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# The Determination of a Minimum Critical Distance for Avoiding Action by a Stand-on Vessel as Permitted by Rule 17a) ii)

**E.W. Rymarz**
*Gdynia Maritime University, Poland*

ABSTRACT: In accordance with Rule 17a)ii) a stand-on vessel may take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of her way is not taking appropriate action in compliance with the Steering and Sailing Rules. Such an action to avoid collision must be taken in proper time. An OOW should know the minimum distance for taking avoiding action in every particular case of approaching vessels. The safe distance mainly depends of the relative bearing of an approaching vessel and her speed. In particular own vessel manoeuvrability should be taken into account. The safe minimum distance could be calculated in advance with an Excel calculation sheet. This paper presents a method for preparing a table of safe minimum distances to be used during a Navigational Watch.

## 1 INTRODUCTION

Rules of Section II Part B - Steering and Sailing Rules – International Regulations for Preventing Collision at Sea apply to vessels in sight of one another. Vessels shall be deemed to be in sight of one another only when one can be observed visually from the other. Rules of Section II are based on the general principle that when two vessels are approaching one another in such a way as to involve risk of collision, then one of them is required to keep out of the way while the other is required to keep her course and speed. The only exception to this principle is Rule 14 (Head on situation). Risk of collision shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change. The distance between vessels should be also taken into account when risk of collision is considered. Rules of Section II apply only to vessels underway and while approaching one another unintentionally.

So far as both vessels comply with the COLREGS requirements and fulfill their obligations in proper time and in a proper way then perfect safety and successful prevention of collisions is assured. Problems appear when one or both approaching vessels fail to comply with Rules 16 and/or 17. Let us consider appropriate COLREGS requirements. It would be especially useful to highlight the interpretation of Rule 17, in particular paragraph a) ii) and b) which are not easy in use. The philosophy of this paragraph is easy to understand and its intention is clear but practical compliance is rather difficult in particular for young and inexperienced OOWs.

## 2 TWO POWER DRIVEN VESSELS IN A CROSSING SITUATION

The most frequent encounters at sea are power driven vessels in crossing situations. When for instance two power driven vessels are crossing (see fig. 1) so as to involve risk of collision, one of them (vessel A ) having the other on her own starboard side is obliged by Rule 15 to keep out of the way and, if the circumstances of the case admit, to avoid crossing ahead of the other vessel. The other one –

the so called stand-on vessel (B) - is required to maintain her course and speed when risk of collision first begins to apply. How long then must she keep her course and speed, waiting for avoiding action by the so called give-way vessel? The distance between vessels is still decreasing. The OOW of the stand-on vessel would like to know why the give-way vessel is not taking appropriate action. It could be several reasons: 1) The OOW of the give–way vessel doesn't know that his obligation is to give way to vessel B: 2) The OOW knows his obligation but having very good ship`s manoeuvring characteristics he considers that it is too early for avoiding action; 3) Finally, it could be possible that the OOW is not present in the bridge. When the stand-on vessel is in doubt whether sufficient action is being taken by the give-way vessel to avoid collision she is obliged immediately indicate such a doubt by giving at least five short and rapid blasts on the whistle in accordance with Rule 34 d). Much more effective is to supplement such acoustic signals by a strong light signal of at least five short and rapid flashes.

Even giving alternative signals (Rule 36) to attract the attention of other vessel is acceptable. It could be useful to call other vessel by VHF when the approaching vessel is still far away. At the last moment calling is useless and dangerous. If, on giving such signals, there is no reaction from the give-way vessel then the OOW of the stand-on vessel can consider that it has become apparent to him that the vessel required to keep out of the way is not taking appropriate action in compliance with the Steering and Sailing Rules. This is the exact moment when the stand-on vessel is permitted to take action to avoid collision by her manoeuvre alone. This is the beginning of stage III. (fig.1)

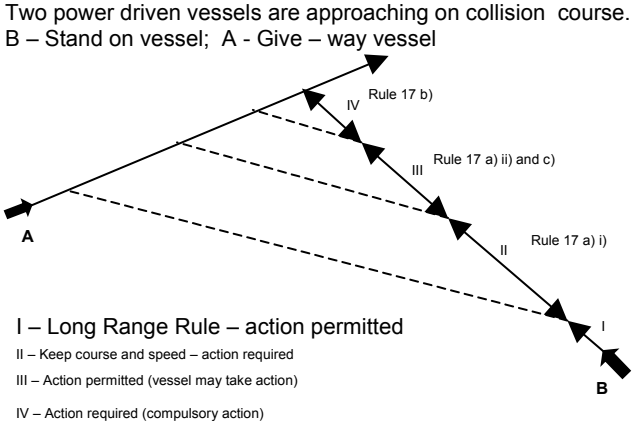



Fig. 1. Action by Stand-on Vessel

## 3 PERMITTED ACTION BY RULE 17A) II)

A stand-on vessel is not specifically required to take action to avoid collision as soon as it becomes apparent that the give-way vessel is not taking appropriate action. She is only permitted to take such an action. She is also permitted to keep her course and speed until collision cannot be avoided by the give-way vessel alone. This is the beginning of stage IV (see fig.1) A stand-on vessel which fails to take permissive action (Rule 17 a) ii)) in sufficient time to avoid collision by her own manoeuvre is likely to be held at fault if a collision should occur. Before entering into stage III the Captain or OOW of stand–on vessel should know the distance to the approaching vessel which shall be necessary for an effective action to avoid collision by the stand-on vessel alone. The earliest moment for permitted action will obviously be related to the range and the rate of change of range which mainly depends on the relative bearing and speed of other vessel. Not only the earliest but also the very last moment should be known. In particular what is the minimum critical distance for taking avoiding action. This limit cannot be crossed otherwise if no action is taken by the give-way vessel, collision would be inevitable. Normally such a critical distance is estimated by the Captain or OOW and is based on their experience and ordinary practice. The estimations, in particular at night, could be inaccurate and approximate only. Considerable errors could be possible. Precise information regarding critical distances for particular stand-on vessels can be calculated in advance. Critical distances to approaching give-way vessels are based on the known manoeuvring ability of the own vessel and are dependent on the relative bearings and speed of the other vessels. Critical distances could be presented in a form of a table. This can be done by using Excel calculating sheets.

## 4 USING AN EXCEL CALCULATION SHEET

The input data for an Excel calculation sheet can be obtained from vessel`s sea trials documentation, in particular information regarding turning circle and crash stop manoeuvres. As an example given in this paper all data information concerning the so called "our vessel" are referred to a bulk carrier PANAMAX vessel; DWT 62108 t. length 221m and sea speed 16,2 kts. The calculation of the critical distance for the PANAMAX vessel is based on the assumption that a CPA 0,2 nm is considered as a collision or "near-collision". Therefore the critical distance to the approaching give-way vessel is such a distance that permits the stand-on vessel to avoid collision by her own manoeuvre with passing distance CPA 0,2 nm.(see table 2) The relative bearing of the other vessel and her speed could be measured with radar. This can be done when the distance to the other vessel is still considerable. The

other necessary input data could be calculated from the interrelations between a vessel`s motion parameters and the trigonometric functions shown at fig. 2. The main input elements of the stand-on vessel are:

1 true course in degrees;
2 speed in meters per minute (m/min);
3 compass bearing in degrees;
4 relative bearing of approaching vessel;
5 Vy "shifting ahead" (Pc);
6 Vx Shifting aside" (Pb);

Input elements of the give-way vessel are:

1 initial true course;
2 speed in metres per minute (m/min)

The most essential step for the calculation of critical distance is to prepare the appropriate calculating program (Excel template). In this regard a general knowledge for using the Excel calculation sheet is necessary.

$$V_x = Vo \cdot \sin \alpha$$
$$V_y = Vo \cdot \cos \alpha$$
$$D = \sqrt{V_x + (V_y + V_w)^2}$$
$$Tan\,\alpha = \frac{\Delta X}{\Delta Y}$$

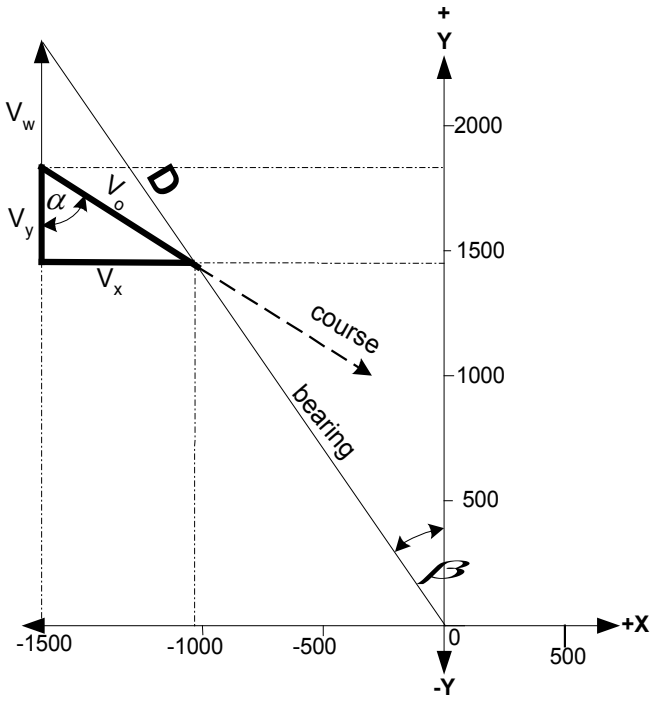



Fig. 2. Interrelations for data calculations

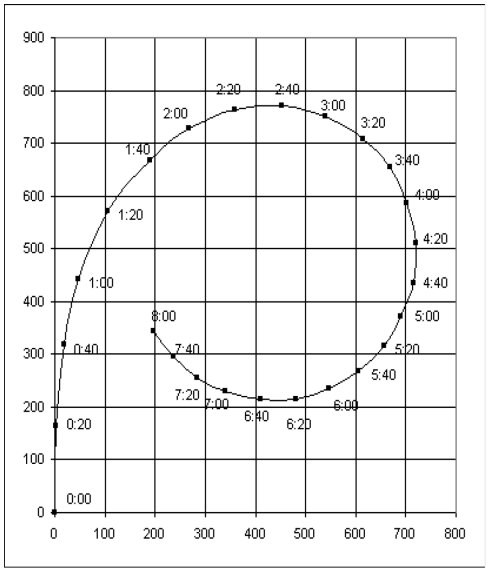
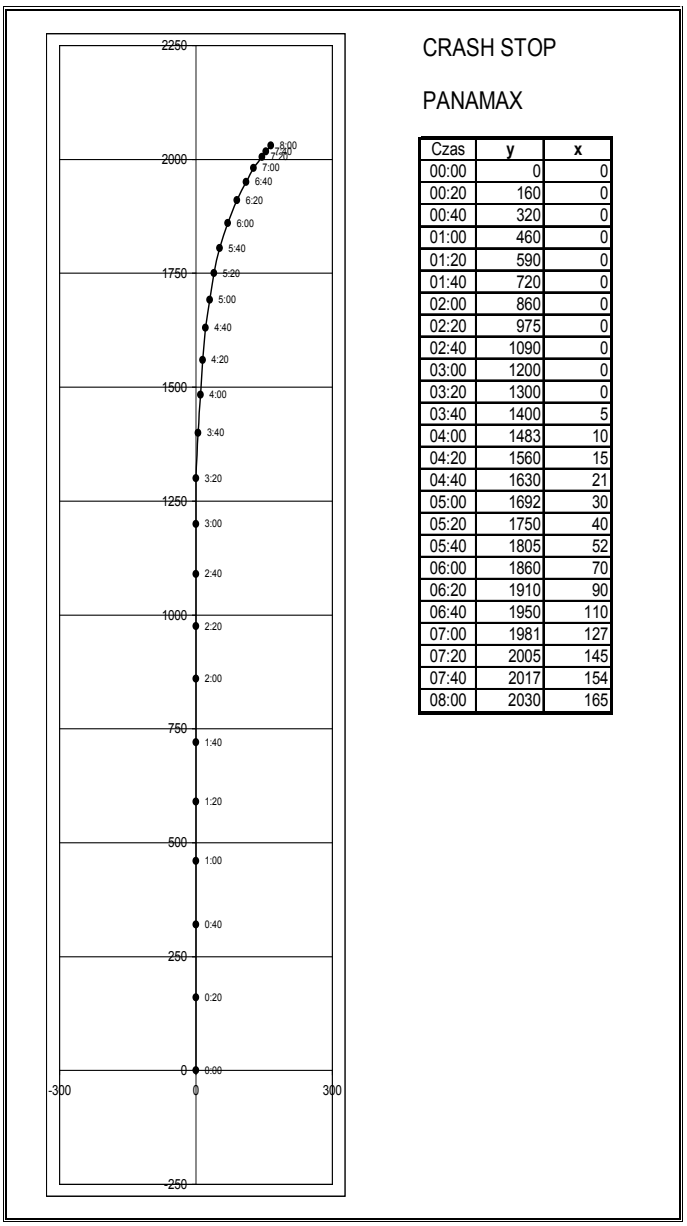



Fig. 3. PANAMAX Turning circle to stbrd. -full sea speed ahead




| Czas | y | x |
|---|---|---|
| 00:00 | 0 | 0 |
| 00:20 | 160 | 0 |
| 00:40 | 320 | 0 |
| 01:00 | 460 | 0 |
| 01:20 | 590 | 0 |
| 01:40 | 720 | 0 |
| 02:00 | 860 | 0 |
| 02:20 | 975 | 0 |
| 02:40 | 1090 | 0 |
| 03:00 | 1200 | 0 |
| 03:20 | 1300 | 0 |
| 03:40 | 1400 | 5 |
| 04:00 | 1483 | 10 |
| 04:20 | 1560 | 15 |
| 04:40 | 1630 | 21 |
| 05:00 | 1692 | 30 |
| 05:20 | 1750 | 40 |
| 05:40 | 1805 | 52 |
| 06:00 | 1860 | 70 |
| 06:20 | 1910 | 90 |
| 06:40 | 1950 | 110 |
| 07:00 | 1981 | 127 |
| 07:20 | 2005 | 145 |
| 07:40 | 2017 | 154 |
| 08:00 | 2030 | 165 |

Fig. 4. PANAMAX - crash stop. From full ahead to stop the vessel by full astern

Table 1 presents the first part of an Excel sheet with all necessary data inserted. In column 2 there is the time from the start of avoiding action (turning circle or crash stop) at 0min.and 00 sec. to the end of the turning circle or to stop the vessel in the case of crash stop which takes 8 minutes. The full time of the turning circle and the crash stop are divided into 25 parts, each of 20 sec. duration. Data in columns 3 and 4 (Pc and Pb) were calculated from the interrelations presented at fig.2 where Pc=Vy and Pb=Vx. See the triangle with the following sides: Vo; Vx; and Vy.

Data in columns 5 and 6 are calculated automatically after other data are inserted.

In the column 7(x) there is only 0 entered because the course of our vessel is "N" 000° and there is no east-west movement in the x axis. Data in column 8 (y) presents northerly movement of our vessel`s position after every 20 sec.

Table 1. Critical distance calculation with Excel system for example PANAMAX vessel

Turning circle to starboard
Bulkcarrier Panamax DWT: 62108 t.; relative bearing port 30; speed: Vo=Vw

**Data:**

Name: bulkcarrier Panamax DWT:62108

| | |
|---|---|
| Length : | 221 m |
| Bearing of an approaching vessel | 330° |
| Relative bearing : | -30° |
| Closest Point of Approach | 370 m |
| Speed of vessels : | Vo=Vw |

| **Own vessel** | **Other vessel** |
|---|---|
| Course 000° | Course 120,0° |
| V 16,2 kts | V 16,2 kts |
| 500m/min | 500m/min |
| Vx 0 m/min | Vx 433 m/min |
| Vy 500 m/min | Vy -250m/min |
| Starting point | Starting point |
| x 0 m | x -1133 m |
| y 0 m | y 1963 m |

**Result of analysis**

Distance at the time 00:00 (m) : 2267
Nautical miles **: 1,224**
Length of vessel multiplicity : 10,3

| Other vessel | | | | | | Own vessel | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | No action | | | | Turning circle to strb. | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| No | Time | Pc(m) | Pbm) | **x** | **y** | **x** | **y** | bearing | distance | **y** | **x** | distance |
| 1 | 00:00 | 0 | 0 | -1133 | 1963 | 0 | 0 | 330 | 2267 | 0 | 0 | 2267 |
| 2 | 00:20 | -83 | 144 | - 989 | 1880 | 0 | 167 | 330 | 1978 | 165 | 2 | 1980 |
| 3 | 00:40 | -167 | 289 | -845 | 1796 | 0 | 333 | 330 | 1689 | 318 | 19 | 1712 |
| 4 | 01:00 | -250 | 433 | -700 | 1713 | 0 | 500 | 330 | 1401 | 442 | 48 | 1475 |
| 5 | 01:20 | -333 | 577 | -556 | 1630 | 0 | 667 | 330 | 1112 | 572 | 105 | 1247 |
| 6 | 01:40 | -417 | 722 | -412 | 1546 | 0 | 833 | 330 | 823 | 667 | 190 | 1065 |
| 7 | 02;00 | -500 | 866 | -267 | 1463 | 0 | 1000 | 330 | 534 | 728 | 268 | 909 |
| 8 | 02:20 | -583 | 1010 | -123 | 1380 | 0 | 1167 | 330 | 246 | 674 | 360 | 782 |
| 9 | 02:40 | -667 | 1155 | 21 | 1296 | 0 | 1333 | 150 | 43 | 772 | 452 | 678 |
| 10 | 03:00 | -750 | 1299 | 166 | 1213 | 0 | 1500 | 150 | 332 | 752 | 539 | 593 |
| 11 | 03:20 | -833 | 1443 | 310 | 1130 | 0 | 1667 | 150 | 620 | 708 | 615 | 520 |
| 12 | 03:40 | -917 | 1588 | 455 | 1046 | 0 | 1833 | 150 | 909 | 654 | 668 | 447 |
| 13 | 04:00 | -1000 | 1732 | 599 | 963 | 0 | 2000 | 150 | 1198 | 587 | 702 | 390 |
| 14 | 04:20 | -1083 | 1877 | 743 | 880 | 0 | 2167 | 150 | 1486 | 510 | 721 | 370 |
| 15 | 04:40 | -1167 | 2021 | 888 | 796 | 0 | 2334 | 150 | 1775 | 436 | 716 | 399 |
| 16 | 05:00 | -1250 | 2165 | 1032 | 713 | 0 | 2500 | 150 | 2064 | 371 | 690 | 484 |
| 17 | 05:20 | -1333 | 2310 | 1176 | 630 | 0 | 2667 | 150 | 2352 | 317 | 656 | 607 |
| 18 | 05:40 | -1417 | 2454 | 1321 | 546 | 0 | 2834 | 150 | 2641 | 269 | 605 | 767 |
| 19 | 06:00 | -1500 | 2598 | 1465 | 463 | 0 | 3000 | 150 | 2930 | 235 | 546 | 947 |
| 20 | 06:20 | -1583 | 2743 | 1605 | 380 | 0 | 3167 | 150 | 3219 | 214 | 480 | 1141 |
| 21 | 06:40 | -1667 | 2887 | 1754 | 296 | 0 | 3334 | 150 | 3507 | 214 | 410 | 1346 |
| 22 | 07:00 | -1750 | 3031 | 1898 | 213 | 0 | 3500 | 150 | 3796 | 230 | 340 | 1558 |
| 23 | 07:20 | -1833 | 3176 | 2042 | 130 | 0 | 3667 | 150 | 4085 | 256 | 283 | 1764 |
| 24 | 07:40 | -1917 | 3320 | 2187 | 46 | 0 | 3834 | 150 | 4373 | 295 | 238 | 1965 |
| 25 | 08:00 | -2000 | 3464 | 2331 | -37 | 0 | 4000 | 150 | 4662 | 344 | 198 | 2167 |

Table 2. PANAMAX critical distances to approaching vessel for permitted avoiding action in accordance with Rule 17 a)ii) Distance in metres (m), Nautocal miles (nm) and length of own vessel (L)

| Relative Bering of approaching vessel | Speed of approaching vessel | | | | | |
|---|---|---|---|---|---|---|
| | **Vo = Vw - 5 knots** | | **Vo = Vw** | | **Vo = Vw + 5 knots** | |
| | Turning circle | Crash stop | Turning circle | Crash stop | Turning circle | Crash stop |
| Port 10° | 1823 m<br>1,0 nm<br>8,2 L | 5427 m<br>3,0 nm<br>25 L | 2269 m<br>1,2 nm<br>10,3 L | 7022 m<br>3,8 nm<br>32 L | 2721 m<br>1,5 nm<br>12,3 L | 8607 m<br>4,7 nm<br>39 L |
| Port 20° | 1715 m<br>0,9 nm<br>7,8 L | 3836 m<br>2,1 nm<br>17,4 L | 2204 m<br>1,2 nm<br>10 L | 4954 m<br>2,7 nm<br>22,4 L | 3286 m<br>1,8 nm<br>15 L | 6031 m<br>3,3 nm<br>27,3 L |
| Port 30° | 1478 m<br>0,8 nm<br>6,7 L | 2685 m<br>1,5 nm<br>12,1 L | 2267 m<br>1,2 nm<br>10,3 L | 3626 m<br>2,0 nm<br>16,4 L | 3030 m<br>1,6 nm<br>13,7 L | 4462 m<br>2,4 nm<br>20,2 L |
| Port 40° | 1021 m<br>0,6 nm<br>4,6 L | 1816 m<br>1,0 nm<br>8,2 L | 1766 m<br>1,0 nm<br>8 L | 2872 m<br>1,6 nm<br>13 L | 2439 m<br>1,3 nm<br>11 L | 3658 m<br>2,0 nm<br>16,6 L |
| Port 50° | N/A | N/A | 1350 m<br>0,7 nm<br>6,1 L | 2256 m<br>1,2 nm<br>10,2 L | 1956 m<br>1,0 nm<br>8,8 L | 3051 m<br>1,7 nm<br>13,8 L |
| Port 60° | N/A | N/A | 992 m<br>0,5 nm<br>4,5 L | 1682 m<br>0,9nm<br>7,6 L | 1568 m<br>0,9 nm<br>7,1 L | 2532 m<br>1,4 nm<br>11,5 L |
| Port 70° | N/A | N/A | 699 m<br>0,4 nm<br>3,2 L | 1170 m<br>0,6 nm<br>5,3 L | 1257 m<br>0,7 nm<br>5,7 L | 2099 m<br>1,1 nm<br>9,5 L |
| Port 80° | N/A | N/A | 484 m<br>0,3 nm<br>2,2 L | 703 m<br>0,4 nm<br>3,2 L | 1019 m<br>0,6 nm<br>4,6 L | 1762 m<br>1,0 nm<br>8,0 L |

Data at fig. 3 and 4 are presenting our (PANAMAX) vessel`s positions for every 20 seconds on the x/y axes. These data are based on the sea trials documentation. Data from fig.3 and 4 should be inserted into the Excel calculating sheet in the column “Own ship” of table 1. When the critical distance is calculated for permitted action “hard to starboard” - turning circle - then data from fig.3 (x/y positions) should be inserted in the columns 11(y) and (12) - “Turning circle to starboard”. When the critical distance is calculated for permitted action “crash stop” then data from fig.4 should be inserted in the same places as in the case of the “turning circle” above.

Data in all other columns will be calculated automatically. The most important information given by Excel (in the inner table of table 1) is a distance at the time 00:00 which means the critical distance. Table 1 is an example only for calculation of one particular case for the PANAMAX vessel, namely for 30° relative bearing of the approaching vessel and her speed which is the same as our speed: 16,2 kts.

A similar calculation must be carried out for every 5 or 10 degrees of port side relative bearings and for different speeds of the other vessel. When preparing a table for presenting critical distances, easy interpolation should be taken into account.

The table 2 presents critical distances from our vessel (stand-on) to the other vessel (giving-way) approaching on a collision course on unchanging compass bearing. Distances in the table are given in metres, nautical miles and length of own vessel. For COLREGS purposes the most suitable are distances in nautical miles. Fig.5 presents a diagram which is easy in use, in particular for interpolation. Critical distances could be prepared in different forms.

## 5 CONCLUSIONS

In the presented research work over one thousand crossing vessel situations were examined and critical distances for permitted actions were calculated. Two types of permitted actions were considered: turning circle to starboard and crash stop. Investigation comprised different speeds of the give-way vessel from11,2 to 21,2 kts. and relative bearings from port 10° to port 80°. It has been proved that in all cases the most effective and safe permitted avoiding action when the distance between vessels approached the critical value, is turning hard to starboard. When a give-way vessel is approaching on a collision course on a relative bearing from 5 to 35 degrees, a crash stop as a permitted avoiding action is nearly useless. Results of conducting this research regarding critical distances have been presented at table 2 and figure 5.

All calculated critical distances were verified and confirmed by manoeuvring simulator. Participants interested in the COLREGS are invited to see the manoeuvring simulator demonstration.

## 6 PROCEDURE TO USE THE CRITICAL DISTANCES TABLE

An example is given for a PANAMAX vessel (speed 16 kts). When for instance on the port side of the vessel on relative bearing 30° a power driven vessel appears, then use the following procedure:

1 Take the compass bearing and observe its changing tendency;
2 If the bearing does not appreciably change and the distance is decreasing– estimate the give-way vessel`s speed by radar; (her speed is for instance 16 kts.)
3 Having relative bearing (port 30°) and speed 16 kts enter the table 2 and from the column "Vo=Vw" -"Turning circle" and line "Port 30°" take the critical distance. In this case the critical distance is 1,2 nm;

This means that before the distance to the approaching vessel has decreased to 1,2 nm you have to give all appropriate signals to "wake-up" the other vessel to undertake proper action. Seeing no response you may consider that it has become apparent to you that the vessel required to keep out of the way is not taking appropriate action in accordance with Rule 15 and 16. In this case you may take action to avoid collision by your manoeuvre alone before the time when the distance reduces to 1.2 nm. Having advance information on the critical distance for the current situation, the time and form for taking avoiding action is rather clear.

## REFERENCES


Cockcroft, A.N. & Lameijer I.N.F. 2004. A guide to the Collision Avoidance Rules. Elsevier Butterworth-Heinemann, Oxford.

Koszewski Z.& Gorazdowski S. 1965. Międzynarodowe prawo drogi morskiej, Gdańsk, Wydawnictwo Morskie.

Curtis Frye 2003 Mocrosoft Office Excel 2003 step by step (Polish translation by Kolczynski P.)

Rymarz W. 2004, Międzynarodowe prawo drogi morskiej w zarysie (in Polish). Wydawnictwo Trademar, Gdynia.

Rymarz W. 2006. Międzynarodowe prawo drogi morskiej – obliczenia za pomocą arkusza kalkulacyjnego Excel manewrów zapobiegawczych zderzeniu zgodnie z prawidłem 17a)ii), Akademia Morska Gdynia (in Polish).