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Determining Ship's Safe Speed and Best Possible Speed for Sea Voyage Legs

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ABSTRACT: The purpose and scope of this paper is to describe factors to consider when determining the ship's safe speed as well as the best speed for the sea voyage legs including directions related to vessel speed that are given in ColRegs, voyage orders and charter parties. Author also tried to describe the definition for the following notions: ship maneuvering, ship handling, safe speed, best possible speed for sea voyage legs.

1 INTRODUCTION

There are numerous criteria that can be used for estimating the 'safety of navigation', 'safety of shipping' as well as estimating 'safe speed' (velocity) when maneuverings and ship-handlings on navigational waters including restricted sea areas. If we say that something has a particular quality by definition, it means that it has this quality simply because of what it is. Unfortunately the real life is not so easy especially with reference to the communication link between the old and new generation of seafarers from the international i.e. multicultural crew. Have we forgotten that the old captains had to be understood when they gave orders to their crew, whom they had shanghaied?

Ship style and company style has changed now to Standard Operation Procedure (SOP) same as seamanship has changed to competence and so on. Nowadays we expect from the seamen to have the adequate knowledge, skills, competences and proficiency. They have to be familiar with the standard procedures as well as with the standardized international terminology used for the official communication on the bridge.

Knowledge can be defined as a clear certain perception of something including the act, fact or state of knowing and understanding. Skill can be defined as an art, craft or science, especially the one involving the use of the hand or body (motor skill). Being competent means answering all requirements as well as being fit for the purpose. Proficiency entails skillfulness obtained in the process of gaining special knowledge.

According to the STCW-95 the minimum mandatory standards of competence for masters and chief mates of ships of 3000 gross tonnage or more are maneuvering / handling ship in all conditions (STCW-95, table A-2/II). Bearing in mind that the master has the ultimate responsibility for the safety of the ship, its passengers, crew and cargo, and that the chief mate shall be in a position to assume that responsibility at any time. It means that all officers (especially captains and chief officers) are expected to have adequate knowledge, skill and competences with reference to ship maneuvering and ship handling in all condition.

According to ColRegs (*International Rules and Regulations for Prevention of Collisions at Sea*) [4], every vessel shall at all times proceed at a safe speed so that

she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. Bearing in mind that as per voyage instruction and charter party requirements every vessel shall also undertakes her passage at sea at the best possible speed, weather and safe navigation permitting, unless otherwise required.

Additionally, we need to accept the fact that the maritime terminology has been developed over centuries and the meaning of the following notions like 'safe speed', 'best possible speed for sea voyage legs', 'ship maneuvering' or 'ship handling' in restricted sea areas is not always the same and now there might be a need for some definitions.

2 SHIP MANEUVERING AND SHIP HANDLING

When we talk about ship maneuvering we basically think about changes in courses and/or speed in open water, usually to avoid other ship traffic.

The ship-handling (compare to ship manoeuvring definition), is a very special one and means close-quarter work done primarily by pilots. Ship-handling is the control and navigation of ship by use of engines, rudders, thrusters and tugs as needed, taking into account the environmental factors such as tide, current, wind, sea waves and weather forecast. Ship-handling may be also explained as the use of forces under control (like engine, propellers, rudders, anchor, moorings, thrusters, tugs) to overcome forces that are not under control (wind, current, waves etc.). However, we also need to remember that there are some forces and momentum under indirect control (i.e. ship's hull, hydrodynamic inertia and hydrodynamic momentum e.g. from tugs) which must be taken also to our consideration. A ship can be more successfully and safely handled by taking advantage of, and co-operating with, the elements to the fullest extent - instead of disregarding and working against them.

3 SAFE SPEED AS PER COLREGS

According to Rule No 6 in ColRegs [4], every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. In such cases what is a safe speed will depend on the vessel and circumstances.

It is worth restating that Rule No 6 applies to all vessels in every situation where the ColRegs apply, which is on the high seas and all waters connected therewith navigable by sea-going vessels. Rule 6 requires from us to make our own judgement on the appropriate speed for our vessel, taking into account the situation we are in and the situation we are moving towards.

Almost all of the foregoing is quite obvious - if visibility is poor, then it is dangerous to go so fast that there is too little time to avoid a hazard. A good rule is to be able to stop our ship in half the distance we can see - although that doesn't prevent the vessel we meet not being able to do that!

Excessive speed contributes too many collisions. Rule 5 in ColRegs on look-out and Rule 6 are closely linked. If we do not obey Rule 5, we cannot obey Rule 6. Generally a 'safe speed' is a reduced speed, because in most cases, if either ship reduces speed, their closest point of approach (CPA) will increase. Then the risk of collision will reduce. It gives us more time to think and to act. Time to think and to act is all important – too much speed and too little time can fatally impair our risk assessment processes. It allows us to stop more effectively. If a collision does occur, the resulting damage will be a lot less.

On Fig.1 (as an example) there are presented manoeuvring stopping tests carried out on tunker ship by running main engine full astern, when vessel was proceeding forward with maneuvering speed half ahead and velocity about 7 knots (3,6 m/s) on deep water as well as on shallow water. From the manoeuvring tests we can see that on deep water the most of the vessels stops in about 4 ships lengths. The bridge has hardly left the original track. At stop, the vessel has altered course about 87º to 90º. As a rule of thumb: 3 knots equals a stopping distance of 1 ship length. However on shallow water the vessel stops in about 6 ships lengths, and time needed is about 50% longer! As a rule the stopping distance usually increases in shallow water. At stop, the vessel has altered course about 100º or more. Notice that the ship has left the original track. Bearing also in mind that ship manoeuvring characteristic posted usually on the bridge on wheelhouse posters are not the same even on sister's type ships and as a result of such measurements of her stopping distances the meaning and understanding of safe speed can be different on different vessels (for reference see also Table 1 with manoeuvring stopping test carried out for PS class container vessel "Emma Maersk").

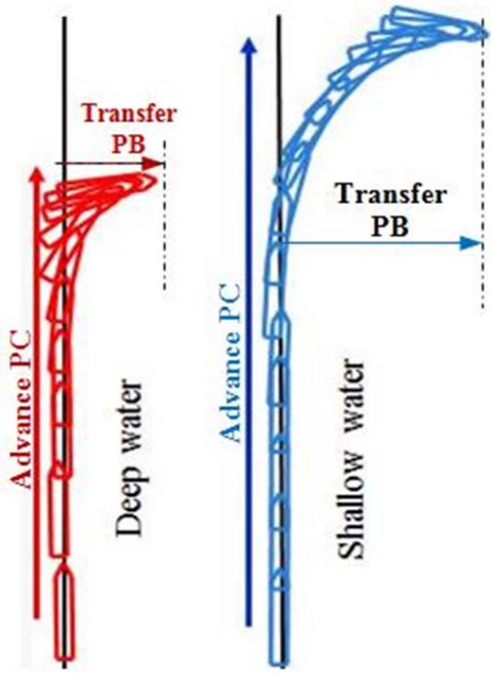

Figure 1.Manoeuvring stopping tests on deep water (on the left) and shallow water (on the right) by running full astern from 7 knots.

Table 1. "Crash Stop"/ FSAH-FAS test estimated for PS Class container vessels"Emma Maersk" (15000 TEU, IMO 9321483, length over all LOA= 397.60 m, breadth B= 56.40 m, CB=0.598 coefficient factor, height Hc= 76.50 m) in a calm sea, with no current and SW 3°B wind. Source: Maersk Line Ship-handling 8.02.01and Ship Maneuverability L203-L210 documentation. [5]

MAIN ENGINE POSITION	RPM	LOADED CONDITION T_D= 16,0 m; T_R= 16,0 m, DWT= 156907 Velocity V [kn]	Time T_{Stop} [min]	Advance PC [m]	Transfer PB [m]	BALLAST CONDITION T_D=7,12 m; T_R= 10,82 m (D≈122219 t) Velocity V [kn]	Time T_{Stop} [min]	Advance PC [m]	Transfer PB [m]
SFH	104	25,7	20,17′	7800	1509	27,5	12,75′	5170	1000
FH	65	16,4	14,58′	4716	1358	18,1	9,75′	3126	900
HH	50	12,4	11,67′	2900	992	14,1	7,42′	1970	675
SH	35	8,6	5,03′	892	184	9,7	3,42′	607	125
DSH	25	6,0	3,25′	630	110	6,8	2,25′	428	75

The ColRegs set out some factors to be taken into account by all vessels and vessels with operational radar. However the ColRegs 'bets are hedged' by saying that the factors in the rules are 'among' those to be taken into account. According to ColRegs in determining a safe speed (v_{SR}) the following factors shall be among those taken into account:

By all vessels (v_S):
- the state of visibility (*STV*);
- the traffic density (*TRD*) including concentrations of fishing vessels or any other vessels;
- the maneuverability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions (*VM*);
- at night the presence of background light such as from shore lights or from back scatter of her own lights (*PBL*);
- the state of wind, sea and current (WSC), and the proximity of navigational hazards (PNH);
- the draught (T) in relation to the available depth of water (h).

Additionally, by vessels with operational radar (Δv_R):
- the characteristics, efficiency and limitations of the radar equipment (LRE);
- any constraints imposed by the radar range scale (RRS) in use;
- the effect on radar detection (ERD) of the sea state, weather and other sources of interference;
- the possibility that small vessels, ice and other floating objects may not be detected by radar at an adequate range (PD_{SO});
- the number, location and movement of vessels detected by radar (NLM_{VD});
- more exact assessment of the visibility that may be possible when radar is used to determine the range of vessels or other objects in the vicinity (AV_{RR}).

Taking into account all mentioned above factors the meaning of the 'safe speed' as per COLREGS can be presented using the following formula:

$$v_{SR} = v_S + \Delta v_R \quad \text{[m/s]} \tag{1}$$

where:
v_{SR} - safe speed determining by ship which is equipped with operational radar;
v_S - safe speed determining by ship without operational radar, ship not equipped with the radar or ship not using the radar on sea passage or when maneuvering on navigational waters, where:

$$v_S = f_1\left(STV, TRD, VM, PBL, WSC, PNH, \frac{T}{h}\right) \quad \text{[m/s]} \tag{2}$$

Δv_R - additional component of safe speed, which need to be take into consideration by ship with operational radar, where:

$$\Delta v_R = f_2\left(LRE, RRS, ERD, PD_{SO}, NLM_{VD}, AV_{RR}\right) \quad \text{[m/s]} \tag{3}$$

In such cases based on the ColRegs explanation the safe speed can be determined only when we take into consideration all factors mentioned above, bearing also in mind that some extra explanation regarding determining safety speed can be justified (i.e. for fishing vessels, background lights, maneuverability, draught in relation to the available depth of water).

With reference to the fishing vessels their movements are often difficult to predict. It can be difficult to state when the vessels are acting together, which might make it dangerous to pass between them; their working lights can make it difficult to keep a good look-out; crews' attention can be distracted when working with nets and etc. Taking all above into consideration the fishing vessels are specifically mentioned in ColRegs as ships in special conditions with the separate rules and regulations.

The maneuverability of a vessel in the prevailing conditions is an important factor. And this is not just the case for large vessels. In some cases for the example the smaller power-driven vessels with shallow draught and high topsides can experience a lot of leeway at low speed. This can mean that a safe speed for a motor cruiser might be higher than for a sailing vessel in a marina - just to keep the control and if needed change the course and/or speed to avoid collision.

Shore lights can be a particular problem. It can be difficult to distinguish ship's lights and navigation marks from shore lights. A technique used by aircraft pilots can be very useful in detecting small movement. Instead of scanning continuously, concentrate on one direction for a second or two, before moving on to the next "sector". This can reveal even very small movement very well. Of course there is always risk that the hazard may not be moving!

A less obvious factor to be considered is a vessel's draught in relation to the available depth of water. In shallow water even large ships can experience effects when moving at speed, such as "squatting" - the draught

increases and swings toward the shore. The ColRegs require a vessel constrained by her draught to navigate with particular caution, having regard to her "special" condition. However the ColRegs state that only a power-driven vessel can be constrained by draught.

In determining a safe speed by vessels with operational Radar there are some additional factors (listed above in ColRegs), which shall be among those taken into account. For example, the detection of hazards might well require a vessel with radar to proceed at a slower speed than one without. In such cases it is entirely possible for restricted visibility to be undetected by the unaided eye - especially on moonless, cloudy nights. A vessel without radar may be unaware of an approaching vessel concealed by fog and proceed at a higher speed.

According to ColRegs we are responsible for proceeding at a safe speed all the time. If an alteration of speed is necessary, we do not have to ask permission. Radar and ARPA are not infallible. They may miss some targets altogether or they may show large targets as weak echoes. Navigational aids such as ECDIS and GPS can be equally suspect. Never rely on one instrument or on one technique – always cross-check. In such cases we need constantly monitor our speed – the situation at sea is always changing and a safe speed in one situation can be too fast in another. And the situations can be changed suddenly.

Unfortunately in the real life depends of the human perception and experiences the meaning of safe speed can be recognized in different way by different seafarers and not always with appropriate understanding (comprehension) as it shall be expected in ColRegs.

4 VOYAGE SPEED AND CHARTER PARTY REQUIREMENTS

Normally a vessel undertakes her passage at sea at the best possible speed, weather and safe navigation permitting, unless otherwise required. This may be adjusted according to environmental conditions, specific ship's owner and/or ship's manager instructions or to meet charter party requirements.

With reference to charter party requirements under a voyage charter, usually there is no direct penalty for failing to meet the speed requirements specified in the charter party. There may, however, be incidental claims against ship's owner or ship's manager if the vessel is inordinately delayed. Before the vessel has actually entered a charterer's service under contract, the vessel may be advised on adjusting her speed and routed appropriately to meet the "lay-can" requirements for the voyage. Upon entering a charterer's service, the vessel must comply with the appropriate charter party (C/P) speed clause or charterer's voyage instructions. However, an average speed of plus or minus 0.5 knots (±0.257 meter/second) is acceptable.

Under a time charter party, a vessel's speed is subject to the relevant C/P requirements, and specific penalties result if these requirements are not met. There may also be specific routing requirements where specific distances have been agreed in advance. Maintain relevant records and documentation to provide adequate reasoning to support route selection or any deviation from C/P requirements.

Under the *Carriage of Goods by Sea Act (COGSA)*, a vessel may deviate from her contracted passage only to save life at sea. This is incorporated into most charter parties and bills of lading. Deviation of the vessel for other purposes can compromise insurance coverage of the vessel as well as her cargo.

Generally it means that deviation from the contracted or agreed route is not permitted unless for reasons of safety or rescue. All deviations must be communicated to the ship team, ship owner and ship insurance department. Vessels who participate in weather routing who are recommended to deviate from their original track may do so as this would be considered reasonable. More information is usually available in "Voyage Orders and Instructions" plus company specific procedure i.e. in Teekay procedure SP0496 [1].

If requested to slow down the vessel or vary the Estimated Time of Arrival (ETA) to suit the charterer's or terminal scheduling, which may cause significant loss of lay time in port, the Master must immediately advise ships team management (both commercial and technical operations). Written confirmation will be sought from the charterer to safeguard against any commercial loss. If a diversion is required, the Master must discuss with both technical and commercial operations and arrangements will be made accordingly.

When vessel is under Time Charter (TC) there may be claims for over / under performance against speed or consumption warranties. Under charter party exclusions, those periods when speed had to be reduced due to inclement weather (subject to charter party agreement on applicable sea state) as well as those periods when ordered to do so by the time charterer will not be subject to any claims. Therefore, it is most important to maintain relevant records and documentation to support route selection and any re-billable costs and claims.

Proceeding at TCP (*time charter party*) *speed* means that the vessel is to attain a speed over the ground equal to that specified in the time charter party warranty of performance. The voyage order: "Proceed at TCP speed 14 knots", means that the vessel is to attain proceed to next port of call with speed over ground equal to 14 knots (7.207 meter/second) and then all exceptions of the relevant charter party will apply.

Proceeding at "*econ speed*" according to the new voyage orders means the speed that will produce the lowest tones per mile consumption of main engine and boiler fuel, consistent with weather, safe navigation, and prudent machinery operating practices.

However when Captain receives the voyage order i.e.: "*Proceed on laden passage at 12 knots*", this means that the vessel's main engine speed is to be set to enable the ship to attain an average speed over ground of at least 12 knots (6.177 meter/second) for the passage. An average speed of within 0.5 knots (±0.257 meter/second) is normally acceptable, weather and safe navigation permitting. Therefore, if because of favorable conditions or over-compensation during adverse conditions, the cumulative speed turns out to be higher than target as the vessel approaches her

destination, the vessel's speed should not be reduced merely for the purpose of attaining target speed over the passage. Similarly, under a voyage charter, the vessel does not always have to speed up beyond the C/P speed to meet the general average speed of 12 knots. The Voyage Manager / Voyage Operations Coordinator (VOC) monitor all such cases for compliance with the charterer's requirements in accordance with the contract.

The order: "*Proceed at min slow speed*", means the minimum sustainable speed on main engine, consistent with weather, safe navigation and prudent machinery operating practices. On the other hand the order: "*Full speed*" means the maximum sustainable speed on the main engine, consistent with weather, safe navigation and prudent machinery operating practices.

There are some factors which are to be taken into consideration regarding expected voyage speed and responsibilities. Usually in each company Voyage Manager consults with the Master to ensure that voyages can be undertaken as per the contracted charter party safely and efficiently, in a cost-effective manner at the best possible speed.

On ship's side there is a Master, who makes decisions on the voyage speed so that the voyage is completed efficiently, costs effectively and at the best possible speed, and is always compliant with international, national, and local laws, conventions, and regulations governing vessel operations. However, in all circumstances the main captain's responsibility is to ensure that the safety of the vessel, crew and cargo is not compromised to meet any requirements of ships owner, ship team management or the charterer. To do so, he plans and executes voyages at the best possible speed and as per charterer and charter party requirements in an efficient and cost-effective manner. He ensures that a passage plan has been prepared, and approves it. He is also responsible to ensure that all navigational charts are kept up to date with the latest corrections and navigational warnings, reviews all relevant weather data, and considers avoiding weather systems that pose a high risk and taking into consideration all mentioned above factors he adjusts speed accordingly.

He is aware of all charterer and charter party (C/P) requirements for voyage routing and when a vessel is not commercially managed by their own ship's management team than he is requested to seek clarification from team management when instructions from charterers are different from procedures used in their own company.

Navigating Officer designated by Master maintains a dynamic and up-to-date passage plan at all times, taking into account any possible changing conditions, changes to destination or change of course due to weather routing. While navigating the vessel he needs to comply with ColRegs, navigates the vessel in accordance with the passage plan and the Master's standing orders.

During the ballast passage leg, if the vessel is on time charter the Master should follow the charterer's instructions if deemed safe to do so. In addition he should take into consideration the following:

- Loading / lay-can dates at the next load port, if the next voyage has already been fixed. In this regard, it may be acceptable for a vessel to arrive halfway through a two or three day lay-can if this means that the ballast voyage can be completed at an economical speed.
- If any repairs are anticipated, either stoppages at sea or at an intermediate port.
- Market conditions / forward prospects at the intended waiting area, if the vessel is proceeding to a place or area "for orders."

Adjust speed (weather and safe navigation permitting) for an optimal arrival time with respect to C/P provisions governing how time is counted for delays due to navigational restrictions at the port, such as tide or darkness.

When vessel is using SHELLVOY5 (Standard Form of C/P issued by Shell company), Captain should adjusts speed to arrive shortly before the optimum "target" navigational window opens. Failing this, he needs to ensure that the vessel arrives well before that window closes.

If vessel is using ASBATANKVOY (Standard Form of C/P issued by ASBA- Association of Ship Brokers & Agents), the "reachable on arrival" provision in Part II, Clause 9, means that the arrival time is strictly at the charterer's risk, regardless of local port restrictions. However, watch out for any C/P rider clause that may contradict this principle. If the speed adjustment is minor, the Master should adjust the speed to arrive at least 6 hours before a navigational window closes.

During a loaded passage, the Master should consider the following:

- If the vessel is on time charter, follow the charterer's instructions if deemed safe to do so.
- Consult the relevant charter party to determine the contracted speed and routing requirements, and follow relevant company guidelines.
- Unless required by the terms of a particular charter party, be aware that an average speed of plus or minus 0.5 knot is acceptable, excluding any time lost due to weather delays or agreed deviations.
- Be aware that during the course of a voyage charter, if unable to meet speed requirements due to prevailing weather conditions during part of the voyage, there is no requirement to increase speed above C/P requirements once weather conditions are more favorable to make up for lost time.

On Fig. 2 there is diagram showing typical process for determining voyage speed by leg implemented in merchant shipping industry (i.e. Teekay Corporation [1]).

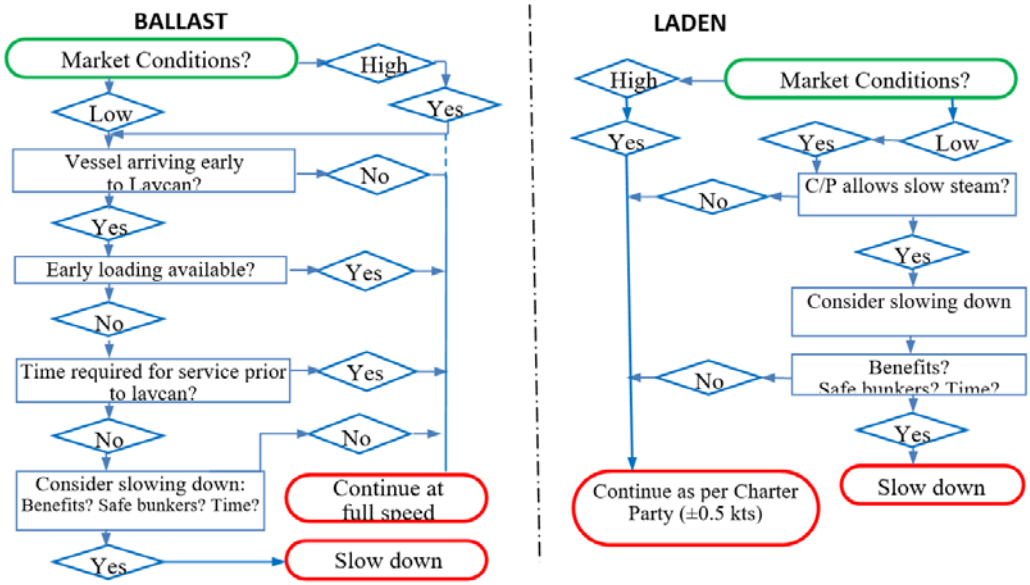

Figure 2. Diagram showing the process for determining voyage speed by leg implemented in Teekay Shipping. [1]

5 CONCLUSION

Navigating Officer while navigating the vessel needs to comply with ColRegs (proceeds at a safe speed all the time), navigates the vessel in accordance with the passage plan and the Master's standing orders. Normally a vessel undertakes her passage at sea at the best possible speed, weather and safe navigation permitting, unless otherwise required. This may be adjusted according to environmental conditions, specific ship's owner and/or ship's manager instructions or to meet charter party requirements.

According to the ColRegs, what is a safe speed will depend on the vessel and circumstances bearing in mind that every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. The ColRegs set out some factors to be taken into account by all vessels and vessels with operational radar.

Unfortunately in reality, a number of factors depend on the human perception and experiences, so the meaning of 'safe speed' or 'best possible speed for voyage legs' can be recognized in a different way by different seafarers and not always with appropriate understanding (comprehension) as it shall be expected in ColRegs, voyage instructions or charter party requirements.

Generally a safe speed is a reduced speed, because in most cases, if either ship reduces speed, their closest point of approach (CPA) will increase. The risk of collision will then reduce. It gives us more time to think and to act. Time to think and to act is all important – too much speed and too little time can fatally impair our risk assessment processes. It allows us to stop more effectively. If a collision does occur, the resulting damage will be a lot less.

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