Paper 25 – Inland vessels at sea: a useful contradiction to solve missing links in waterway systems

VANTORRE M.; ELOOT K.; GEERTS S.
Ghent University (EA15, Maritime Technology Division), Ghent, Belgium
Flanders Hydraulics Research, Antwerp, Belgium

Email (1st author): marc.vantorre@ugent.be

ABSTRACT: For a limited number of maritime ports, the local regulations conditionally allow inland vessels to carry out short sea voyages to reach the inland waterway network. This type of traffic, usually referred to as ‘estuarine’, ‘fluvio-maritime’ or ‘sea-river’ traffic, is well established in e.g. Zeebrugge, Le Havre, the Italian Adriatic coast. Inland vessels have to fulfil a set of technical requirements, issued by both the classification society and the local authorities, while they can only navigate at sea in favourable weather conditions. An overview is given of the regulations valid for the different areas where river-sea traffic is common practice. Apparently, no uniformity exists among neither the requirements nor the restrictions.

1 INTRODUCTION

In general, inland vessels are not allowed to navigate at sea. For sea ports with a suitable connection to an inland waterway system, this restriction raises no problems, as the inland waterway network is directly accessible from the maritime terminals. In some harbours, however, the connection between the berths for sea-going vessels and the inland waterway system is either not adequate for large traffic flows, or even non-existent. In case the connection with inland waterways involve a (limited) trajectory over sea, feeder activities can principally only be performed by ships with a maritime status, such as coasters. For a limited number of maritime ports, however, the local regulations conditionally allow a specific type of inland vessels to perform short sea voyages in favourable weather conditions to reach the inland waterway network. This type of traffic is referred to as ‘estuarine’, ‘fluvio-maritime’ or ‘sea-river’ traffic, although the latter is preferable, taking account of the recent proposal (UN/ECE, 2013) for amendments to the chapter on inland waterways of the Glossary for Transport Services (European Union, ITF, UNECE, 2010). Sea-river traffic is well established in Zeebrugge, which is located at a short distance from either the sea lock (north access) or the river Seine (south access). Similar practice is also applicable in Italian (Ravenna, Venice) and Chinese (Ningbo) ports. An overview of fluvio-maritime practice and the regulations was recently issued by a PIANC INCOM/MARCOM Expert Group (PIANC, 2013).

To be allowed to perform a sea voyage in coastal areas, an inland vessel has to meet several sets of requirements, issued by both the classification society and the local authorities. These requirements need to be fulfilled to guarantee that an ‘estuary’ vessel is able to resist the additional loads (bending moments, shear forces, torsion moments, accelerations, ...) acting on the ship due to the more severe wave climate at sea, and to ensure that the wave induced motions will not result into undesired events such as flooding of the holds, excessive overtaking of water on the decks, slamming,... The different sets of requirements lead to restrictions concerning the loading conditions of the vessels, expressed in (both upper and lower) limits for the draft of the ship, but also accounting for the height of the centre of gravity which influences the stability and, hence, the roll motion.

Obviously, there is no uniformity among the regulations issued by the different local authorities, which makes it difficult to compare the levels of safety achieved by the different regulations. The
The present paper intends to give an overview of and a comparison between the different local regulations, with emphasis on the situation in Zeebrugge and Le Havre.

2 LOCAL REGULATIONS: BELGIUM

2.1 Background

The Belgian coastal ports of Zeebrugge and Ostend are not efficiently connected to the inland waterway network, as they are only accessible for inland vessels of class IV (1350 ton), while long travelling times are required due to passage of bridges and locks. On the other hand, the outer harbour of Zeebrugge is only located at a distance of 16 nautical miles or less than 30 km from the mouth of the Western Scheldt estuary, giving access to the ports of Ghent and Antwerp and to the Belgian and European inland waterway network. Even before the major expansion of the port in the 1970s, inland vessels of the so-called estuarine type were allowed to cover the stretch between Flushing and Zeebrugge; these vessels had to fulfil a number of technical requirements concerning structural strength and freeboard, as described in a service rule issued by the Belgian Shipping Inspectorate in 1962. This practice was only allowed in favourable weather conditions, characterized by a significant wave height less than 1.2 m (or 5 Beaufort wind force), which implies a downtime of about 16%. Nevertheless, this estuarine traffic was particularly of importance for Antwerp based bunkering companies who could serve their clients in Zeebrugge by inland bunkering tankers in this way.

The spectacular growth of Zeebrugge as a container and ro-ro port required alternative hinterland connections. Estuarine traffic could only make a significant contribution if the 1.2 m limit for the significant wave height could be overcome. In the first decade of the 21st century, the Belgian Maritime Inspectorate granted several certificates to inland tankers, container carriers and car carriers for operation between Zeebrugge and the Western Scheldt in significant wave heights up to a limiting value between 1.6 m and 1.9 m. Initially, certification was taken into consideration on an individual base, in close consultation with classification societies, until in March 2007 the Royal Decree concerning inland vessels also used for non-international sea voyages (Belgisch Staatsblad / Moniteur Belge, 2007) entered into force, supplying a set of regulations and criteria.

2.2 Royal Decree (March 2007)

The scope of this decree is restricted to fully certified inland waterway vessels transporting cargo on non-international voyages and going out to sea in a restricted area between the Scheldt estuary and the ports on the Belgian coast under verifiable restrictions regarding wave conditions, freeboard, speed and loading condition. These restrictions are annotated in the Supplementary Community inland navigation certificate of the vessel. This annotated certificate, delivered by the Belgian inspection body for inland navigation, has a validity of five years and is subject to a yearly survey. It is mandatory to register the vessel with an approved organisation: it must be classified, for the hull and the machine installations, in the highest class of its category. The vessel needs full ADNR certification (Regulation for the carriage of dangerous substances on the Rhine) and the competence of the crew will have to be supplemented with specific STCW-certification.

The list of supplementary requirements to be fulfilled for ensuring the vessel’s conditional seaworthiness is given in Annex I to the Royal Decree, and comprises:

- full compliance with MARPOL, COLREG and the European marine equipment directive;
- restrictions with regard to the probability of slamming, water intake, roll, bending moment, torsional moment and accelerations, to be demonstrated through a risk analysis. The latter is not required for vessels with watertight steel hatch covers or with a watertight deck operating in significant wave heights of 1.2 m or less, although these vessels have to fulfil a number of additional requirements with respect to freeboard, sheer and height of hatch covers, allowing ships complying with the 1962 service rule to continue their operations;
- stability requirements, which for ships operating in significant wave heights over 1.2 m are almost identical to the Code on intact stability for all types of ships covered by IMO instruments, including the Severe wind and rolling criterion, and the necessity of a heeling experiment;
- supplementary requirements on fire safety, stability, freeboard, container stowage, structural strength, draft scales, manoeuvrability, navigation aids, communication equipment, propulsion, bilge pumps, electrical installations, fire fighting equipment, anchor equipment, personal life saving equipment, bulwarks and railings.

The Royal Decree (Annex II) also formulates requirements concerning the procedure the captain has to follow for deciding whether or not to start a sea voyage, based on actual meteorological observations and forecasts.
2.3 Seakeeping criteria

As mentioned in 2.2, the Royal Decree formulates a number of restrictions with regard to the probability of undesired events during the sea voyage. Probability calculations must be based on the assumption that the vessel performs 300 round trips on a yearly base and a ship’s lifetime of 20 years. The following upper limits are prescribed:

- The probability of emergence of the most forward point of the ship’s keel must not exceed once a year.
- The probability that the water reaches the fore deck or the top of watertight bulwarks (which must extend at least 7% of the LPP aft of the fore perpendicular) on the forecastle must not exceed once in a lifetime. An allowance must be taken into account for the height of the bow wave and the dynamic piling-up due to diffraction and radiation.
- The probability that the water level reaches a reference level at the ship’s sides must not exceed once in a lifetime. The location of this reference level depends on the type of ship (making a distinction between ships with watertight steel hatches, with open hatches, and with a continuous watertight deck); for ships with open hatches, the reference level is defined as the lowest of either a point located at a safety distance under the top of the hatch covers, being 20% of the height of the latter above the waterline, or a point located 0.90 m above the deck at side.
- The probability that the water level reaches the aft deck or the top of watertight bulwarks (which must extend at least 7% of the LPP fore of the aft perpendicular) on the aft deck must not exceed once in a lifetime.
- The probability that the roll angle exceeds 2/3 of either the angle of flooding, or the angle corresponding with the maximum of the stability curve, or 15 degrees, must not exceed once in a lifetime.
- A calculation is required of the values for the vertical longitudinal bending moment, the torsional moment and accelerations of selected points occurring once in a lifetime.

2.4 Fleet

The present fleet of inland vessels that are allowed to perform sea voyages between the Western Scheldt and the Belgian coast consists of four container vessels (Amberes, Deseo, Euroports, Tripoli), two car carriers (Waterways 1, Waterways 3), one multipurpose barge for cars, containers and high and heavy cargo (Polybotes, formerly Waterways 2) and nine (bunkering) tankers. Six of these tankers are certified to navigate in seaways with a significant wave height exceeding 1.20 m (Breitling, Montana, Mozart, New York, Tanzanite, Texas).

3 LOCAL REGULATIONS: FRANCE

3.1 Background

Since 2006, the container terminal Port 2000 is in operation in the port of Le Havre, with 4000 m of quay wall able to host ultra large container carriers with a draft up to 17 m. As there is no direct connection with the inland waterways system, feeder activity is only possible through maritime traffic or so-called fluvio-maritime vessels. Two routes can be followed (see Figure 1): the northern route (accès nord) connecting the entrance to Port 2000 with the western entrance to the avant-port of Le Havre which is connected to the River Seine by means of the Canal de Tancarville, and the southern route (accès sud), connecting Port 2000 directly with the Seine estuary. While the distance at sea is only about 2 nautical miles for a vessel making use of the northern access, the southern access involves a voyage of about 20 nautical miles in open sea.

Figure 1: Northern (red) and southern (green) connection between Port 2000 and the River Seine.

3.2 Legislation: northern access to Port 2000

The present legal frame for fluvio-maritime traffic is determined by a number of documents. For vessels making use of the north access, the Arrêté du 10 janvier 2007 relatif à la navigation de bateaux fluviaux en mer pour la desserte de Port 2000 (French Decree of 10 January 2007 with respect to the navigation of inland vessels at sea for the access to Port 2000), modified on 6 April 2012, specifies that no navigation is allowed if one of the following conditions is not fulfilled:

- The significant wave height, as observed by a local wave buoy, must be less than 1.20 m;
- The maximum wind speed must not exceed 21 knots;
• The visibility from the vessel must be at least 2 nautical miles.

The required hydro-meteo data are available through the harbour authorities (information system SIMBAD).

The north access can only be used by self-propelled barges constructed after January 1st, 1997, disposing of RVBR and ADNR certificates, with double hull equipped and reinforced to carry containers. The vessel must be classified by a classification society as at least equivalent to Bureau Veritas \( 5 {\text{IN}}(1,2) \) Z.

The freeboard of the vessel must always be greater than 1 m, with a safety distance (i.e. vertical distance between the waterline and the lowest point of the vessel which is not watertight) of at least 1.5 m. However, these values can be reduced with maximum 0.2 m in case this is proved to be safe by means of a risk study. The latter has to be performed by means of either seakeeping tests with a ship model or a numerical analysis with approved software. These tests or calculations must be performed in long-crested, irregular waves with a significant wave height of 1.20 m at the most unfavourable zero-crossing period. Following wave directions have to be considered: following seas (0 deg), quarter following seas (45/315 deg), beam seas (90/270 deg), quarter head waves (135/225 deg), head waves (180 deg). Maximum sustained speed must be applied in (quarter) head seas, minimum manoeuvring speed in (quarter) following seas, and zero speed in beam waves. The test duration is at least one hour, and the probability of water ingress during each test must be less than 50%. The vertical distance of the centre of gravity above the keel has to coincide with the most likely value during exploitation; if this value is subject to important variations, several values must be taken into consideration. It is worth mentioning that the description of the model test conditions is based on the Interim guidelines for open-top containerships issued by IMO (1994), which requires tests to be conducted in waves with a significant wave height of 8.5 m to determine the maximum hourly rate of ingress of green water likely to be shipped into each cargo hold.

For intact stability criteria, reference is made to Division 211, the French regulation which – at least with respect to stability – reflects the IMO code; however, the weather criterion does not need to be met. If the criterion for the flooding angle is not met (i.e. if the latter is less than 30 deg), alternative criteria concerning the area under the stability curve and the maximum of the stability curve are valid. The flooding angle must not be less than 17 deg.

3.3 Legislation: southern access to Port 2000

Navigation of inland vessels between Port 2000 and the river Seine by the southern access was made possible by the Arrêté du 30 août 2007 relatif à la navigation de bateaux fluviaux "porte-conteneurs" en mer pour la desserte de Port 2000 par l’estuaire de la Seine. This Decree refers to Division 229 (Navaire de charge de jauge brute égale ou supérieure à 500 effectuant une navigation nationale en 4e ou en 5e catégorie), which is the French regulation for (maritime) cargo vessels operated in sheltered maritime stretches. Navigation in 4th category is characterized by a maximum distance of 5 nautical miles from the sheltered waters in which the port of departure is located, while ships operating in navigation of 5th category do not leave sheltered waters such as lakes and docks.

Unlike the Decree of 10 January 2007 for the north access to Port 2000, the Decree of 30 August 2007 does not provide quantitative criteria with respect to the determination of the required freeboard or safety distance. Division 229 refers to the International Load Line Convention (IMO, 1966), but gives the authorities the opportunity to grant exemptions to take account of the significant wave height in the zones where the vessel will operate. Consequently, the authorities have to give an additional indication with respect to the wave conditions to be considered which, similar to the legislation for the north access, can be formulated in terms of a maximum significant wave height value (e.g. 2.0 m).

3.4 Fleet

According to VNF (2013), two operators offer river-sea transportation services making use of the northern access to Port 2000, by means of five inland vessels (Smack, Arc-en-ciel, Oural, Bosphore, Euroports). The southern access route is used by a third operator by means of the sea-going vessel Serenada.

4 OTHER REGULATIONS

4.1 Classification societies

The local regulations referred to in Sections 2 and 3 require that inland vessels used for sea-river traffic have to be registered with a classification society. In the rules and regulations of most classification societies, notations are foreseen to indicate the range of navigation.
Lloyd’s Register (LR) deals with inland vessels operating in more severe stretches in another way. A zone notation can be assigned to an inland navigation vessel designed, modified or arranged to operate in Zones 1 and/or 2, defined as zones where the maximum significant wave height based on long-term statistics, excluding the highest 5% of the observed waves, does not exceed 1.6 m or 1.0 m, respectively. An inland vessel without zone notation can operate in Zone 3, characterised in a similar way by a significant wave height of 0.5 m.

The class regulations that have the most important impact on design and operation of sea-river ships are concerned with strength and stability.

Except for class notation IN(0) or navigation in Zone 3, an additional vertical wave bending moment and shear force has to be taken into consideration depending on the maximum significant wave height to be expected during navigation, leading to scantlings adapted to the navigation range.

The LR Rules for inland vessels do not cover stability issues. Stability regulations for inland vessels, as issued by BV and GL, in general require a minimum area under the righting lever curve of 0.024 m rad up to the flooding angle or 27 deg, a righting lever (GZ) of not less than 0.10 m in that area, and a minimum GM value of 0.10 m. However, additional requirements are formulated for container vessels, making a distinction between non-secured and secured containers. In the case of non-secured containers, GM shall not be less than 1.00 m; the joint action of wind, centrifugal forces due to turning and free surfaces must not result into a heel angle greater than 5 deg or into deck immersion; and a maximum value for the height KG of the centre of gravity above the keel is prescribed. These criteria are somewhat released in the case of secured containers: GM must be at least 0.50 m; wind, centrifugal forces and free surface effects shall not result into immersion of hull openings, and KG_max is formulated in a different way. Class notation IN(x) affects the stability criteria through the estimation of the wind effects, as the specific wind pressure to be used in the calculations is a function of the significant wave height \( x \): while for \( x = 0 \) and 0.6, 0.25 kN/m² is taken for this pressure, this value varies between 0.30 and 0.39 kN/m² for x-values between 1.2 and 2, expressing the more exposed character of the navigation areas.

4.2 Economic Commission for Europe (ECE)

4.2.1 Introduction

The recommendations formulated by the United Nations Economic Commission for Europe are intended to facilitate the recognition of ship’s certificates through standardization of technical requirements for inland navigation vessels. The text is not a substitute for national laws and regulations. Actually, sea-river navigation is not covered, as the recommendations apply to vessels intended to navigate in European inland waterways, classified as Zone 1, 2 and 3. These zones are differentiated by the maximum significant wave height corresponding to a 5% probability of overtopping. However, caution is in order for the definition of “significant wave height” in the ECE recommendations: “the average of heights of 10% of the total number of waves having the greater heights measured between wave trough and wave crest, observed over a short period”, for which commonly the notation \( H_{1/10} \) is used. This definition for the significant wave height is rather unusual (and therefore confusing), as most commonly \( H_{1/3} \) is considered in this respect. Assuming that the wave height population follows a Rayleigh distribution, \( H_{1/10} = 1.27 H_{1/3} \), which implies that the boundaries for the navigation zones defined by ECE are given by the following values:

- Zone 1: \( H_{1/10} < 2.0 \) m; \( H_{1/3} < 1.57 \) m
- Zone 2: \( H_{1/10} < 1.2 \) m; \( H_{1/3} < 0.94 \) m
- Zone 3: \( H_{1/10} < 0.6 \) m; \( H_{1/3} < 0.47 \) m

which approximately coincides with the navigation zones defined in the rules of Lloyd’s Register.

Although these recommendations do not cover navigation of inland vessels in maritime waters, the way ECE takes increased wave height into consideration could be of interest.
4.2.2 Freeboard

ECE recommends minimum values for the freeboard as a function of ship type, ship length and navigation zone. For ships over 80 m of length, this minimum value is, for:

- decked vessels: 0.57 m in zone 1, 0.34 m in zone 2;
- tankers: 0.42 m in zone 1, 0.22 m in zone 2;
- open vessels: 1.00 m in zone 1, 0.60 m in zone 2. Furthermore, the sum of the freeboard and the height of coamings must not be less than 1.20 m for zone 1, and 1.00 m for zone 2.

4.2.3 Stability

Concerning stability requirements, ECE recommends a set of general requirements: the initial metacentric height must be positive and the vessel must satisfy weather criteria. Furthermore, specific criteria are suggested for different types of vessel.

The proposed weather criterion is generally formulated as $M_{perm} \geq M_{req}$: the permissible moment produced by the dynamic inclinations of the vessels corresponding to the critical angle or the capsizing angle has to be greater than the heeling moment resulting from the dynamic pressure of wind. For navigation zones 2 and 3, the dynamic wind pressure depends on the vertical position of the centre of gravity of the lateral wind area above the waterline, and covers a range of $0.232 - 0.388$ kN/m² for zone 2, and $0.178 - 0.302$ kN/m² for zone 3.

For navigation in zone 1, supplementary requirements are recommended. The heeling moment resulting from the dynamic pressure of wind shall be calculated as for zone 2, but the permissible heeling moment must take account of a roll angle opposite to the wind action. The magnitude of this roll angle is expressed as a function of geometric parameters (beam, beam/draft, displacement), GM and KG. However, the presence of bilge keels – not common for inland vessels, but recommended for sea-river operations – is not accounted for.

ECE also formulates additional stability requirements for container carriers, making a distinction between fixed and non-fixed containers. However, for navigation in zone 1, container cargo must be fixed according to ECE. For fixed containers, the requirements are similar to the BV criteria for container carriers, although different values for the dynamic wind pressure are considered.

4.2.4 Special provisions for river-sea navigation

In 2011, amendments were adopted by ECE Working Party on Inland Water Transport decided to add a new chapter 20B on special provisions applicable to river-sea navigation vessels.

By these amendments, the following zones and conditions of sea navigation have been established:

- Restricted zone between ports of the same country (domestic voyages) where inland navigation vessels are allowed to navigate with season and wave height restrictions provided that specific requirements of the Administration or a recognized classification society concerning seaworthiness, stability, hull structure, machinery, electrical equipment and communication facilities are met.
- Zones RS 2.0, RS 3.0, RS 3.5 (wave height up to 2.0 m, 3.0 m, 3.5 m, respectively): sea areas within specified geographical borders where river-sea navigation vessels are allowed to navigate with season restrictions.
- Zones RS 4.5 and 6.0 (wave height up to 4.5 m and 6.0 m, respectively): sea areas where river-sea navigation vessels are allowed to navigate in closed seas away from shelter at a distance up to 100 miles (distance between shelters up to 200 miles); in open seas away from shelter at a distance up to 50 miles (distance between shelters up to 100 miles).

In this new chapter, a “river-sea navigation vessel” is defined as a vessel intended for navigation on inland waterways and suitable for restricted navigation at sea. A distinction is made between international and coastal voyages, an international voyage being a voyage from a port to a country to which international conventions apply to a port outside such country or inverse. Any other voyage is a coastal voyage.

Unfortunately, the definition of “wave height” is not specified. It is only mentioned in a footnote that “In the present Chapter wave height means a wave height of 3 per cent probability”.

The new chapter recommends that river-sea navigation vessels be built under the supervision of a recognized classification society. River-sea navigation vessels involved in international voyages shall be covered by SOLAS (1974) or the International Convention on Load Lines (1966). MARPOL 73, Annex VI of MARPOL 73. For coastal voyages, the vessels involved must carry the certificates (including a sea pollution prevention certificate) required by the laws of their state of registry. Except for navigation in restricted zone,
vessels involved in coastal voyages shall comply with the requirements of a selection of international conventions and IMO instruments.

Strength requirements are left to the classification society, which shall specify for which zone(s) the vessel is fit.

A minimum value for the bow draft of cargo vessels is prescribed. For ships with a length over 60 m, this value is equal to:
- for RS 2.0: 0.9 m
- for RS 3.0: 1.4 m
- for RS 3.5: 1.7 m
- for RS 4.5: 2.2 m
- for RS 6.0: 2.9 m.

With regard to stability requirements, reference is made to the Code on Intact Stability for all types of ships.

5 DISCUSSION

5.1 Seakeeping criteria

In both national legislations considered, the response of the inland vessel to the local wave climate is taken into account as a part of the procedure for granting a certificate to an individual ship for a specified range of operation. Both the Belgian and French decrees make use of a probabilistic approach for limiting the risk of undesired effects due to excessive response to waves. However, a fundamental difference exists between both procedures.

The risk analysis to be executed in the Belgian procedure for certifying inland vessels for traffic between the Western Scheldt and the Belgian coastal ports (Zeebrugge/Ostend/Nieuwpoort) is based on exceedance of acceptable levels on a once-in-a-lifetime base, assuming 300 round trips a year during a 20 years lifetime. The local wave climate is taken into account by exposing the vessel to measured directional spectra registered over a full year. In this way, the effect of the frequency distribution, the directional spreading and the short-crested character of the waves is taken into account. In a given loading condition, it is calculated up to which value for the significant wave height voyages can be carried out without exceeding the acceptable occurrence frequency levels for unwanted events. In this way, the limiting value for Hs is based on the cumulative conditional frequency of occurrence, i.e. the average number of (unwanted) events occurring during an arbitrary round trip, under the condition that no voyage takes place in case the significant wave height exceeds the considered value.

![Figure 2: Example of a plot showing the relation between the actual significant wave height and the (conditional) minimum, maximum and average number of times a given critical level is expected to be exceeded during a round trip, as well as the relation between the maximum allowable significant wave height and the (cumulative) average number of times the critical value is expected to be exceeded during any round trip (PIANC, 2013).](image)

The French legislation for fluvio-maritime vessels to/from Port 2000, on the other hand, is based on the response of the vessel in long-crested wave spectra, with a selection of arbitrary combinations of wave directions with respect to the ship’s heading and ship speeds, a significant wave height equal to the limiting value (1.2 m for the north access, 2.0 m for the south access) and a range of average zero-crossing periods (3 to 8 s).

Actually, both ways of formulating an acceptable probability of exceedance are essentially different. This is illustrated by Fig. 2, which is a graphical representation of the way the limiting significant wave height for a particular criterion is determined according to the Belgian Royal Decree. The dashed black curves show the maximum and minimum values of the expected number of exceedances of the considered criterion during one return trip as a result of individual measured spectra. This figure illustrates that the significant wave height is an important parameter, but not the only one: for instance, a spectrum with a significant wave height of 1.8 m may, for the considered example, result in a probability of exceedance between about $3 \times 10^{-4}$ and $1 \times 10^{-1}$; the average number of exceedances over all observed spectra with a significant wave height between 1.79 m and 1.80 m is about $2 \times 10^{-2}$, as indicated by the solid black line. The limiting significant wave height, however, is determined by means of the red curve, i.e. the cumulative average number of exceedances per round trip, under the
condition that this trip can only take place if the significant wave height is less or equal to the value indicated by the abscissa. For events that are accepted to occur only once in a lifetime or once a year, a cumulative average of 1/6000 or 1/300, respectively, results into the limiting significant wave height (for the case in Figure 2: 1.8 m and 2.2 m, respectively).

Up to a certain extent, it can be stated that the French legislation is based on the “conditional maximum” line: for all individual cases considered, the conditional probability of exceedance shall be not greater than 0.5 for incident waves with the limiting value for the significant wave height. This implies that the French approach tends to limit the risk for each individual (hour of) voyage, while the Belgian legislation considers the risk over the vessel’s expected lifetime.

Another difference between the French and Belgian approaches, as already mentioned, concerns the selection of sea-states: a limited number of long-crested theoretical spectra (with main parameters based on local observations) versus a comprehensive set of observed directional spectra. Finally, the Belgian legislation only accounts for the seakeeping behaviour of the vessel along the considered route at cruising speed, while the French decree also considers minimum manoeuvring speed and zero speed.

In spite of these important differences, calculations for individual existing ships have demonstrated that there are only minor differences between the limiting significant wave height values resulting from both approaches. On the other hand, vessels optimised for operation under each legislation may still look rather different, due to the fact that safety margins are formulated more explicitly in the Belgian legislation.

5.2 Stability criteria

Stability criteria are incorporated in both national legislations considered, as well as in some of the classification regulations. Also the ECE formulates recommendations for inland vessels navigating in zones 1 and 2, though not meant to be applied to sea-river navigation. However, considerable differences between the criteria can be noticed.

The requirements mentioned in the Belgian Royal Decree are very strict, as they are a copy of the IMO code for sea-going vessels; as a result, it is practically impossible to meet these criteria. In practice, exemption is granted based on adapted, more realistic criteria, often inspired by class regulations and making use of the results of the seakeeping calculations. However, an adaptation of the stability criteria to more realistic requirements is most desirable.

The French decree for the northern access to Port 2000 contains adapted stability requirements, adapted to the reduced significant wave height in which the vessels operate (1.2 m). For the southern access, it is less clear which stability criteria are applicable.

Although recent ECE amendments have recognised that separate regulations for sea-river traffic should be developed, mostly reference is made to either regulations issued by national administrations (for sea-river traffic in restricted areas) or IMO conventions (for coastal or international voyages). The ECE recommendations for navigation zones 1, 2 and 3 are more comprehensive, but are not directly applicable, not only because of the limited significant wave height, but also because some specific characteristics of sea-river vessels (e.g. the roll damping effect of bilge keels) are not taken into account.

The mutual differences make it difficult to move towards a harmonisation of the stability criteria. These differences are related to characteristics of the stability curve (areas to critical angles), minimum values for characteristic angles and the flooding angle, roll amplitudes and wind pressures used in weather criteria. Especially for restricted, specified zones it seems recommendable to make use of local meteorological data and the results of the seakeeping calculations.

5.3 Minimum draft

The Belgian legislation also requires a minimum draft at the fore perpendicular, in order to avoid slamming, as the hull structure of an inland vessel is not designed for this type of loads. The value for this draft fore results from the risk analysis; typically, values of 2 – 2.5 m are found for limiting Hs-values of 1.6 – 1.9 m. While the French regulations do not mention this topic, recommendations for a minimum draft are also formulated in the ECE provisions for sea-river navigation. As the definition of “wave height” in the latter is not clear, it is hard to compare the values mentioned before with the ECE recommended values, but the values for the lower RS classes (0.9 m – 1.7 m for RS 2.0 – RS 3.5) seem rather low.
REMARKS – RECOMMENDATIONS

Sea-river traffic has proved to be a reliable link for ports as Zeebrugge and Le Havre. In Zeebrugge, so-called estuarine traffic has a long tradition for low sea states (up to significant wave heights of 1.2 m); since 2005, the limiting Hs-value has been increased up to 2.0 m.

The existence of clear regulations is very important for all parties: authorities, classification societies, ship owners, ship designers, operators. Most existing regulations are based on the local conditions, but are often also inspired on international maritime regulations. In some cases, this leads to contradictions which require an ad hoc solution.

As sea-river traffic has per definition a local character, the local hydro-meteo and shipping traffic conditions have to be taken as a starting point for setting up regulations and criteria. As a consequence, the availability of a dense and reliable hydro-meteo measuring and forecasting network is essential in the development of sea-river traffic. However, the formulation of requirements can be based on general principles, such as reducing the probability of undesired events (slamming, shipping of water ...) and ensuring sufficient stability. In this way, the development of a general framework for assessing the ship’s response to local wind and waves in the specific local conditions is of importance to stimulate this specific type of shipping traffic.

REFERENCES


