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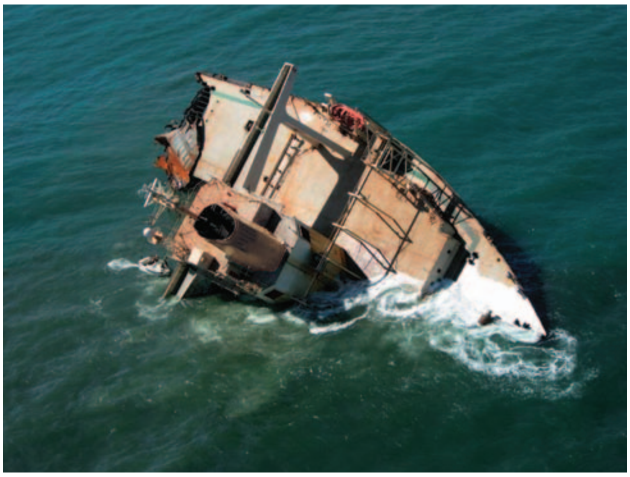
走錨とその防止対策
Dragging Anchor and the Preventive Measures

1 はじめに

昭和29年9月26日、洞爺丸(4,337トン乗員乗客1,314人)は台風避難のため函館湾で錨泊中、最大瞬間風速50m/sを超える暴風と波高6mのうねりで走錨し、七重浜沖に乗り揚げて転覆し、1,155人が死亡・行方不明となりました。詳細な事故原因の調査がなされ、本船の運航上の過失が認定されています。55年を経た現在では、走錨の原因・防止等についての文献は多くの情報を与えてくれますが、同種事故はしばしば発生しています。



走錨後の本船の漂流に続き、しばしば、衝突、乗揚、転覆、座礁といった重大事故、これによる船舶全損、油流出、船骸撤去が生じます。走錨船に

1 Introduction

Tohya Maru case in 1954 was at that time the second worst accident, following Titanic. Having encountered a typhoon Marie, Tohya Maru, a 4,337 grt Japan Railway passenger ferry, took a refuge at Hakodake Bay. With the violent weather of 50m/s gust and 6m height waves, she dragged her anchor, went aground and capsized. Full scales of investigations were pursued, which concluded the negligence in Tohya Maru's navigation and operation. Since then, there have been so many informative and advisable materials and publications with respect to the prevention of dragging anchor, but we still have many cases involving dragging anchor.

Dragging anchor will be followed by ship's drifting and then often a collision with other ships or property, grounding, capsizing or sinking, having a result of ship's total loss, wreck removal, oil pollution. A collision with another anchored ship might cause that ship's dragging and drifting, which could then cause further damage or loss to the other ship or property or environment. Dragging will occur

接触されて走錨した船舶が他船や港湾構造物や港湾環境に多大の損害を与える場合もあります。走錨は荒天時に生じ、それ故に本船が操縦可能になるまでに時間のかかることが多く、ここでは、本船上で日常行われている錨関連作業が高度の技術・経験と即時かつ冷静な判断を要する緊急措置に変貌します。日常の錨作業での十分な安全停泊・走錨防止措置が求められる所以です。近年では、操船上制約のある大型船や風圧影響を受け易い自動車運搬船・大型客船が多数運航しており、この種の船舶では更なる注意喚起が求められることは言うまでもありません。

2 類似事故例（過去海難審判裁決）

錨地選定不適切、水路情報の把握不十分、守錨当直不十分等により避難措置に遅延・不適切が生じ、その結果、走錨ないしその後の事故が発生したとされるケースがほとんどです。

(1) 一般貨物船（498GT）

1999年3月8日、茨城県鹿島港

鹿島港南防波堤内側の水深約10m（底質貝殻と砂）に左舷錨2.5節（1節25m）で単錨泊中、風速15m/sの北寄り風で港口から波高3mのうねりが侵入。走錨を始めるも守錨当直者は気付かず。昇橋した船長がレーダーで船位確認して走錨を知り、直ちに機関用意としたが消波ブロックに乗揚げ。

(2) ばら積み貨物船（36,080GT）

2002年7月25日、鹿児島県志布志湾

台風避難のため志布志湾（水深25m、底質砂）に錨鎖6節で錨泊。その後、右半円の暴風域に入

in an unfavorable weather, where the ship needs time to recover her maneuverability. Anchor handling is day-to-day work for seafarers, but once the anchor is dragged, it will radically change its nature to the emergency and imminent action, which need the seafarer's highest skill and experience as well as their quick but calm decision. Recently, there are so many large-sized ships, such as VLCC, ULCC, Cape Size bulker and ships with large superstructure, such as pure car carrier and passenger ship, all those are vulnerable to bad weather. Not to mention, we need further attentions to the safe anchorage and prevention of dragging anchor.

2 Cases of Japan Maritime Accident Inquiry Agency(MAIA)

In most of MAIA cases involving dragging anchor, MAIA found, improper choice of anchorage, inadequate anchor watch, insufficient recognition of forthcoming bad weather and the other circumstances at the anchorage resulting in late or improper sheltering or departure or other counter measures.

(1)General cargo vessel (498GT)

March 8, 1999 in Kashima Port, Ibaraki Pref.

The vessel dropped her port anchor in the inside water of Kashima South Breakwater with 2.5 shackles (25m/cable) in 10 meters of water with shell and sandy seabed. The 3m of swell came in from the mouse of harbor with 15m/s of northerly wind. The vessel dragged her anchor but the duty seaman failed to detect it. The master, who came up to the bridge confirmed dragging anchor by fixing the position by radar, immediately ordered to prepare the engine, but too late.

り風向が変化、湾口から大きなうねりが侵入。風速25m/sの暴風と波高約5mのうねりで走錨、海岸に乗揚げ。なお、同湾北部水深約40m地点に同型船が錨鎖9節で錨泊(機関使用)していたが、同じ頃走錨。再度錨鎖10節で錨泊(機関使用)したが再び走錨。

(3) 練習帆船 (2,556GT)

2004年10月20日、富山県伏木富山港

台風が接近するなか、富山湾の特性(長時間の北東風の吹続、海底構造により湾奥でも相当高い波がおこること)を把握せず、水深17m、底質砂の海底に右舷錨7節で単錨泊。その後、最大28m/sの風、波6mの予報を入手したが、揚錨して沖合でちちゅうする(風浪を船首方向に受けるようにし操舵できる最小限の推力で航走し荒天をしのぐ)方法等の避難措置をとらず、右舷錨9節・左舷錨3節投入として錨泊を続け、風速25m/sを超え機関を使用するも走錨、風力12の風と波高6mの波で圧流され浅所に乗揚げ。

(4) コンテナ専用船 (9,931GT)

2007年9月7日、京浜港横浜区

甲板積みコンテナで風圧影響を受けやすい状況下、台風避難のため左舷錨6節、至近の他錨泊船のため錨鎖を伸ばせぬまま、機関用意、右舷錨を投錨できる状態で単錨泊。その後、20m/sを超える風のなか、機関を適宜使用して錨鎖張力を緩和するなどの走錨防止措置を十分にとらず、走錨を検知後機関全速・右舷錨投下、2節としたが、漂流して防波堤に衝突。

She went aground on the breakwater.

(2)Bulk carrier (36,080GT)

July 25, 2002 in Shibushi Bay, Kagoshima Pref.

Having an approaching typhoon, the vessel took a refuge and dropped her anchor in Shibushi Bay with 6 shackles in 25m depth of water with sandy seabed. The area entered in "dangerous semicircle" of the typhoon, and the wind direction changed. The big swell came in from the outside of bay. She dragged her anchor, having 25m/s strong wind and 5m swell, and she went aground on the shore. At the same time, another vessel of similar type lying on anchor with 9 shackles in 40m depth in the northern part of the bay also dragged anchor. She tried to keep her position by use of main engine, and succeeded in dropping her anchor again with 10 shackles. However, her anchor was again dragged.

(3)Sail training ship (2,556GT)

October 20, 2004 at Toyama Port, Toyama Pref.

When a typhoon was approaching, the ship dropped her starboard anchor with 7 shackles in 17m depth of water in Toyama Bay, without recognizing that in that bay higher waves would develop even in the inner bay area due to geographic feature of sea bottom when northeasterly wind blows for a considerable period. Though she received the forecast of 28m/s wind and 6m swell in maximum, she did not take shelter at sea by "heave to" (the method of a ship's hold at sea in severe weather by giving minimum thrust to maintain the heading against wind and wave) and remained at anchor with 9 shackles of starboard anchor and 3 shackles of port anchor. She dragged her anchors. In spite of her endeavor by using her engine in the strong wind over 25m/s, she went aground in

③ 錨泊の安全または走錨危険の判断に影響を及ぼす事項

船舶が錨泊中、錨・錨鎖は、風圧力、波、うねり、潮流などの外力による影響を受けます。これらの外力による影響は本船の状態、例えば喫水、排水量、載貨量、トリム、水面上構造物などにより変わります。このような外力のみでなく、錨泊中の船体の振れ回りの中で船首が風下に移動するときに発生する衝撃力があります。このような衝撃力は振れ回り運動の両端において船体が風上に切り上がり錨鎖が一旦緩んだ後急激な船首回頭とともに船首が風下におとされる過程で発生します。衝撃力の発生時期は「船首尾線と錨鎖方位の一致した所」を過ぎ、「船首方位に対して錨鎖方位が50度前後となる所」であるとの研究結果があります。この衝撃は本船船首が風下に振れ回る時に船首方に舵をとることにより和らげることができます。同様の衝撃は、本船が外力により上下・前後に動く場合にも発生します。この衝撃は錨鎖を更に繰り出すことにより緩和されます。しかし、いずれの方法もこれらの衝撃を完全に無くすことは出来ません。錨・錨鎖の把駐力合計より作用する外力が勝る場合に走錨が起きます。走錨を生じさせる要因は多岐にわたっています。以下、安全な錨泊のため考慮すべき事項について述べます。

(1) 気象条件

錨泊の安全は現在の及び予測される気象状況、特に気圧、台風・低気圧・前線の進路と速度に左右されます。台風の暴風域に入ること、風向きの変化、波浪の侵入の現状及び予測は極めて重要です。

a shallow water in force 12 wind and 6m wave.

(4) Container carrier (9,931GT)

September 7, 2007 in Yokohama port, Kanagawa pref.

The vessel dropped her port anchor with 6 shackles at Yokohama port. She could not extend her anchor cables as the other vessels were anchoring nearby. She was ready to use the engine and to drop her starboard anchor. The wind speed became over 20m/s, but having a large superstructure on sea surface, she failed to use the engine properly to reduce the stress on anchor chain. When the crew became aware of her dragging anchor, she put the engine to full ahead and dropped her starboard anchor with 2 shackles of chain. However, she drifted and collided with the breakwater.

③ Factors for safe anchorage or for assessing a risk of dragging anchor

When a vessel is at anchor, her anchor and cable will have various external forces, such as wind effect, wave actions, swell, tidal stream/current flow, etc. The stress on the anchor and cable is dependant on the ship's drafts, displacement, trim, superstructure, ballast/loaded conditions. In addition to such external forces, the anchor and cables are given the shock force in ship's yawing. The shock force is given when the vessel's bow turns quickly and falls down towards lee, after the slack of anchor cables during the bow's facing windward. Based on one research, the shock force is given at the point of time when the direction of anchor cables makes about 50 degrees against the vessel's heading after passing the time when the heading

(2) 外力条件

a. 風

風圧力は風速の二乗に比例して増大します。低緯度地方等ではスコールにより一時的に急激に風が強まることがあります。最大瞬間風速は平均風速の1.4－1.6倍とされ船体に瞬間的な外力を与えます。

b. 波

風の吹続時間と吹走距離により波高が高くなります。例えば、風速15m/sの風が20時間、500kmにわたり吹くと波高5mになります。また、波が高くなると走錨の可能性も増します。前示2(2)の事件では錨泊中の風圧力の他にうねりによる波漂流力の影響を警告しています。なお、波浪による船体上下動は錨鎖に急張力を与え走錨の可能性は高まることになります。

(3) 錨地条件

a. 底質

最も錨効きのよいのは粘土、砂と泥が半々の混合土(SM or MS)、次に泥、固い砂。一方、細かい砂、軟泥、柔らかい泥混じり粘土は錨掻きが悪いといわれています。

corresponds to the direction of anchor cables. Ship's personnel could reduce such stress on her anchor and cables, for instance, by turning the rudder to provide a sheer to her head. Similar impact may occur in ship's pitch and surge movement. Such stress may be reduced by lengthening the scope; i.e. paying out the cables further. We should note that these methods only reduce a part of those forces, but not eliminate the stress. The anchor starts dragging when those all forces exceed the total holding power of ship's anchor and cables. A risk of dragging anchor should be assessed on various factors. The following brief on each factor would help such assessment for the safe anchorage.

(1)Weather

Present and forecasted weather conditions, esp. atmospheric pressure, course and speed of typhoon, low depression, front are basic factors to consider the safety of the anchorage. Especially, ship handlers shall review if and how the anchorage would enter into typhoon's stormy area; e.g. any change and severity of wind and waves as well as their timing.

(2)External forces

a. Wind

The wind effects on the ship and then on her anchor and cables will increase by the square value of the wind speed. Squalls in the area of low latitude raise the wind speed very quickly and they have a sudden gust. The maximum speed of gust is known as 1.4-1.6 times of average wind speed, which will give a sudden momentum on ship's anchor and its scope.

b. 水深

船乗りが繰り出し錨鎖長を決定する時にまず基礎とするのが水深です。喫水の2倍程が最低水深です。触底・走錨時の対処を踏まえ予想波高の3倍以上の余裕水深を確保すべきです。十分な錨鎖長により錨に対して水平の牽引力を与え、更に錨鎖による大きな把駐力を得る必要があります。錨の牽引方向が水平から5度変わるだけで20%の把駐力が失われると言われています。

c. その他の地理的条件
（湾の形状、海底谷、周囲の遮蔽物等）

風波を遮蔽する地形が望まれます。潮流・潮汐の影響の少ないことも条件です。先に述べたように、湾奥部は、吹走距離が長く波が高くなると、波が崩れ大きな波圧が船体に加わることとなる一方、波による船体動揺は錨鎖に衝撃を与えることとなります。日本海海上で一定期間の荒天により発達した波浪が荒天の過ぎた後にうねりとして富山湾に伝搬し海岸部を襲います。この高波は「寄り回り波」として知られています。

d. 周辺水域の余裕、他錨泊船の状況

余裕水域が十分でない状態や他船と接近した状態では走錨による相互間衝突の危険があります。他船の航路の至近も不適当です。昭和24年8月31日のキティ台風では、横浜停泊中の90隻中26隻が沈没しました。船舶が密集して錨泊中、風下の近距離に港湾施設のある場合、走錨が発生すると大きな被害になることを示唆しています。荒天となるまでの時間が短くなるとともに錨地は混雑し、投錨時に良好であった錨地

b. Waves

Waves and swell will develop with the wind's fetch/duration. In theory, if 15m/s wind blows over 500km for 20 hours, the wave will be developed to 5m high. Not to mention, a risk of dragging anchor will increase as the wave becomes higher. The above MAIA case 2(2) warns the effect due to the "drift force" by swell in addition to the wind effects. The ship's pitching actions by wave and swell gives anchor cables a sudden tension, which raises a risk of dragging anchor.

(3)Anchorage

a. Sea bed nature

The best holding ground for the anchor is clay, followed by mixture of half sand and half mud (SM or MS), although mud or hard sand is quite acceptable. Fine/soft sand, soft mud, clay but with soft mud would not give the anchor a good holding power.

b. Water depth

Most seamen first check the water depth, if the ship will have an enough under keel clearance, and when they will decide the amount of scope to pay out. Appropriate water depth is dependent on the other various factors, but at minimum about twice as deep as ship's draft. It would be necessary to keep the underwater clearance as 3 times as much as the predicted wave height, to avoid any possible contact between hull and sea bed or so as to enable the ship to take effective and flexible measures responding to a situation of dragging anchor.

Sufficient amount of scope will give the horizontal pull to the anchor, and then the higher holding power of the anchor and cable. It is said that change of 5 degs in

も条件は悪化します。他船の状況には十分注意すべきです。

(4) 船体条件

a. 船種・船型

受風面積が大きく風圧中心が前方にある船型(自動車・コンテナ専用船等)では船体は大きく振れ回り錨鎖張力が大きくなります。

b. 排水量・喫水・トリム

特に自動車専用船は、深さに対して喫水が浅く、風の影響を受けやすく、また、船首フレアーが大きく大波を受けて上下動が激しくなり波の衝撃が強くなります。6,000台積自動車専用船では、風速25m/sで、振れ回り中心より船長の約2倍横方向に振り出されるとの研究結果があります。

c. 主機・バウスラスター性能

主機及びバウスラスター性能は錨泊の計画を策定するに重要な要素です。6,000台積自動車専用船において、走錨後に姿勢を制御するためには、風速30m/sではスタンバイフルが必要。実際は、波浪により船体動揺、プロペラレーシングで連続運転が困難な場合が多いと思われます。また、姿勢制御のためのバウスラスター(推力12ー17トン)使用は、走錨後に船体が一定速度で圧流され始める段階での圧流抑止は困難である、と言われています。

d. 錨の種類・重量・寸法

①投錨後に爪が確実に海底にかき込むこと、②大きな把駐抵抗を持つこと、③ひきずられても回転せず姿勢が安定していること、が求められ

pulling direction from the horizontal pull to the anchor will lose 20% of the anchor's holding power.

c. Geographic feature (land shapes, underwater canyon, shelters etc)

The good anchorage shelters wind and waves, and gives favorable current and tide. As mentioned on the above, when the fetch of wind becomes longer, the waves will be developed higher and their break will add the wave effects on the ship. The waves shake the hull and give a sudden stress to the anchor cables. For instance, Yorimawari Waves in Toyama Bay is well known, which swell is generated in Japan Sea after a certain fetch and duration of rough weather, and after the rough weather passes away the developed waves are propagated to Toyama Bay, where the high waves will attack the shore and the shallow waters.

d. Swinging room; other anchored vessels nearby

The ship should drop anchors in a position having safe distances to the other ships. Anchoring at a shorter distance will risk the ship to a collision with the other ship when she or the other drags her anchor. The anchoring position should be as clear as possible of through traffic. The 26 out of 90 anchoring vessels in Yokohama sank due to a typhoon Kitty on August 31, 1949. It tells us that the damage becomes more disastrous if many vessels were anchoring so close each other or to the port facility. Please note that as time goes and rough weather coming closer, the anchorage might become more and more congested.

ます。商船にはJIS型、AC14型、ダンフォース型等がよく用いられます。

e. 錨鎖の重量

錨鎖も種類によって重量、従って把駐力が異なります。 船舶設備規定によれば、原形のほぼ1割摩耗までは錨鎖は使用可能ですが、摩耗による重量減少は把駐力を低下させます。

(5) 錨泊方法

通常は単錨泊です。双錨泊は投錨・揚錨に手間を要し、錨を絡ます可能性もあります。これらの事情から荒天時も単錨泊を採用することが多いようです。

4 走錨防止対策

強風下での自船走錨による衝突や乗揚げ、他船の走錨による自船との衝突による損害が発生しています。走錨及びこれより生じる事故を防ぐための措置として以下が挙げられます。

(1) 良好な錨地の選定

前記 3(3) 錨地条件をご参照下さい。

(4) Ship's condition

a. Kind/type of ship

Car carriers and container ships have larger superstructures on sea surface to receive the wind effect. In those ships, the center of the wind effect on the hull is located on their forward parts. Those ships will make heavier yawing, and give more stress on anchor cables.

b. Displacement, draft, and trim

A car carrier is vulnerable to the wind, since their draft is rather small compared with their depth. Also, as their bow flare is relatively large, the wind and waves will make their pitching and shaking heavier and put stronger stress on their anchor and cable. The result of investigation says that the car carrier of 6,000 units will make yawing in a width almost twice as much as her length in 25m/s of wind speed.

c. Power of main engine and bow thruster

Ship handlers always consider the power of main engine and if any of her bow thruster in setting up their anchor plan. The result of one research says, the stand-by full power of main engine is the minimum must to maneuver the car carrier of 6,000 units once she dragged her anchor in 30m/s of wind. In fact however, it would be difficult to keep running the engine in the weather which makes ships heavy pitching and rolling as well as propeller racing. Also, the same research says, it is difficult to stop the drift of vessel of same type even if she used the bow thruster (12-17 tons of thrust) to establish her sufficient maneuverability while she is drifting after dragging anchor.

(2) 錨位の正確な把握

投錨時の船首方向と船位（船橋位置）を測定し、船位から船首方向に船首船橋間距離分だけ移動した地点が正確な投錨地点となります。同位置から、伸出錨鎖長さ＋船長を半径とする円を描き、同円から船位が外れたら走錨を疑うこととなります。

早期検知法としてよく知られている方法として、以下の方法があります。

ログ示度から得られる前後速力と船首方向を一定時間間隔で読取り、ログ示度を縦軸、船首方向を横軸でプロットすると八の字軌跡が得られます。走錨し始めると形状が変化、特に縦軸を横切る時の値が常に負となります。

また、もっと簡易な方法として、
- レーダー上の陸岸及び数個の目標をマークしておく
- 位置をいくつかの方法で測定する。少なくとも3個以上の物標で交叉位置測定を行う

があります。

(3) 気象他の情報入手、VHFの聴取

a. 強風・暴風域に入ること、風向きの変化、波浪の侵入についての危機意識を常に持ち、台風の動向についての楽観的な予測をしないことが大切です。また、台風に対してのみ情報を入手して避難対策をとるだけでなく、低気圧/前線に対しても油断せず情報を入手すべきです。

本邦では、暴風警報は通常海上平均風速25m/s以上、波浪警報は地域により異なり、愛知県では有義波高外海6m、内海3m以上を予想する場合に発表されます。また、一定の風速を超えることが予想され走錨の可能性

d. Type, weight and size of anchor

Modern merchant ships employ anchors of the types: JIS, AC-14, and Danforth. These kinds of anchors are known as good holding of seabed, higher holding resistance and good stability not easy to rotate.

e. Weight of anchor chain

Depending on the grade of cable, its weight and thus holding power will vary. According to Japanese Regulation for Equipment of Ships, the anchor cables could be used only before about one tenth of the original diameter of cables was worn out. The decrease of weight results less holding power.

(5) Anchoring method

Single Anchor is usual. It takes longer time to drop/pick up two anchors, and the anchor cables might get fouled. Ships are not usually taking two anchors.

4 Measures to prevent dragging anchor

Various accidents and then loss/damage/liability arises from dragging ship's own anchor in rough weather, or from a collision with another vessel which dragged her anchor. It may be useful to repeat here what to do in order to avoid dragging anchor and subsequent incident.

(1) Choosing proper anchorage is first priority.

Please see the above 3 (3) Anchorage.

(2) Checking her anchor's position

The vessel's heading and the position of bridge should be checked exactly at the time when she drops her anchor. Her anchor position can be fixed by extending a line

のある場合、「走錨（そうびょう）注意情報」を発令しています。例えば、鹿島港では、北～東寄り（0～120度）の波高4m以上且つ平均風速10m/s以上となる場合は、3,000dwt以上の港外錨泊中の船舶に対し、抜錨・漂泊避難を勧告（避難勧告）しています。

b. 一般に、台風の左半円は可航半円、右半円は危険半円と言われていますが、高気圧の縁で吹出す風が左半円の風に重なり風が強まることがあり注意を要します。前示2(3)の事件はこのような状況下で発生しています。

(4) 守錨当直を常時行い、自船・他船の走錨を直ちに検知できる態勢とします。

a. 台風通過前後の風向の変化に注意します。

b. AIS等で周囲の錨泊船名を把握しておき連絡体制を確保しておきます。

c. 風上の錨泊船には特に注意を払います。

d. 守錨当直者に対し、報告事項・基準・風速等を具体的に指示徹底させます。風向変化や周囲の錨泊船などの状況について、どのような状況で報告してほしいかを具体的に示すべきです。

e. 走錨すると以下の状況が船上で検知されます。
(1) コースレコーダー記録紙が規則的なサインカーブを描かない
(2) 船首が風にたたない
(3) 風を受ける舷が変わらない
(4) 風を受ける舷が変わる直前あたりで錨鎖がたるむ現象が見られない
(5) 異常な振動が錨鎖を伝わって感じられる

from the bridge's position to her heading and in a distance between bridge to stem. Her anchor position should be marked on the chart. Then, the circle with a radius of the length of anchor cable plus bridge-stem distance can be drawn, centered on the exact anchor position. In such a drawing on the chart, if the (bridge) position went out of the circle, you should suspect dragging anchor.

Well-known method to find dragging anchor earlier is: -
Vessel's speed showing in speed log and her heading should be recorded periodically. The 8-shaped track by plotting speed on the vertical and heading on the transverse would be obtained. If the anchor dragged, the 8-shaped track would change. Particularly, the speed value crossing at the vertical becomes always negative.

More simply, seafarers do: -
- mark on the radar land shapes and fix objects.
- fix ship's position in several ways, and get at least three objects in cross bearing position fix.

(3) Getting weather information by all available means

a. Ship handlers should always review all weather information and forecast, and pay attentions gale/storm warning, the change of wind and waves. They should not be in optimistic on predictions for the movement of a typhoon or weather in general. They should carefully obtain all available weather information not only for a typhoon but also for a low depression/front.

In Japan, Storm Warning will generally be issued when 25m/s of average wind speed or more at sea is forecasted. Also, High Wave Warning, though it

(6) 速力計に連続した負の値がでる

左記(3)(4)については、一定速度で風下に走錨する前に、船体は振れ回りながらも風下に少しずつ圧流されるような過渡的な走錨状態のあることがわかっておりますので、注意が必要です。

(5) 荒天時の錨泊

a. 錨鎖の伸出

錨鎖と海底との摩擦抵抗が増加、カテナリー部も長くなり、把駐力の増加や波浪による衝撃力、振れ回り運動の緩和に効果があります。

旧日本海軍で使用された略算式が知られています(D：高潮時の水深m)
通常(最大風速20m/sの風を船首ほぼ2.5点に受ける)：3D＋90m
荒天(最大風速30m/s ー同上ー)：4D＋145m

要は、推定最大外力と対抗し得る錨鎖量を伸出しなければ走錨は防げないということです。錨鎖張力は概ね風速の二乗に比例して増大します。把駐力、風圧合力(外力)は以下の数式で算出されます(P＞Rなら、理論上走錨の可能性は低いことになります)。

varies in each area, will be issued, for instance, in Aichi Prefecture, when it is forecasted 6m of significant wave height in the open sea and 3m of the same in the inland sea. Japan Coast Guard from time to time issue the "Advice to prevent dragging anchors" if the strong wind and a risk of dragging anchor is predicted. For instance, in the port of Kashima, vessels of 3,000 deadweight tons or more which had been anchored outside the port are recommended to pick up anchor and to evacuate the coastal waters if the wave height of 4m or more in northerly to easterly directions (0-120 degrees) and the average wind speed of 10m/s or more were forecasted - Alert of evacuation.

b. The left semicircle of a typhoon is called as the "navigable semicircle", while the right is called as the "dangerous semicircle." On the other hand, you should pay attention to the strong wind blow beside high pressure if it is affected by the wind of navigable semicircle. (The incident referred to in the 2 (3) occurred under such a situation.)

(4) Anchor watch should be kept 24 hours to check if there is any dragging anchor of her own or another vessel.

a. Ship handlers should pay attentions to the change of wind direction before/after passing the typhoon.

b. They should check names of anchoring vessels nearby by AIS, VHF or other means in advance for possible communication in necessity.

c. Especially, they should pay close attentions to the anchoring vessels on windward.

d. Anchor watch officers should be asked to report necessary information, such as wind speed, direction, wave/swell height and direction, their change tendency, the

$$P = \lambda_a \cdot \omega_a + \lambda_c \cdot \omega_c \cdot l$$

λ_a：錨の把駐係数
ω_a：錨の重量(kg)
λ_c：錨鎖の摩擦抵抗係数
ω_c：錨鎖1mあたりの重量(kg)
l：把駐部の錨鎖長(m)

$$R = 1/2\rho_a C_a v_a^2 (A\cos^2\theta + B\sin^2\theta)$$

ρ_a：空気密度(0.124kg・sec^2/m^4)
C_a：風圧係数
v_a：相対風速(m/s)
A：船体正面投影面積(m^2)
B：船体側面投影面積(m^2)
θ：風向

b. 喫水を深くする

受風面積が減少し、排水量が増加して船体の振れ回りが小さくなる効果を期待出来ます。

c. 船首トリムとする

風圧中心が船尾に移動、水流力の作用中心は船首方向に移動し、船体の振れ回りが小さくなる効果を期待出来ます。

d. 機関用意とし、いつでも使用できる態勢とする

機関用意に必要な時間を把握しておくべきです。走錨後、機関用意・使用までの間に事故になる例は少なくありません。

e. 第二錨の投錨

振止め錨として使用すると船首振れ回りを半減させ錨への作用力も30－40%減少することが期待出来ます。可能であれば、予想風速最大となる時の風位をはさむように両舷錨を投入伸出

movement of the other ships nearby.

e. In case the anchor is dragged, the following phenomena can be found.
(i) Course recorder does not show regular sine curve.
(ii) Ship's heading is not directed windward.
(iii) Ship receives the wind from only either of starboard or port side.
(iv) Anchor cables remain tight even when the wind receiving side changes.
(v) Anchor cables has unusual vibration.
(vi) Speed meter keep indicating a minus speed.

For the above (iii) (iv), please note that the vessel might fall down leeward slowly during her swinging as a transient state before her constant drift towards leeward due to dragging anchor.

(5) Anchoring method in rough sea

a. Paying out more anchor cables

The friction force between cables and sea bed would increase as the scope becomes longer. It would contribute to increase the holding power, and to subsiding the shock by wave and the vessel's swinging movement.

The formula traditionally used in Japan
(D: water depth at high tide)

Normal (Receiving 20m/s max wind on abt 2.5 points on starboard/port bow) 3D+90m

Rough sea (Receiving 30m/s max wind on abt 2.5 points on starboard/port bow)
4D+145m

The dragging anchor could not be avoided unless the anchor cables are extended to increase the holding power compared to the estimated maximum outer force. The

すると、船体の振れ回りが軽減され大きな把駐力が得られます。双錨泊では錨鎖の開き角が50ー60度に設定されると錨への作用力が約40%減少することになります。但し大型船型では、第二錨投下に際し、意図する角度を得るような操船は困難でしょう。

f. 主機/バウスラスターの使用

舵や機関、スラスターで船首を風波に立てます。バウスラスター制御に加えて微々速後進推力を使用する場合、錨鎖に余分な負荷を加えることになりますが船体の振れ回りは抑制されます。後進推力の実用上の限界は風圧の0.5倍以下と考えられる、との研究報告がありますが、実務上、ディーゼル船が微速後進を長時間維持するのは困難でしょう。また、前進推力と舵を併用し船首を風に立てるようにすると振れ回り抑制に効果があります。但し、前進推力を使用して錨鎖を一時的にたるませると、その後船体が風下に落とされる時に錨鎖にしゃくりが生じ走錨の危険が増すので注意を要します。

g. 錨鎖の伸長

走錨防止のために錨鎖を伸長することにより、把駐力を増すことができます。走錨の際に錨鎖を繰り出し本船位置を保持しようとしばしば考えられていますが、既に走錨している錨に、より水平方向の牽引力を与えることで走錨が止まることは稀なので、走錨前または走錨の初期の場合を除き必ずしも適当な措置とは言えません。また、錨鎖の繰り出しは後に本船避航のための揚錨作業を増やすことになります。このような荒天下での揚錨作業では、風雨により作業が困難とな

tension on anchor cables generally increases by the square value of wind force. The holding power and the sum of wind pressure (outer force) are calculated by the following formula. (In theory, if P > R, there is the low possibility of dragging anchor.)

$P = \lambda_a \cdot \omega_a + \lambda_c \cdot \omega_c \cdot l$

λ_a : anchor holding power coefficient
ω_a : weight of anchor (kg)
λ_c : frictional resistance coefficient of anchor chain
ω_c : weight of anchor chain per meter (kg)
l : length of anchor chain for its holding part (meter)

$R = 1/2 \rho_a C_a v_a^2 (A\cos^2\theta + B\sin^2\theta)$

ρ_a : air density (0.124 kg·sec²/m⁴)
C_a : wind pressure coefficient
v_a : relative wind speed (m/s)
A : projected area of the front of hull (m²)
B : projected area of the side of hull (m²)
θ : wind direction

b. Deeper draft

With deeper draft, the ship's wind receiving area on the sea decreases and the displacement increases, which helps to subside the ship's swinging movement.

c. Trim by the head

The center of wind pressure shifts the vessel's aftward, while the center of force of water flow moves to her forward, and her swinging momentum would subside.

d. Standby engine

The engine should be ready for use at any time. The time required by preparing main engine should always be kept in mind. Many incidents occurred before preparing/using main engine when the anchor was dragged.

ることを事前に十分に考慮しておくべきです。

h. 捨錨

捨錨は、容易に判断し実行できるものではありませんが、走錨を始めると錨鎖を繰り出しても止まらず、荒天による風波により錨の巻き上げ作業も困難な場合も多く、早期に考慮すべきでしょう。

i. 沖出し

錨地の安全停泊に自信が持てなければ、早期に沖出しするのが常に最良策です。

j. 陸上の支援

情報不足から対処が遅れる場合も少なくありません。会社、船舶代理店等陸上関係者は、気象情報や各港湾の地域特性等を適時に本船に伝えるべきです。また、本船が行おうとする避難方法を確認し必要な助言を行うことが肝要です。

5 おわりに

走錨に起因する事故により乗組員の死傷・油流出（海洋汚染）等の大事故に繋がる可能性が極めて高いこと、また、気象情報の予測と速やかな防止対策が必要不可欠であることがお分かりいただけたと思います。

STCW条約では、「第8章　当直に関する基準」のうち「第3ー1部　航海当直の維持にあたり遵守すべき原則」において、船長が必要と認めるときは錨泊中も航海当直を継続し、当直職員は必要な種々の措置をとることを規定しています。錨泊船はデッドシップ（陸上と錨で繋がり主機及び補機が停止した状態）で、自ら積極的に危険を回

e. Use of the second anchor

When the second anchor is used as "hammer lock", the swinging movement would greatly subside and 30 to 40% of outer force on the anchor would be reduced. The more holding power could be obtained if the vessel dropped two anchors and extended both anchor cables to a direction as same as the wind direction at the time when the maximum wind speed is predicted. As to "the riding of two anchors", if an angle between anchor cables became 50 to 60 degrees, about 40% of outer force on anchors be reduced. However, it would be very difficult to pursue it in a larger vessel to form the intended angle of two sets of anchor cables when the second anchor was to be dropped.

f. Use of main engine/thruster

Keeping the ship's heading against the wind/wave by rudder, main engine and thruster may be effective to prevent her from dragging anchor.

To avoid dragging anchor, the use of bow thruster and, if appropriate, the use of dead slow astern engines would subside her swinging movement, though the anchor cables receive an additional force due to her astern thrust. The limit of astern thrust would correspond to the half of wind pressure if it is used practically. In practice however, it would be difficult for diesel engine vessels to maintain slow astern engines for a long time. Also, facing of the vessel's bow against the wind by giving the headway and by use of rudder at the same time would be effective the same. If the anchor cables are slacked temporarily by giving the headway, you should pay

避し得る状態でないことから、乗組員の当直態勢が重視される所以であります。

なお、万一走錨に続いて衝突事故に遭遇し、後日相手方と損害賠償交渉が行われる段階では、たとえ相手船が走錨し自船に衝突した場合でも、衝突時以前の注意義務の程度（周囲の監視と衝突防止対策の如何）が問題とされ、自船側にも衝突原因の一部ありとの主張を受ける場合が多々あります。これに備え、反論の根拠となる事故以前の記録（他船との交信、位置情報等）の作成と保管は必要不可欠です。一方、先の種々注意事項を遵守するとともに都度記録をとることは、錨泊中の安全対策の適切な履行につながり、同種事故の予防に十分寄与すると考えます。

attentions to a shock when the ship falls down leeward.

g. Paying out anchor cables

Extending anchor cables is a good tactics to increase the holding power in order to avoid dragging. However, it is an incorrect belief that in case the anchor is dragging, paying out more cable will hold the ship in position, because adding additional cable produces a more horizontal pull on the anchor but once dragged the anchor rarely could grasp seabed again. Extending anchor cables would add the ship's work to pick up her anchor, esp. in rough weather. You should note that all the work, even a minor part of the work would become more difficult due to the wind, waves and the other ships' similar actions, if the ship is picking up her anchor and depart the anchorage.

h. Slipping anchor

Once the anchor is started to drag, it is often very tough to pick up the anchor. Slipping anchor should be considered as soon as possible.

i. Leaving anchorage

The best tactics is always just to leave the anchorage and stay at open sea earlier, if ship handlers are not confident in staying at the anchorage.

j. Assistance from others

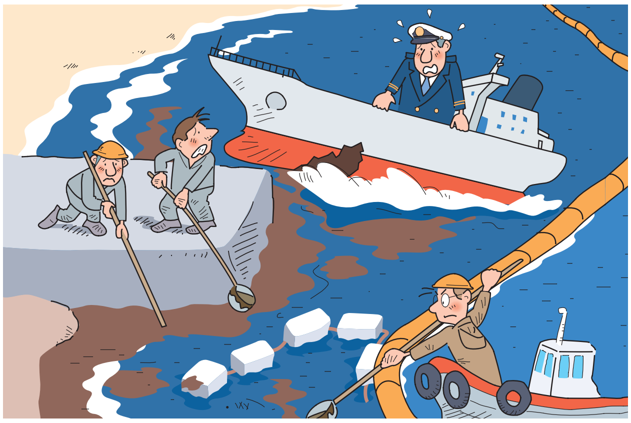
Taking proper measures may be delayed due to lack of information or ship handler's hesitation. The owners, charters and agents should inform her of weather information and forecast and characteristics of anchorage. Also, they should give her advice when she is about to take shelter.

5 Concluding remarks

As mentioned above, dragging anchor would often result in a serious incident such as crew's death/injury and marine pollution. It is essential to predict the weather and to take preventive measures as early as possible.

STCW Convention states in the "Part 3-1: Principles to be observed in keeping a navigational watch" of the "Chapter 8: Standard regarding watch keeping" that a continuous navigational watch shall be maintained at anchor if the master considers it necessary, and that the officer in charge of the navigation watch at anchor shall take appropriate measures. An anchoring vessel is found as the "dead ship" (the vessel which main engine and auxiliary machinery are stopped), and she could not take positive actions to escape herself from dangerous situation. Anchor watch by the crew is thus imperative for the safety of anchoring ship.

If you are involved in a collision due to dragging anchor, the issue would be how the ship pursued her anchor watch and measures for preventing the incident. The opposing parties assert in many cases that there was a fault on the anchored vessel even the opposing vessel dragged her anchor and hit the anchored vessel. Preparing for such assertions, it is necessary even for a party on the side of anchored vessel to make/keep the records before the incident, such as communications with other vessels, information of her own actions and her positions, etc. We believe that following the above precautions and constant recording would contribute to the safety of ship at anchor.



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