

Polski Rejestr Statków

RULES

PUBLICATION NO. 27/P

NAVIGABILITY AND MANOEUVRABILITY TESTS OF INLAND WATERWAY VESSELS AND CONVOYS

2010

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the Rules and are mandatory where applicable.



GDAŃSK

Publication No.27 /P – Navigability and manoeuvrability tests of inland waterway vessels and convoys – 2010, is an extension of the requirements contained in *Part I – Classification Regulations of the Rules for the Classification and Construction of Inland Waterways Vessels*, as well as in all other PRS Rules, in which reference to the *Publication* has been made.

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1 GENERAL

1.1 Application

1.1.1 The requirements of the present *Publication* apply to powered (motor) vessels and pushed convoys (hereafter called vessels and convoys) employed in navigation on inland waterways.

1.1.2 Unpowered vessels intended to be towed are not subject to the requirements of the present *Publication*.

1.2 Navigability and manoeuvrability

1.2.1 Vessels and convoys shall display adequate navigability and manoeuvrability. These capacities shall be confirmed by means of navigation tests, during which the following shall be checked:

- capacity for achieving the prescribed forward speed,
- stopping capacity and capacity for going astern,
- capacity for taking evasive action,
- turning capacity.

If, resulting from the carried out tests, it proves that the vessel or convoy does not meet the requirements of the present *Publication*, the obtained results shall be submitted by PRS for approval to the right administrative body for inland waterways navigation.

1.2.2 The inspection body may dispense with all or part of the test where compliance with the navigability and manoeuvrability requirements is proven in another manner.

1.3 Conditions of navigability and manoeuvrability tests

1.3.1 The navigation tests shall be carried out on areas of inland waterways that have been designed by the competent authority.

1.3.2 Those test areas shall be situated on a stretch of flowing or standing water that is if possible straight, at least 2 km long and sufficiently wide and is equipped with highly-distinctive marks for determining the position of the vessel.

1.3.3 It shall be possible for the inspection body to plot the hydrological data such as depth of water, width of navigable channel and average speed of the current in the navigation area as a function of the various water levels.

1.3.4 During navigation tests, vessels and convoys intended to carry goods shall be loaded to at least 70% of their tonnage and loading, distributed in such a way as to ensure a horizontal attitude as far as possible. If the tests are carried out with a lesser load, the approval for downstream shall be restricted to that loading.

1.3.5 During the tests the requirements shall be complied with keeping a keel clearance of at least 20% of the draught, but not less than 0.50 m.

1.3.6 During the navigation tests, all the vessel's equipment which may be actuated from the steering position may be used, except the anchors. However, during the test of turning capacity, bow anchors may be used.

1.3.7 During the navigation tests, the use of the special equipment of pushed craft, such as the steering system, propulsion units or manoeuvring equipment is acceptable (see paragraph 3.3).

2 REQUIREMENTS RELATED TO STEERING SYSTEMS

2.1 Notwithstanding meeting those requirements given in *Part III – Hull Equipment* and *Part VI – Machinery Installations and Refrigerating Plants of the Rules for the Classification and Construction of Inland Waterways Vessels* which apply to steering systems, the compliance with the following requirements shall be confirmed during the tests:

- for manually operated steering systems: one rotation of the steering wheel shall correspond to the change of rudder angle by least 3°;
- for powered steering systems: within the full design range of rudder angle the mean rate of turning equaling 4°/s shall be ensured, at the maximum immersion of the rudder blade. This requirement shall be also met for rudders angles from 35° to SB up to 35° to PS when the vessel sails at the full speed. In addition, it shall be ensured that the rudder maintains its maximum angle when the propulsion system works with the maximum power output. Analogical requirements are in force for active rudders and rudders of a special construction.

3 DOCUMENTATION OF THE TESTS

3.1 As a result of the carried out tests, PRS issues the following documents:

- report on stopping and going astern test;
- report on taking evasive action test;
- *test Certificate*.

3.2 In the reports, all the values measured during the tests and data referring to the test area, and data referring to the tested vessel/convoy are indicated.

3.3 If, in order to meet the requirements given in Annexes, it was necessary during the tests to use special equipment of pushed craft (see paragraph 1.3.7) or, if articulated coupling was used to couple the craft, the information about the used equipment shall be written down and the names and register numbers of the craft forming the convoy and their position in the convoy shall be given in the test documentation.

3.4 Apart from taking measurements, during the tests it shall be checked if the rigid connection of all the craft in the convoy is maintained throughout the manoeuvres.

3.5 The forms of documents referred to in paragraph 3.1 are presented in Annex V. Those forms are not samples of official documents issued by PRS.

ANNEX I
FORWARD SPEED

I Maximum prescribed (forward) speed

I.1 Vessels and convoys shall achieve a speed in relation to the water of at least 13 km/h. That condition is not mandatory where pusher tugs are operating solo.

I.2 The inspection body may grant exemptions to vessels and convoys operating solely in estuaries and ports.

I.3 The speed in relation to the water is satisfactory when it reaches at least 13 km/h. During tests, the following conditions shall be met in the same way as for the stopping test:

- the keel clearance set out in paragraph 1.3.5 shall be complied with;
- the measuring, recording, registration and evaluation of test data shall be carried out.

I.4 The inspection body shall check if the unladed vessel is capable of exceeding a speed of 40 km/h in relation to water. If this can be confirmed, the following entry shall be made in item 52 of the Community certificate:

“The vessel is capable of exceeding a speed of 40 km/h in relation to water”.

ANNEX II

STOPPING MANOEUVRE AND GOING ASTERN MANOEUVRE

II.1 Requirements concerning stopping capacity and capacity for going astern

II.1.1 Vessels and convoys shall be able to stop facing downstream in good time while remaining adequately manoeuvrable.

II.1.2 Where vessels and convoys are not longer than 86 m and not wider than 22.90 m the stopping capacity may be replaced by turning capacity.

II.1.3 The stopping capacity shall be proved by means of stopping manoeuvres carried out within a test area as referred to in paragraphs 1.3.1÷1.3.3 and the turning capacity by turning manoeuvres in accordance with Annex III.2.1 ÷ Annex III.2.3.

II.1.4 Where the stopping manoeuvre required by paragraphs II.1.1÷II.1.3 is carried out in standing water it shall be followed by a navigation test while going astern.

II.1.5 Vessels and convoys are deemed able to stop facing downstream in good time when this is proved during a test of stopping in relation to the ground facing downstream at an initial speed in relation to the water 13 km/h, with a keel clearance equal to at least 20% of the draught but not less than 0.50 m.

(a) In flowing water (current velocity of 1.5 m/s), stopping in relation to the water shall be demonstrated over a maximum distance measured in relation to the ground of:

550 m for vessels and convoys of:

- length $L > 110$ m or
- width $B > 11.45$ m

or

480 m for vessels and convoys of:

- length $L \leq 110$ m and
- width $B \leq 11.45$ m.

The stopping manoeuvre is completed on coming to stop in relation to the ground.

(b) In standing water (current velocity of less than 0.2 m/s), stopping in relation to the water shall be demonstrated over a maximum distance, measured in relation to the ground of:

350 m for vessels and convoys of:

- length $L > 110$ m or
- width $B > 11.45$ m

or

305 m for vessels and convoys of:

- length $L \leq 110$ m and
- width $B \leq 11.45$ m.

In standing water, a test shall also be performed to demonstrate that a speed of not less than 6.5 km/h can be reached when going astern.

The measuring, recording and registration of the test data referred to in (a) or (b) shall be carried out in accordance with the procedure set out in paragraphs from II.2 to II.5 and Annex V.

Through the entire test, the vessel or the convoy shall have adequate manoeuvrability.

II.1.6 In accordance with paragraph 1.3.4, during the test, vessels shall be loaded as far as possible to 70 ÷ 100% of their deadweight. This load condition shall be evaluated in accordance with paragraph II.5. When the vessel or the convoy is loaded to less than 70% at the time of the test, the permitted maximum displacement in downstream navigation shall be set in accordance with the actual load, provided that the limit values of paragraph II.1.5 are complied with.

II.1.7 If the actual values of the initial speed and current velocity at the time of the test do not meet the conditions set out in paragraph II.1.5, the results obtained shall be evaluated according to the procedure described in paragraph II.5.

The permitted deviation of the initial speed of 13 km/h shall be not more than +1 km/h, and the current velocity in flowing water shall be between 1.3 and 2.2 m/s, otherwise the tests shall be repeated.

II.1.8 The permitted maximum displacement or the respective maximum load or the maximum immersed cross-section for vessels and convoys in downstream navigation shall be determined on the basis of the tests and entered in the Community Certificate.

II.2 Stopping manoeuvre

II.2.1 The vessels and convoys shall carry out a test in flowing water or in standing water, in a test area, to prove that they are capable of stopping facing downstream only with their propulsion system without the use of anchors. The stopping manoeuvre shall, in principle, be carried out in accordance with Fig. II.4.2. It begins when the vessel is traveling at a constant speed of as near as possible to 13 km/h in relation to the water by reversing the engines from “ahead” to “astern” (point **A** of the order “stop”) and is completed when the vessel is stationary in relation to the ground (point **E**: $v = 0$ in relation to the ground or point **D**: $v = 0$ in relation to the water and in relation to the ground if the stopping manoeuvre is carried out in standing water).

II.2.2 When stopping manoeuvres are carried out in flowing water, the position and the moment of stopping in relation to the water shall also be recorded (the vessel moves at the speed of the current; point **D**: $v = 0$ in relation to the water).

II.2.3 The data measured shall be entered in a report as shown in the diagram of table Annex V.1. Before the stopping manoeuvre is carried out, the unchanging data shall be entered at the top of the form.

II.2.4 The average current velocity (v_{STR}) in the fairway shall be determined, if available, based on the reading of an established water level gauge, or by measuring the movement of a floating body and shall be entered in the report.

II.2.5 In principle, the use of current meters is permitted to determine the speed of the vessel in relation to the water during the stopping manoeuvre, if it is possible to record the movement and the required data in accordance with the procedure above.

II.3 Registration of the data measured and recording in the report

II.3.1 For the stopping manoeuvre, first of all the initial speed in relation to the water shall be determined. This can be done by measuring the time taken to travel between two markers on land. In flowing water, the average current velocity shall be taken into account.

II.3.2 The stopping manoeuvre is initiated by the order “stop” **A**, given on passing a marker on land. Passing the land marker shall be recorded perpendicularly to the axis of the vessel and shall be entered in the report. Passing all other land markers during the stopping manoeuvre shall be similarly recorded and each marker (e.g. kilometer post) and the time of passing shall be noted in the report.

II.3.3 The values measured shall, if possible, be recorded at intervals of 50 m. In each case, note should be taken of the time when points **B** and **C** – if possible – as well as when points **D** and **E** are reached and the respective position shall be estimated. The data concerning the engine speed need not be recorded in the report, but should be noted to permit more accurate control of the initial speed.

II.4 Description of the stopping manoeuvre

II.4.1 The stopping manoeuvre according to Figure II.4.2 shall be presented in the form of a diagram. First of all, the time-traverse diagram shall be plotted using the measurements entered in the test report and points **A** to **E** shall be indicated. It will then be possible to determine the average speed between two measurement points and to plot the speed/time diagram.

II.4.2 This is done as follows (see Fig. II.4.2):

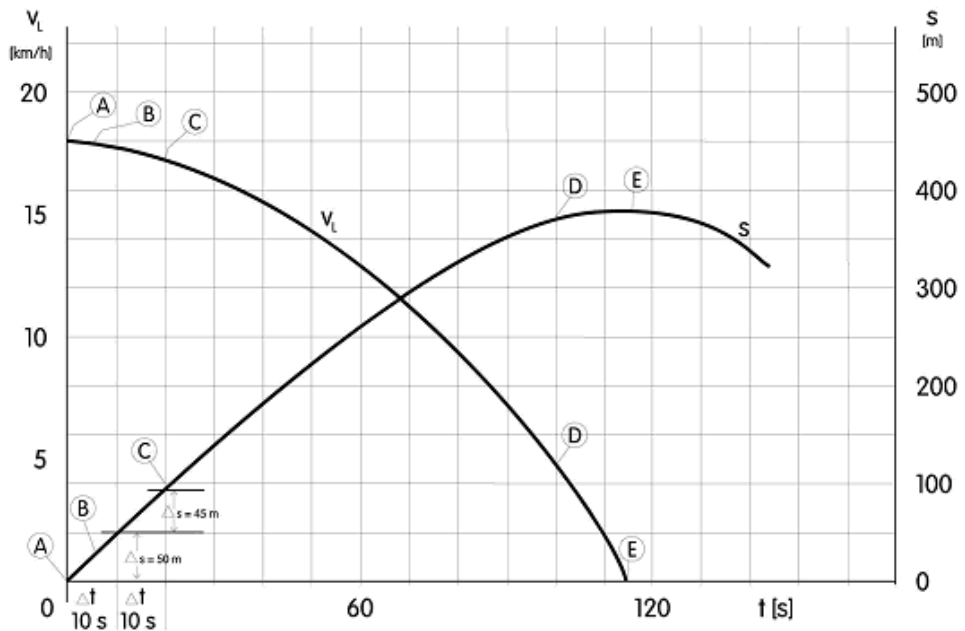


Fig. II.4.2 Stopping manoeuvre

Key to symbols in Fig. II.4.2:

- A** – “stop” order
- B** – propeller stopped
- C** – propeller in reverse
- D** – $v = 0$ in relation to the water
- E** – $v = 0$ in relation to the ground
- v – speed of vessel
- v_L – v in relation to the ground
- s – distance covered in relation to the ground
- t – measured time

II.4.3 By determining the quotient of the difference of position over the difference in time $\Delta s/\Delta t$, the average speed of the vessel for this period can be calculated.

Example:

During the interval between 0 s and 10 s, the distance from 0 m to 50 m is covered.

$$\Delta s/\Delta t = 50 \text{ m}/10 \text{ s} = 5.0 \text{ m/s} = 18.0 \text{ km/h}$$

This value is entered as the average speed at the 5 s abscissa-position. During the second interval, from 10 s to 20 s, a distance of 45 m is covered.

$$\Delta s/\Delta t = 45 \text{ m}/10 \text{ s} = 4.5 \text{ m/s} = 16.2 \text{ km/h}$$

At marker **D**, the vessel has stopped in relation to the water i.e. current velocity is approximately 5 km/h.

II.5 Evaluation of the results of the stopping manoeuvre

II.5.1 On the basis of the values recorded compliance with the limit values in accordance with II.2 to II.4 shall be verified. If the conditions for the stopping manoeuvre deviate substantially from the standard conditions, or if there are doubts as to the compliance with the limit values, the results shall be evaluated. To that end the following procedure may be applied for calculating stopping manoeuvres.

II.5.2 Theoretical stopping distances are determined under the standard conditions ($S_{reference}$) of paragraph II.1.5 and under stopping manoeuvre conditions (S_{actual}) and are compared with the stopping distance measured ($S_{measured}$). The corrected stopping distance of the stopping manoeuvre under standard conditions ($S_{standard}$) is calculated as follows:

Formula 2.1:

$$S_{standard} = S_{measured} \cdot \frac{S_{reference}}{S_{actual}} \leq \text{limit value in accordance with paragraphs II.1.5 (a) or (b).}$$

When the stopping manoeuvre has been carried out with a load of 70÷100 % of the maximum deadweight in accordance with paragraph II.1.6, in order to calculate $S_{standard}$ the displacement ($D_{reference} = D_{actual}$) corresponding to the load at the time of the test shall be used for the determination of $S_{reference}$ and S_{actual} .

When in determining $S_{standard}$ according to formula 2.1, the limit value in question is exceeded or not reached, the value of $S_{reference}$ shall be reduced or increased by variation of $D_{reference}$ so that the limit value is complied with ($S_{standard} = \text{limit value in question}$). The maximum displacement permitted in downstream navigation shall be set accordingly.

II.5.3 According to the limit values given in paragraphs II.1.5 (a) or (b), only the stopping distances measured in:

– Phase I (“Full ahead” reversed to “full astern”): S_I
and

– Phase II (End of reversal until vessel stops in relation to the water): S_{II}
shall be calculated (see fig. II.4.2). The total stopping distance is then:

Formula 3.1:

$$S_{total} = S_I + S_{II}$$

II.5.4 The particular stopping distances shall be calculated as follows:

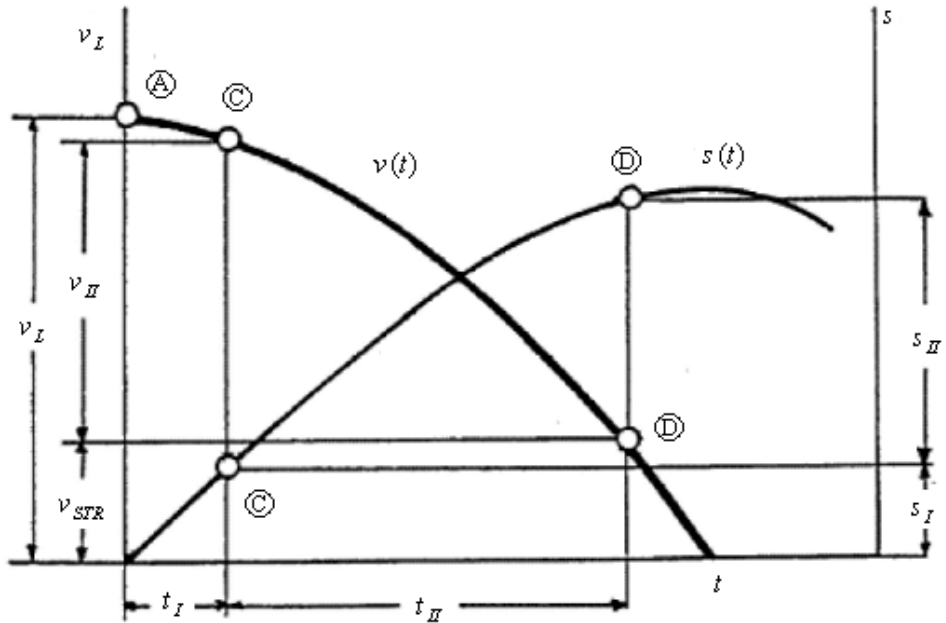


Fig. II.5.4 Diagram

Calculation Formulae:

$$(II.5.4.1) \quad S_I = k_1 \cdot v_L \cdot t_I; \quad t_I \leq 20 \text{ s}$$

(II.5.4.2)

$$S_{II} = k_2 \cdot v_{II}^2 \frac{D \cdot g}{k_3 \cdot F_{POR} + R_{TmII} - R_G} \left(k_4 + \frac{v_{STR}}{v_{II}} \right) \quad - k_2, k_3, k_4 \text{ according to table II.5.4-1}$$

$$(II.5.4.3) \quad R_{TmII} = (R_T / v^2) \cdot (k_7 \cdot k_6 \cdot (v_L - v_{STR}))^2 \quad - k_6, k_7 \text{ according to table II.5.4-1}$$

- R_T / v^2 according to table II.5.4-3

$$(II.5.4.4) \quad R_G = i \cdot D \cdot \rho \cdot g \cdot 10^{-6}$$

$$(II.5.4.5) \quad v_{II} = k_6 \cdot (v_L - v_{STR}) \quad - k_6 \text{ according to table II.5.4-1}$$

$$(II.5.4.6) \quad F_{POR} = f \cdot P_B \quad - f \text{ according to table II.5.4-2}$$

$$(II.5.4.7) \quad t_{II} = \frac{S_{II}}{v_{II} \cdot \left(k_4 + \frac{v_{STR}}{v_{II}} \right)} \quad - k_4 \text{ according to table II.5.4-1}$$

In formulae (II.5.4.1) to (II.5.4.7):

v_L - speed in relation to the ground at the start of reversal, [m/s]

t_I - reversal time, [s]

D - displacement, [m³]

- F_{POR} – bollard pull in reverse, [kN]
 P_B – power of propulsion engine, [kW]
 R_{TmII} – average resistance during phase II, to be determined using the diagram for determining R_T/v^2 , [kN]
 R_G – gradient resistance, [kN]
 i – gradient in [m/km] (if missing to be taken as 0.16)
 v_{STR} – average current velocity, [m/s]
 g – acceleration due to gravity ($g = 9.81 \text{ m/s}^2$), [m/s^2]
 ρ – density of water, for fresh water $\rho = 1000 \text{ kg/m}^3$, [kg/m^3]
 T – maximum draught (of vessel or convoy), [m]
 h – water depth, [m]
 B – width, [m]
 L – length, [m]

The coefficients for the formulae (II.5.4.1) to (II.5.4.7) can be taken from the tables below.

Table II.5.4-1

k factors for:

- a** – motor vessels and single file convoys
b – two-abreast convoys
c – three-abreast convoys

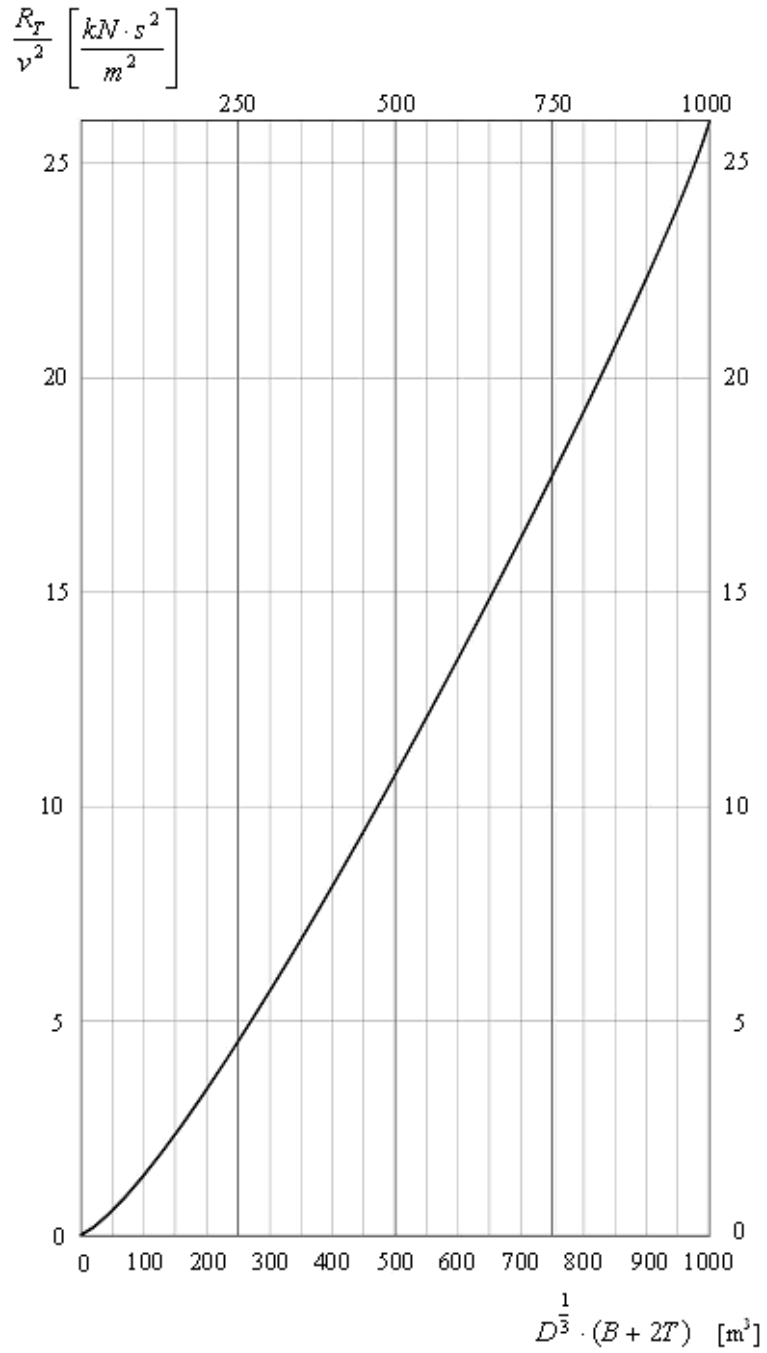
	a	b	c	Units
k_1	0.95	0.95	0.95	–
k_2	0.115	0.120	0.125	$\frac{\text{kg} \cdot \text{s}^2}{\text{m}^4}$
k_3	1.20	1.15	1.10	–
k_4	0.48	0.48	0.48	–
k_6	0.90	0.85	0.80	–
k_7	0.58	0.55	0.52	–

Table II.5.4-2

Coefficient f for ratio between bollard pull in reverse and the power of the propulsion engines

Propulsion system	f	Units
Modern nozzles with rounded rear edge	0.118	kN/kW
Old nozzles with sharp rear edge	0.112	kN/kW
Propellers without nozzle	0.096	kN/kW
Rudder propellers with nozzles (generally sharp rear edge)	0.157	kN/kW
Rudder propellers without nozzles	0.113	kN/kW

Table II.5.4-3
Diagram concerning the calculation of resistance to determine the value
of R_T / v^2 in relation to $D^{1/3}(B + 2T)$



II.6 Examples on the application of paragraph II.5 (Evaluation of the results of the stopping manoeuvre)

II.6.1 Example 1

1. Data of vessels and convoy

Formation: ordinary motor vessel with a (Europa IIa) lighter coupled abreast

	L [m]	B [m]	T_{\max} [m]	Dwt (*) [t]	D_{\max} [m ³]	P_B [kW]
Motor vessel	110	11.4	3.5	2900	3731	1500
Lighter	76.5	11.4	3.7	2600	2743	–
Convoy	110	22.8	3.7	5500	6474	1500
Propulsion system of the motor vessel: modern nozzles rounded rear edge Dwt (*) = deadweight						

2. Values measured during the stopping manoeuvre

Current velocity:	$v_{STR\ actual}$	=	1.4 m/s	≈	5.1 km/h
Speed of vessel (in relation to the water):	$v_S\ actual$	=	3.5 m/s	≈	12.5 km/h
Speed of vessel (in relation to the ground):	$v_L\ actual$	=	4.9 m/s	≈	17.6 km/h
Reversal time (measured) (point A to C):	t_I	=	16 s		
Stopping distance in relation to the water (point A to D):	$S_{measured}$	=	340 m		
Load condition (possibly estimated):	D_{actual}	=	5179 m ³	≈	0.8 D_{\max}
Actual draught of convoy:	T_{actual}	=	2.96 m	≈	0.8 T_{\max}

3. Limit values according to paragraphs II.1.5 (a) or (b) to be compared with $S_{standard}$

Since $B > 11.45$ m and since the convoy is in flowing water, the following $S_{standard}$ is applicable for this convoy under paragraph II.1.5 (a):

$$S_{standard} < 550 \text{ m}$$

4. Determination of corrected stopping distance compared to standard conditions

– measured value according to II.3

$$S_{measured} = 340 \text{ m}$$

– to be calculated:

S_{actual} as the sum of

$S_{I\ actual}$ (according to formula II.5.4.1 with $v_{L\ actual}$)

and

$S_{II\ actual}$ (according to formula II.5.4.2 to II.5.4.6 with actual speeds $v_{II\ actual}$, $v_{STR\ actual}$ and D_{actual})

$S_{reference}$ as the sum of

$S_{I reference}$ (according to formula II.5.4.1 with $v_{L reference}$)

and

$S_{II reference}$ (according to formula II.5.4.2 to II.5.4.6 with the reference speeds according to paragraph II.1.5 given that the load condition is greater than 70% of the maximum load ($\approx 80\%$): $D_{reference} = D_{actual}$ and $T_{reference} = T_{actual}$)

– to be checked:

$$S_{standard} = S_{measured} \cdot \frac{S_{reference}}{S_{actual}} \leq 550 \text{ m}$$

4.1. Coefficients for the calculation taken from paragraph II.5.4

Table II.5.4-1

for $S_{I actual}$ and $S_{I reference}$ $k_1 = 0.95$

for $S_{II actual}$ and $S_{II reference}$ $k_2 = 0.12$

$k_3 = 1.14$

$k_4 = 0.48$

$k_6 = 0.85$

$k_7 = 0.55$

Table II.5.4-2 (for modern nozzles with rounded rear edge)

$f = 0.118$

4.2. Calculation of S_{actual}

(a) $S_{I actual}$ with the values measured during the stopping manoeuvre (formula II.5.4.1)

$$S_{I actual} = k_1 \cdot v_{L actual} \cdot t_{I actual}$$

$$S_{I actual} = 0.95 \cdot 4.9 \cdot 16 = 74.5 \text{ m}$$

(b) Formula for $S_{II actual}$

$$S_{II actual} = k_2 \cdot v_{II actual}^2 \cdot \frac{D_{actual} \cdot g}{k_3 \cdot F_{POR} + R_{TmII actual} - R_G} \cdot \left(k_4 + \frac{v_{STR actual}}{v_{II actual}} \right)$$

(c) Calculation $R_{TmII actual}$ if according to table II.5.4-3 and formula II.5.4.3

$$D_{actual}^{1/3} = 5179^{1/3} + 17.3 \text{ [m]}$$

$$D_{actual}^{1/3} \cdot (B + 2 \cdot T_{actual}) = 17.3 \cdot (22.8 + 5.92) = 496.8 \text{ [m}^2\text{]}$$

$$\text{according to table II.5.4-3: } \frac{R_T}{v^2} = 10.8 \left[\frac{\text{kN} \cdot \text{s}^2}{\text{m}^2} \right]$$

$$v_{L\text{ actual}} - v_{STR\text{ actual}} = 4.9 - 1.4 = 3.5 \text{ [m/s]}$$

$$R_{TmII\text{ actual}} = \frac{R_T}{v^2} \left(k_7 \cdot k_6 \cdot (v_{L\text{ actual}} - v_{STR\text{ actual}}) \right)^2 = 10.8 \cdot (0.55 \cdot 0.85 \cdot 3.5)^2 = 28.8 \text{ [kN]}$$

(d) Calculation of resistance to gradient R_G according to formula II.5.4.4

$$R_G = 10^{-6} \cdot (0.16 \cdot D_{\text{actual}} \cdot \rho \cdot g) = 10^{-6} \cdot (0.16 \cdot 5179 \cdot 1000 \cdot 9.81) = 8.13 \text{ [kN]}$$

(e) Calculation of $v_{II\text{ actual}}$ according to formula II.5.4.5

$$v_{II\text{ actual}} = k_6 \cdot (v_{L\text{ actual}} - v_{STR\text{ actual}}) = 0.85 \cdot 3.5 = 2.97 \text{ [m/s]}$$

$$v_{II\text{ actual}}^2 = 8.85 \text{ [m/s]}^2$$

(f) Calculation of F_{POR} according to formula II.5.4.6 and table II.5.4-2

$$F_{POR} = 0.118 \cdot 1500 = 177 \text{ [kN]}$$

(g) Calculation of $S_{II\text{ actual}}$ using formula (b) and the results of (c), (d), (e) and (f)

$$S_{II\text{ actual}} = \frac{0.12 \cdot 8.85 \cdot 9.81 \cdot \left(0.48 + \frac{1.4}{2.97} \right)}{1.15 \cdot 177 + 28.8 - 8.13} \cdot 5179 = 228.9 \text{ m}$$

(h) Calculation of total distance according to formula 3.1

$$S_{\text{actual}} = 74.51 + 228.9 = 303.4 \text{ m}$$

Note: The term $(R_{TmII} - R_G)$, which is a function of D , with an actual value of 20.67 kN is obviously relatively small compared to $k_3 \cdot F_{POR}$ with an actual value of 203.55 kN, so for simplification purposes, S_{II} can be taken as proportional to D , i.e. $S_{II} = \text{Constant} \cdot D$.

4.3. Calculation of $S_{\text{reference}}$

Initial values

$$v_{STR\text{ reference}} = 1.5 \text{ m/s} = 5.4 \text{ km/h} \quad D_{\text{reference}} = D_{\text{actual}} = 5179 \text{ m}^3$$

$$v_{S\text{ reference}} = 3.6 \text{ m/s} = 13 \text{ km/h} \quad T_{\text{reference}} = T_{\text{actual}} = 2.96 \text{ m}$$

$$v_{L\text{ reference}} = 5.1 \text{ m/s} = 18.4 \text{ km/h}$$

(a) $S_{I\text{ reference}} = k_1 \cdot v_{L\text{ reference}} \cdot t_I$

$$S_{I\text{ reference}} = 0.95 \cdot 5.1 \cdot 16 = 77.50 \text{ m}$$

(b)
$$S_{II\text{ reference}} = k_2 \cdot v_{II\text{ reference}}^2 \cdot \frac{D_{\text{reference}} \cdot g}{k_3 \cdot F_{POR} + R_{TmII\text{ reference}} - R_G} \cdot \left(k_4 + \frac{v_{STR\text{ reference}}}{v_{II\text{ reference}}} \right)$$

(c) Calculation of $R_{TmII\ reference}$

$\frac{R_T}{v^2} = 10.8 \left[\frac{\text{kN} \cdot \text{s}^2}{\text{m}^2} \right]$ as in paragraph 4.2 of II.6.1, since B , D and T are unchanged.

$$v_{L\ reference} - v_{STR\ reference} = 3.6 \text{ [m/s]}$$

$$R_{TmII\ reference} = \frac{R_T}{v^2} \cdot (k_7 \cdot k_6 \cdot (v_{L\ reference} - v_{STR\ reference}))^2 = 10.8 \cdot (0.55 \cdot 0.85 \cdot 3.6)^2 = 30.99 \text{ [kN]}$$

(a) Resistance due to gradient R_G as in paragraph 4.2 of II.6.1

(b) Calculation of $v_{II\ reference}$

$$v_{II\ reference} = k_6 \cdot (v_{L\ reference} - v_{STR\ reference}) = 0.85 \cdot 3.6 = 3.06 \text{ [m/s]}$$

$$v_{II\ reference}^2 = 9.36 \text{ [m/s]}^2$$

(c) F_{POR} as in paragraph 4.2 of II.6.1.

(d) Calculation of $S_{II\ reference}$ using formula (b) and the result from (c) to (f)

$$S_{II\ reference} = \frac{0.12 \cdot 9.36 \cdot 9.81 \cdot \left(0.48 + \frac{1.5}{3.06} \right)}{1.15 \cdot 177 + 30.99 - 8.13} \cdot 5179 = \underbrace{0.0472}_{\text{Constant reference}} \cdot 5179 = 244.5 \text{ m}$$

(e) Calculation of total distance

$$S_{reference} = S_{I\ reference} + S_{II\ reference} = 77.5 + 244.5 = 322 \text{ m}$$

4.4. Verification of compliance with permissible stopping distance under standard conditions $S_{standard}$ according to formula 2.1 of paragraph II.5.2

$$S_{standard} = S_{measured} \cdot \frac{S_{reference}}{S_{actual}} = 340 \cdot \frac{322}{303.4} = 360.8 \text{ m} < 550 \text{ m}$$

Conclusion:

The permissible limit value is far from being reached, i.e.:

- admission to downstream navigation is possible without problems for the actual load condition ($0.8 \cdot D_{max}$),
- a higher load condition is possible and may be calculated according to paragraph 5 below.

5. Possible increase of D_{actual} in downstream navigation

$$(S_{standard})_{Limit} = S_{measured} \cdot \frac{(S_{reference})_{Limit}}{S_{actual}} = 550 \text{ m}$$

$$(S_{reference})_{Limit} = 550 \cdot \frac{S_{actual}}{S_{measured}} = 550 \cdot \frac{303.4}{340} = 490.8 \text{ m}$$

With $S_{II\ reference} = Constant\ reference \cdot D$ according to the note under paragraph 4.2 of II.6.1

$$(S_{reference})_{Limit} = (S_{I\ reference} + S_{II\ reference})_{Limit} + 0.0472 \cdot (D_{reference})_{Limit}$$

Hence

$$(D_{reference})_{Limit} = \frac{(S_{reference})_{Limit} - S_{I\ reference}}{0.0472} = \frac{490.8 - 77.5}{0.0472} = 8756 \text{ m}^3$$

From this follows that:

Since $(D_{reference})_{Limit} > D_{max}$ ($8756 > 6474$) this formation (see paragraph 1 of II.6.1) may be permitted in downstream navigation with full load.

II.6.2 Example 2

1. Data of vessels and convoy

Formation:

large motor vessel propelling

2 lighters side-by-side in front and

1 lighter coupled side-by-side

	L [m]	B [m]	T_{max} [m]	Dwt (*) _{max} [t]	D_{max} [m ³]	P_B [kW]
Motor vessel	110	11.4	3.5	2900	3731	1500
Each Lighter	76.5	11.4	3.7	2600	2743	–
Convoy	186.5	22.8	3.7	10700	11960	1500
Propulsion system of the motor vessel: modern nozzles rounded rear edge						
Dwt (*) = deadweight						

2. Values measured during the stopping manoeuvre

Current velocity:	$v_{STR\ actual}$	=	1.4 m/s	≈	5.1 km/h
Speed of vessel (in relation to the water):	$v_S\ actual$	=	3.5 m/s	≈	12.5 km/h
Speed of vessel (in relation to the ground):	$v_L\ actual$	=	4.9 m/s	≈	17.6 km/h
Reversal time (measured) (point A to C):	t_1	=	16 s		
Stopping distance in relation to the water (point A to D):	$S_{measured}$	=	580 m		
Load condition (possibly estimated):	D_{actual}	=	9568 m ³	≈	0.8 D_{max}
Actual draught of convoy:	T_{actual}	=	2.96 m	≈	0.8 T_{max}

3. Limit value according to paragraph II.1.5 (a) or (b) to be compared with $S_{standard}$

Since $B > 11.45$ m and the convoy is in flowing water, the following $S_{standard}$ applies for this convoy under paragraph II.1.5(a):

$$S_{standard} < 550 \text{ m}$$

4. Determination of corrected stopping distance compared with standard conditions

– measured value:

$$S_{measured} = 340 \text{ m}$$

– calculations to be made:

S_{actual} as the sum of

$S_{I actual}$ (according to formula II.5.4.1 with $v_{L actual}$)

and

$S_{II actual}$ (according to formula II.5.4.2 to II.5.4.6 with real speeds $v_{II actual}$ (see under 2 above) and D_{actual})

$S_{reference}$: sum $S_{I reference} + S_{II reference}$ (according to formula II.5.4.1 to II.5.4.6 with reference speeds and in conformity paragraph II.5, because the load condition $> 70\%$ of maximum, where $D_{reference} = D_{actual}$ and $T_{reference} = T_{actual}$)

– to be verified:

$$S_{standard} = S_{measured} \cdot \frac{S_{reference}}{S_{actual}} \leq 550 \text{ m, otherwise}$$

– calculate:

$$S_{standard}^* = 550 \text{ m by reduction of } D_{actual} \text{ to } D^*$$

4.1. Coefficients for the calculation according to paragraph II.5.4

Table II.5.4-1

For $S_{I actual}$ and $S_{I reference}$ $k_1 = 0.95$

for $S_{II actual}$ and $S_{II reference}$ $k_2 = 0.12$

$$k_3 = 1.15$$

$$k_4 = 0.48$$

$$k_6 = 0.85$$

$$k_7 = 0.55$$

Table II.5.4-2 (for modern nozzles with rounded rear edge)

$$F = 0.118$$

4.2. Calculation of S_{actual}

- (a) $S_{I actual}$ using the values measured during the stopping manoeuvre

$$S_{I actual} = k_1 \cdot v_{L actual} \cdot t_{I actual}$$

$$S_{I actual} = 0.95 \cdot 4.8 \cdot 16 = 73 \text{ m}$$

- (b) Formula for $S_{II actual}$

$$S_{II actual} = k_2 \cdot v_{II actual}^2 \cdot \frac{D_{actual} \cdot g}{k_3 \cdot F_{POR} + R_{TmII actual} - R_G} \cdot \left(k_4 + \frac{v_{STR actual}}{v_{II actual}} \right)$$

- (c) Calculation $R_{TmII actual}$ according to table II.5.4-3 and formula II.5.4.3

$$D_{actual}^{1/3} = 9568^{1/3} = 21.2 \text{ [m]}$$

$$D_{actual}^{1/3} \cdot (B + 2 \cdot T_{actual}) = 21.2 \cdot (22.8 + 5.92) = 609 \text{ [m}^2\text{]}$$

$$\text{according to table II.5.4-3: } \frac{R_T}{v^2} = 14.0 \left[\frac{\text{kN} \cdot \text{s}^2}{\text{m}^2} \right]$$

$$v_{L actual} - v_{STR actual} = 4.8 - 1.4 = 3.4 \text{ [m/s]}$$

$$R_{TmII actual} = \frac{R_T}{v^2} \cdot (k_7 \cdot k_6 \cdot (v_{L actual} - v_{STR actual}))^2 = 14.0 \cdot (0.55 \cdot 0.85 \cdot 3.4)^2 = 35.4 \text{ [kN]}$$

- (d) Calculation of resistance due to gradient R_G according to formula II.5.4.4.

$$R_G = 10^{-6} \cdot (0.16 \cdot D_{actual} \cdot \rho \cdot g) = 10^{-6} \cdot (0.16 \cdot 9568 \cdot 1000 \cdot 9.81) = 15.02 \text{ [kN]}$$

- (e) Calculation of $v_{II actual}$ according to formula II.5.4.5

$$v_{II actual} = k_6 \cdot (v_{L actual} - v_{STR actual}) = 2.89 \text{ [m/s]}$$

$$v_{II actual}^2 = 8.35 \text{ [m/s]}^2$$

- (f) Calculation of F_{POR} according to formula II.5.4.6 and table II.5.4-2

$$F_{POR} = 0.118 \cdot 1500 = 177 \text{ [kN]}$$

- (g) Calculation of $S_{II actual}$ using formula (b) and the results of (c), (d), (e) and (f)

$$S_{II actual} = \frac{0.12 \cdot 8.35 \cdot 9.81 \cdot \left(0.48 + \frac{1.4}{2.89} \right)}{1.15 \cdot 177 + 35.4 - 15.02} \cdot 9568 = 402 \text{ m}$$

(h) Calculation of total distance according to formula 3.1

$$S_{actual} = 73 + 402 = 475 \text{ m}$$

4.3. Calculation of $S_{reference}$

Initial values

$$v_{STR\ reference} = 1.5 \text{ m/s} = 5.4 \text{ km/h}$$

$$D_{reference} = D_{actual} = 9568 \text{ m}^3$$

$$v_{S\ reference} = 3.6 \text{ m/s} = 13 \text{ km/h}$$

$$T_{reference} = T_{actual} = 2.96 \text{ m}$$

$$v_{I\ reference} = 5.1 \text{ m/s} = 18.4 \text{ km/h}$$

(a) $S_{I\ reference} = k_1 \cdot v_{I\ reference} \cdot t_I$

$$S_{I\ reference} = 0.95 \cdot 5.1 \cdot 16 = 77.50 \text{ m}$$

(b)
$$S_{II\ reference} = k_2 \cdot v_{II\ reference}^2 \cdot \frac{D_{reference} \cdot g}{k_3 \cdot F_{POR} + R_{TmII\ reference} - R_G} \cdot \left(k_4 + \frac{v_{STR\ reference}}{v_{II\ reference}} \right)$$

(c) Calculation of $R_{TmII\ reference}$

$$\frac{R_T}{v^2} = 14.0 \left[\frac{\text{kN} \cdot \text{s}^2}{\text{m}^2} \right] \text{ as under paragraph 4.2 of II.6.2, since } B, D \text{ and } T \text{ are}$$

unchanged.

$$v_{L\ reference} - v_{STR\ reference} = 3.6 \text{ [m/s]}$$

$$R_{TmII\ reference} = 14.0 \cdot (0.55 \cdot 0.85 \cdot 3.6)^2 = 39.6 \text{ [kN]}$$

(d) Resistance due to gradient R_G as under paragraph 4.2 of II.6.2

(e) Calculation of $v_{II\ reference}$

$$v_{II\ reference} = 0.85 \cdot 3.6 = 3.06 \text{ [m/s]}$$

$$v_{II\ reference}^2 = 9.36 \text{ [m/s]}^2$$

(f) F_{POR} as under paragraph 4.2 of II.6.2.

(g) Calculation of $S_{II\ reference}$ using formula (b) and the result of (c) to (f)

$$S_{II\ reference} = \frac{0.12 \cdot 9.36 \cdot 9.81 \cdot \left(0.48 + \frac{1.5}{3.06} \right)}{1.15 \cdot 177 + 39.6 - 15.02} \cdot 9568 = \underbrace{0.04684}_{\text{Constant reference}} \cdot 9568 = 448 \text{ m}$$

(h) Calculation of total distance

$$S_{reference} = S_{I\ reference} + S_{II\ reference} = 77.5 + 448 = 525.5 \text{ m}$$

4.4. Verification of compliance with permissible stopping distance under standard conditions $S_{standard}$ according to formula 2.1 of paragraph II.5.2.

$$S_{standard} = S_{measured} \cdot \frac{S_{reference}}{S_{actual}} = 580 \cdot \frac{525.5}{475} = 641 \text{ m} > 550 \text{ m}$$

Conclusion: The limit value has clearly been exceeded, admission to downstream navigation is possible only with a load restriction. This restricted load can be determined in conformity with 5 below.

5. D^* permissible in downstream navigation according to formulae 2.1 of paragraph II.5.2

$$S_{standard} = S_{measured} \cdot \frac{S_{reference}^*}{S_{actual}} = 550 \text{ m}$$

Therefore:

$$S_{reference}^* = 550 \cdot \frac{S_{actual}}{S_{measured}} = S_{I reference} + S_{II reference}^*$$

$$S_{II reference}^* = Constant_{reference} \cdot D^* = 0.04684 \cdot D^*$$

$$D^* = \frac{550 \cdot \frac{478}{580} - 77.5}{0.04684} = 7950 \text{ m}^3$$

Consequence: Since in downstream navigation the permissible D^* is only 7950 m³, the permissible deadweight (perm. Dwt) in this formation is approximately:

$$perm. Dwt = \frac{D^*}{D_{max}} \cdot Dwt(*)_{max} = \frac{7950}{11960} \cdot 10700 = 0.66 \cdot 10700 = 7112 \text{ t}$$

Permissible deadweight (see paragraph 1 of II.6.2)

$$0.66 \cdot 10700 = 7112 \text{ t}$$

ANNEX III

EVASIVE ACTION TEST AND TURNING CAPACITY

III.1 Evasive action test procedure and recording of data

(See fig. III.5)

III.1.1 Vessels and convoys shall be able to take evasive action in good time. That capacity shall be proven by means of evasive manoeuvres carried out within a test area as referred to in paragraphs from 1.3.1 to 1.3.3. This shall be proved by simulated evasive action manoeuvres to port and starboard with prescribed values whereby for specific turning speeds of the vessel in response to putting across and then checking the helm a certain time limit shall be complied with.

III.1.2 During evasive action tests the requirements shall be complied with keeping a keel clearance of at least 20% of the draught, but not less than 0.50 m.

III.1.3 The load condition during the evasive action manoeuvre shall be between 70% and 100% of the maximum deadweight. If the test is carried out with a smaller load, approval for downstream and upstream navigation shall be restricted to that load limit.

III.1.4 Evasive action manoeuvres shall be performed as follows:

With the vessel or convoy under way at a constant speed of $V_0 = 13$ km/h in relation to the water, at the start of the manoeuvre (time $t_0 = 0$ s, turning speed $r = 0^\circ/\text{min}$, rudder angle $\delta_0 = 0^\circ$, engine speed kept constant), evasive action to port or starboard is to be initiated by putting across the helm. The rudder shall be set to an angle δ , or the steering unit to an angle δ_a in the case of an active steering device, at the start of the manoeuvre, in accordance with the indications given in paragraph III.1.5. The rudder angle δ (e.g. 20° to starboard) shall be maintained until the value r_1 of the turning speed referred to in paragraph III.1.6 for the corresponding dimensions of the vessel or convoy is reached. When the turning speed r_1 is reached, the time t_1 shall be recorded and the rudder set to the same angle on the opposite side (e.g. 20° to port) so as to stop the turn and commence turning in the opposite direction, i.e., to reduce the turning speed to $r_2 = 0$ and let it to rise again to the value given in paragraph III.1.6. When the turning speed $r_2 = 0$ is reached, the time t_2 shall be recorded. When the turning speed r_3 given in paragraph III.1.6 is reached, the rudder shall be set in the opposite direction to the same angle δ , so as to stop the turning movement. The time t_3 shall be recorded. When the turning speed $r_4 = 0$ is reached, the time t_4 shall be recorded and the vessel or convoy shall be returned to its original course.

III.1.5 At least four evasive action manoeuvres shall be carried out, namely:

- one to starboard with a rudder angle $\delta = 20^\circ$,
- one to port with a rudder angle $\delta = 20^\circ$,
- one to starboard with a rudder angle $\delta = 45^\circ$,
- one to port with a rudder angle $\delta = 45^\circ$.

If necessary (e.g. in the case of uncertainty about the values measured or of unsatisfactory manoeuvres), the evasive action manoeuvres shall be repeated. The turning speeds given in paragraph III.1.6 and the time limits shall be complied with. For active steering devices or special types of rudder, a position δ_a of the steering unit or rudder angle δ_a other than $\delta = 20^\circ$ and $\delta = 45^\circ$ may be selected, according to the expert's assessment, depending on the type of steering system.

III.1.6 The following limit values shall be complied with to reach turning speed r_4 depending on the dimensions of the vessels or the convoys and on the water depth h (see table III.1.6):

Table III.1.6
Required turning speed and limit values of time

	Dimensions of vessels or convoys $L \times B$	Required turning speed $r_1 = r_3$ [°/min]		Limit values for the time t_4 [s] in shallow and deep water		
		$\delta = 20^\circ$	$\delta = 45^\circ$	$1.2 \leq h/T \leq 1.4$	$1.4 < h/T < 2$	$h/T > 2$
1	All motor vessels; single-in-line convoys $\leq 110 \times 11.45$	20	28	150	110	110
2	Single-in-line convoys up to 193×11.45 or two-abreast convoys up to 110×22.90	12	18	180	130	110
3	Two-abreast convoys $\leq 193 \times 22.9$	8	12	180	130	110
4	Two-abreast convoys up to 270×22.90 or three-abreast convoys up to 193×34.35	6	8	(*)	(*)	(*)
(*) In accordance with the decision of the nautical expert						

III.1.7 In order to determine the turning speed, a rate-of-turn indicator shall be on board.

III.2 Turning capacity

III.2.1 Vessels and convoys not exceeding 86 m in length or 22.90 m in breadth shall be able to turn in good time.

III.2.2 That turning capacity may be replaced by the stopping capacity.

III.2.3 The turning capacity shall be proven by means of turning manoeuvres against the current.

III.2.4 The turning capacity of vessels and convoys whose length (L) does not exceed 86 m and width (B) does not exceed 22.90 m shall be considered when during an upstream turning manoeuvre with an initial speed in relation to the water of

13 km/h, the limit values for stopping facing downstream established in paragraph Annex II.1.5 are complied with. The keel clearance conditions according to paragraph III.1.2 shall be complied with.

III.2.5 However, during the test involving turning into the current referred to paragraphs III.2.1 to III.2.3, bow anchors may be used.

III.3 Other requirements

III.3.1 Notwithstanding paragraphs III.1.1, III.1.2, III.1.4 to III.1.7 and III.2.4, the following requirements shall be met:

- (a) for manually controlled steering systems, a single turn of the wheel shall correspond to a rudder angle of at least 3°;
- (b) for powered steering systems, when the rudder is at maximum immersion, it shall be possible to achieve an average angular velocity of 4°/s over the rudder's entire turning range.

This requirement shall also be checked, with the vessel at full speed, for moving the rudder over a range from 35° port to 35° starboard. In addition, it shall be checked whether the rudder keeps the position of maximum angle at maximum propulsion power. For active steering systems or special types of rudder, this provision applies *mutatis mutandis*.

III.3.2 If any of the additional equipment referred to in paragraphs 1.3.6 and III.2.5 is needed in order to reach the required manoeuvring capacities, it shall comply with the requirements of chapter 2, and the following particulars shall be entered in the Community Certificate:

“Flanking rudders*/ bow steering systems*/other equipment* referred to under item 34 is*/are* necessary to comply with the manoeuvrability requirements of chapter 5”.

III.4 Recording of data and reports

The measurements, reports and recording of data shall be carried out according to the procedure set out in paragraph Annex V.2.

* Delete as appropriate.

III.5. Diagram of the evasive action manoeuvre

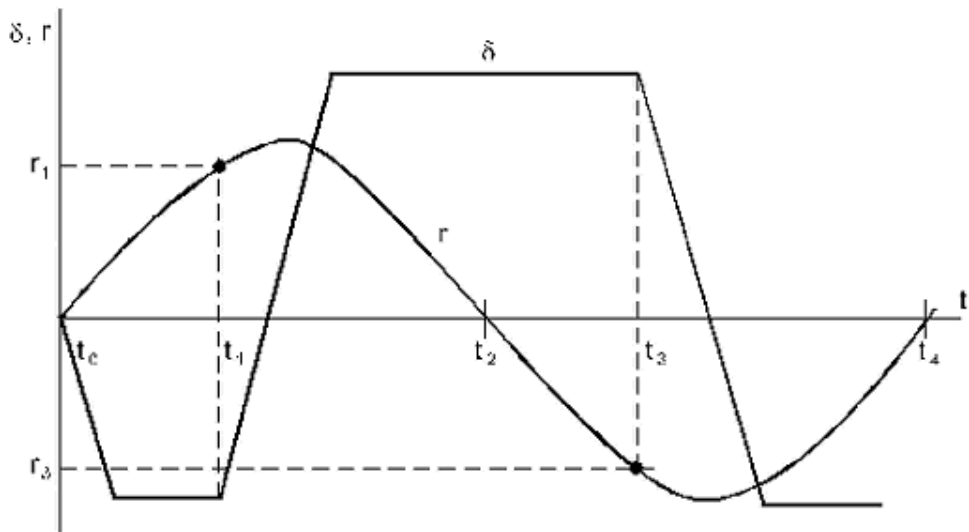


Fig. III.5 Diagram of the evasive action

- t_0 = Start of evasive action manoeuvre,
- t_1 = Time to reach turning speed r_1 ,
- t_2 = Time to reach turning speed $r_2 = 0$,
- t_3 = Time to reach turning speed r_3 ,
- t_4 = Time to reach turning speed $r_4 = 0$ (end of evasive action manoeuvre),
- δ = Rudder angle [$^\circ$],
- r = Turning speed [$^\circ/\text{min}$].

ANNEX IV
REQUIREMENTS FOR COUPLING SYSTEMS AND COUPLING DEVICES
FOR CRAFT SUITABLE FOR PROPELING OR BEING PROPELLED
IN A RIGID ASSEMBLY

IV.1 General Requirements

IV.1.1 In order to authorize a pusher or motor vessel to propel a rigid convoy, and to enter this on the Community certificate, the inspection body shall decide which formations are to be presented and shall conduct the navigation tests referred to in paragraph 1.2 with the convoy in the formation(s) applied for, which the inspection body regards to be the least favorable one(s). The requirements set out in the present *Publication* shall be met by this convoy.

IV.1.2 The inspection body shall check that the rigid connection of all craft in the convoy is maintained during the manoeuvres required by navigability and manoeuvrability.

IV.1.3 If during the navigation tests referred to in paragraph IV.1.1 there are specific installations on board, the craft are being either pushed or propelled side-by-side, such as the steering system, propulsion units or manoeuvring equipment, or articulated couplings in order to meet the requirements set out in the present *Publication*, the following shall be entered on the Community certificate for the craft propelling the convoy: formation, position, name and official number of those craft which are fitted with the specific installations used.

IV.1.4 Every coupling system shall guarantee the rigid coupling of all the craft in convoy, i.e. under foreseen operating conditions the coupling devices shall prevent longitudinal or transversal movement between the vessels, so that the assembly can be seen as a “nautical unit”.

IV.1.5 The coupling system and its components shall be safe and easy to use, enabling craft to be coupled rapidly without endangering personnel.

IV.1.6 The forces arising from foreseen operating conditions shall be properly absorbed and safely transmitted into the vessel’s structure by the coupling system and its components.

IV.1.4 A sufficient number of coupling points shall be available.

IV.2 Coupling forces and dimensioning of coupling devices

IV.2.1 The coupling devices of convoys and formations of vessels to be authorized shall be dimensioned so as to guarantee sufficient safety levels. This condition is deemed to be fulfilled if the coupling forces determined according paragraphs IV.2.2a, IV.2.2b and IV.2.2c are assumed to be the tensile strength for the dimensioning of the longitudinal coupling components.

IV.2.2 Coupling points between:

(a) pusher and pushed lighters or other craft:

$$F_{SB} = 270 \cdot P_B \cdot \frac{L_S}{B_S} \cdot 10^{-3} \text{ [kN]} \quad (\text{IV.2.2-1})$$

(b) pushing motor vessel and pushed craft:

$$F_{SF} = 80 \cdot P_B \cdot \frac{L_S}{h_K} \cdot 10^{-3} \text{ [kN]} \quad (\text{IV.2.2-2})$$

(c) pushed craft:

$$F_{SL} = 80 \cdot P_B \cdot \frac{L'_S}{h'_K} \cdot 10^{-3} \text{ [kN]} \quad (\text{IV.2.2-3})$$

Where:

F_{SB}, F_{SF}, F_{SL} – coupling force of the longitudinal connection, [kN];

P_B – installed power of the propulsion engine, [kW];

L_S – distance from the stern of the pusher or pushing craft to the coupling point, [m];

L'_S – distance from the stern of the pusher craft to the coupling point between the first pushed craft and the craft coupled ahead of it, [m];

h_K, h'_K – respective lever arm of the longitudinal connection, [m];

B_S – width of the pushing craft, [m];

270 and $80 \left[\frac{\text{kN}}{\text{kW}} \right]$ – empirically established values for the conversion of installed power to thrust while ensuring adequate levels of safety.

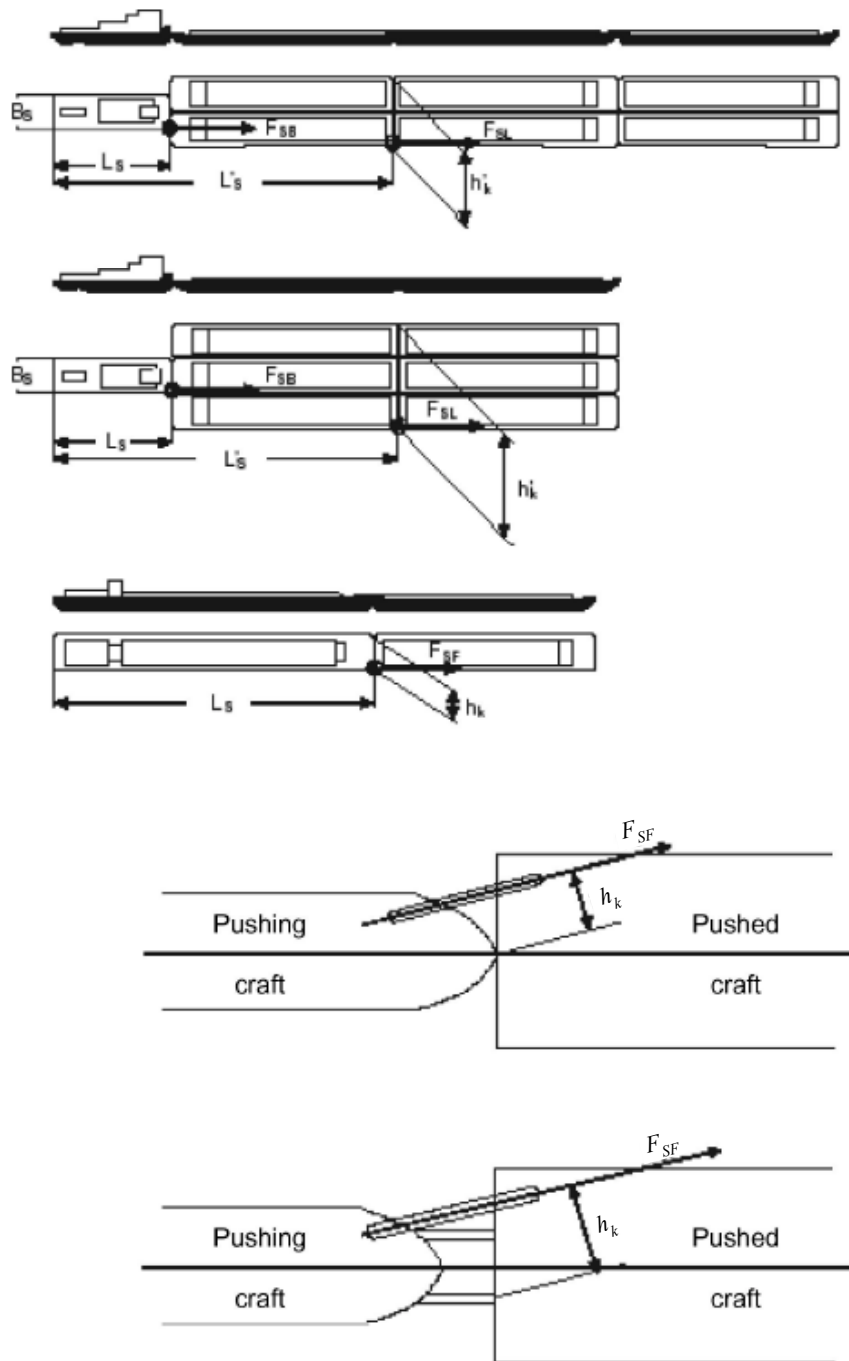


Fig. IV.2.2

IV.2.3 A value 1200 kN is deemed to be sufficient for the maximum coupling force for a pushing craft at the coupling point between the first pushed craft and the craft coupled ahead of it, even formula IV.2.2-3 produces a higher value.

IV.2.4 For the coupling points of all other longitudinal connections between pushed craft, the dimensioning of the coupling devices shall be based on the coupling force determining according to formula IV.2.2-3.

IV.2.5 For the longitudinal coupling of individual craft at least two coupling points shall be used. Each coupling point shall be dimensioned for the coupling force determined according formulae IV.2.2-1 to IV.2.2-3. If rigid coupling components are used, a single coupling point may be authorized if that point ensures secure connection of the craft.

IV.2.6 The tensile strength of the cables shall be selected according to the foreseen number of windings. There shall be no more than three windings at the coupling point. Cables shall be selected according to their intended use.

IV.2.7 In the case of pushers with a single pushed lighter, formula IV.2.2-2 can be used to determine the coupling force if such pushers have been authorized to propel several such lighters.

IV.2.8 Sufficient numbers of bollards or equivalent devices shall be available and be capable of absorbing the coupling forces arising.

IV.3 Special requirements for articulated couplings

IV.3.1 Articulated couplings shall be designed so as to also ensure a rigid coupling between craft. Compliance with the requirements of navigability and manoeuvrability shall be checked during navigation tests with a rigid convoy in accordance with paragraphs IV.1.1 to IV.1.3.

IV.3.2 The drive unit of the articulated coupling shall enable a satisfactory return from the articulated position. The requirements of the steering systems shall be applied *mutatis mutandis*, hence when a powered drive unit is used, a second independent drive unit and energy source shall be available in the even of failure.

IV.3.3 It shall be possible to operate and monitor the articulated coupling (its articulated movement, at least) from the wheelhouse, the requirements of control, indicating, monitoring equipment and navigation lights, light signals and sound signal shall be applied *mutatis mutandis*.

ANNEX V REPORTS

V.1 Report of the stopping manoeuvre

Inspection Body:
 Date:
 Name:.....
 Test run No:
 Type of vessel or convoy Test area:
 $L \times B$ [m]:
 T at test [m]:
 Load at test [t]:% of maximum deadweight.....
 Power of propulsion engines P_B [kW]
 Propulsion system according to paragraph Annex II.5.4, table Annex II.5.4-2:
 Water level gauge reading [m]:
 Water depth [m]:
 Gradient [m/km]:
 v_{STR} [km/h]: [m/s]:
 Max displacement [m³]:

Position [river-km]	Time [sec.]	Δs [m]	Δt [s]	v_{LL} [km/h]	Engine speed n [min ⁻¹]	Observations

Special equipment of pushed craft:

Kind of special equipment:.....
 Position(s) of craft with special equipment in the convoy:
 Name(s) and register number(s) of craft with special equipment:

V.2 Report on evasive action manoeuvre and turning capacity

Inspection body:
 Date:
 Name:
 Name of craft:
 Owner:
 Type of craft: Test area:
 or convoy: Relevant water level [m]:
 $L \times B$ [m \times m]: Depth of water h [m]:
 T_{test} [m]: h/T :
 Speed of the current [m/s]:
 Load:% of maximum deadweight:
 (during test) [t]:
 Rate-of turn indicator
 Type:
 Type of rudder construction: normal construction/special construction *
 Active steering system: yes/no *

Results of evasive action manoeuvres:

Time t_1 to t_4 required for the evasive action	Rudder angle δ or δ_a^* at which evasive action commences and turning speed to be complied with $r_1 = r_3$				Comments
	$\delta = 20^\circ$ SB*	$\delta = 20^\circ$ PS*	$\delta = 45^\circ$ SB*	$\delta = 45^\circ$ PS*	
	$\delta_a = \dots$ SB*	$\delta_a = \dots$ PS*	$\delta_a = \dots$ SB*	$\delta_a = \dots$ PS*	
	$r_1 = r_3 = \dots$ °/min		$r_1 = r_3 = \dots$ °/min		
t_1 [s]					
t_2 [s]					
t_3 [s]					
t_4 [s]					
Limit value t_4 according to Annex III.1.6	Limit value $t_4 = \dots$ [s]				

Turning capacity *

Geographic position at start of turning manoeuvre km

Geographic position at end of turning manoeuvre km

Steering apparatus

Type of operation: manual/powerd *

Rudder angle for each turn of the wheel * : °

Angular velocity of the rudder over the whole range * : °/s

Angular velocity of the rudder over the range 35° PS to 35° SB* : °/s

Special equipment of pushed craft:

Kind of special equipment:

Position(s) of craft with special equipment in the convoy:

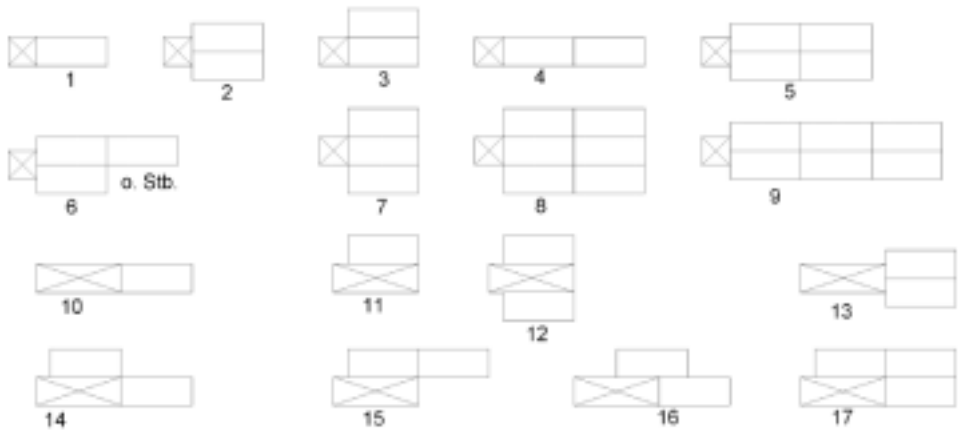
Name(s) and register number(s) of craft with special equipment:

* Delete as appropriate.

V.3 Test Certificate

1. The craft is authorized to propel the following formations:

Formation figure	Restrictions resulting from navigability and manoeuvrability								Remarks
	Maximum dimensions [m]		Navigation direction and load status				Maximum wetted section in [m ²]		
			Upstream		Downstream				
No	Length	Breadth	Loaded [t]	Empty	Loaded [t]	Empty	Upstream	Downstream	



Other formations

Key to symbols:



2. Couplings:

Type of coupling: Number of couplings per side:
Number of coupling cables: Length of each coupling cable: m
Tensile strength per longitudinal coupling: Number of cable windings:
.....kN
Tensile strength per coupling cable:kN

Special equipment of pushed craft:

Kind of special equipment:
Position(s) of craft with special equipment in the convoy:.....
Name(s) and register number(s) of craft with special equipment:
Special equipment is indispensable in order to meet requirements related to navigability: yes / no *

* Delete as appropriate.