. Heaving anchor in heavy weather involves significant risks
5. Preparing for departure

- Ensure the anchor is safely secured before sailing
  - The anchor to be securely stowed in the hawse pipe
- Excessive slack may cause “hammering” of the anchor to the ship hull and loss of the D-shackle securing pin.
  - Winch brakes have to be applied
  - Chain stoppers to be engaged
  - Further secured with lashings with turnbuckles or other similar fasteners
  - Windlass clutch has to be disconnected from the gear at sea to avoid risk of damage
Main learnings!

- The environmental limitations
- The depth limitations
- Securing of the D-shackle
- The condition of the anchor winch brakes
- Well implemented routines for anchoring operation
  - Planning the anchorage
  - Dropping the anchor
  - At anchorage
  - Heaving the anchor
For further guidance...

http://Gard Newsletter 2011

Maritime Safety Scenario

First Edition - 2010
Appendix – Safety Scenario Loss of Anchor (The Swedish Club)

- Case study loss of anchor

http://www.swedishclub.com/media_upload/files/Loss%20Prevention/MSS%20Cases/Loss%20of%20Anchor_October%202015.pdf
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