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The use of advanced materials for the construction on river cruise vessels according to the latest technical requirements for inland waterway vessels in the European Union

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Abstract: In 2015, the Central Commission for the Navigation of the Rhine (CCNR) created at its plenary session the European committee for drawing up common standards in the field of inland navigation (Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure – CESNI). The mission of the new body is to prepare and adopt technical standards in a variety of fields on inland navigation, and unify their standards for all EU countries.

26th November 2015 CESNI adopted the first resolution – European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN). The document adopts in a standardised way the requirements contained in directive 2006/87/EC and in the Rhine Vessel Inspection Regulations. At the moment, ES-TRIN is not binding per se, by the time it will be referred in legal frameworks EU Member States.

For this paper, the most important chapters of Directive 2006/87/EC and ES-TRIN concern engine design (chapter 8) and emissions of gaseous and particulate pollutants from diesel engines. It is worth to say that both documents has got the same regulations.

Introduction

Referred to the Directive of the European Parliament and the Council of 12 December 2006 laying down technical requirements for inland waterway vessel and repealing Council Directive 82/714/EEC (2006/87/EC), the ENI number can only be issued to:

- vessels having a length (L) of 20 metres or more; and
- vessels for which the product of length (L), breadth (B), and draught (T) is a volume of 100 m³ or more.

This Directive shall also apply, in accordance with Article 1.01 of Annex II, to all of the following crafts:

- tugs and pushers intended for towing or pushing a craft referred to in paragraph 1 or floating equipment, or for moving such a craft or floating equipment alongside;
- vessels intended for passenger transport which carry more than 12 passengers in addition to the crew; and
- floating equipment.

In 2006, an EC Directive laid down the technical requirements for inland waterway vessels, and this introduced full harmonisation of the technical requirements for inland waterway vessels and Rhine regulatory provisions. On the basis of this equivalence, the CCNR has recognised the validity of Community certificates on the Rhine. The requirements are the strictest and technically most advanced. Its flexibility can be seen from the range of implementation options:

1. Transitory provisions, so as to take account of the vested rights of older vessels.
2. Temporary 3-year provisions: before adopting a new technical rule, the CCNR may test it out for 3 years, following which the provision will be abandoned or definitively adopted.
3. Waivers: vessel operators may request the use of technology other than that laid down by regulation if it can provide comparable guarantees. The use of alternative technologies as a result of the waivers may thus open the door to regulatory amendments.

Every vessel navigating on the Rhine must have a vessel certificate issued after the boat has been examined by an inspection commission. Any Rhine craft can apply for a vessel certificate from any inspection commission, regardless of the relevant nationality.

1. CCNR

Central Commission for the Navigation of the Rhine is the oldest international organisation in modern history. Dating back to the Congress of Vienna (1815), the Central Commission is an up-to-date international institution with an administration that enables it to address effectively all the issues concerning inland navigation.



Fig. 1. Headquarters of Central Commission for Navigation of the Rhine in Strasbourg

Source: retrieved from <http://www.ccr-zkr.org> (on the left); CESNI Experts – photo by W. Ignalewski (on the right).

The CCNR created Observer State status in order to encourage the participation of the States not included in its activities. Eleven States currently have Observer status at the CCNR (Austria, Bulgaria, the Grand-Duchy of Luxembourg, Hungary, the Slovak Republic, the Czech Republic, Romania, the United Kingdom, Ukraine, Poland, and the Republic of Serbia).

With respect to the technical requirements for vessels used in inland navigation, the CCNR and the EU have adopted identical regulations and have agreed to mutually recognize their vessel certificates. For the purpose of ensuring identical requirements as well as a common safety policy in the long term, a Joint Working Group (JWG) has been established with the mandate of preparing proposals for amending the technical requirements.

2. Activities

During the almost two centuries of its existence, the CCNR has achieved these objectives in a number of directions:

- activity of regulating navigation on rivers,
- maintenance of good conditions for navigation on the Rhine,
- promotion of ecological inland navigation,
- development of the law of inland navigation,
- coordination of national regulations regarding the social protection of boatmen, and
- economic issues.

3. Committees

The plenary meeting's resolutions are prepared by committees and working parties (Articles 17 to 25 of the Rules of Procedure). These play a key role in the work of the Central Commission. There are about ten committees:

- the Budget Committee,
- the Administrative Sub-Committee,
- the Preparatory Committee,
- the Economic Committee,
- the River Law Committee,
- the Police Regulations Committee,
- the Inspection Regulations Committee,
- the Dangerous Substances Committee,
- the Committee for the Elimination of Waste and Environment-related Issues concerning Navigation on the Rhine,
- the Standing Technical Committee,
- the Committee on Social Issues, Employment and Professional Training, and
- the Management Committee for Market Observation.

The CCNR also has regular contact with OECD's International Transport Forum, and more occasional contact with intergovernmental Organization for International Carriage by Rail (OTIF) and United Nations Environment Programme (UNEP).

Protection in the context of working practices and every-day operations include:

- a) reducing emissions of harmful exhaust fumes,
- b) reducing carbon gas emissions, and
- c) handling of waste generated on board vessels.

Fibre Reinforced Plastics (FRP), also known as Glass Reinforced Plastics (GRP),⁽¹⁾ is a modern composite material of construction for chemical plant equipment like tanks and vessels. Chemical equipment that range in size from less than a metre to 20 metres are fabricated using FRP as the material of construction. FRP Chemical Equipments are manufactured mainly by Hand Lay-up and filament winding processes. FRP are used for the construction of Superstructures on River Cruise Vessels.

SAERTEX GmbH were analysed for the use of FRP in inland vessels:

- a) River cruise vessels built with conventional design.
 - Length: 110 m – 135 m, Draught: 1.08 m – 1.60 m,
 - Due to the draught, the vessels can be used only seasonally.
- b) “Concept for innovative river cruise vessels:”
 - facing new operating areas,
 - reduction of energy consumption and pollutant emissions,
 - extension of period of operation to shallow waters, with draught of 0.85 m – 1.10 m.

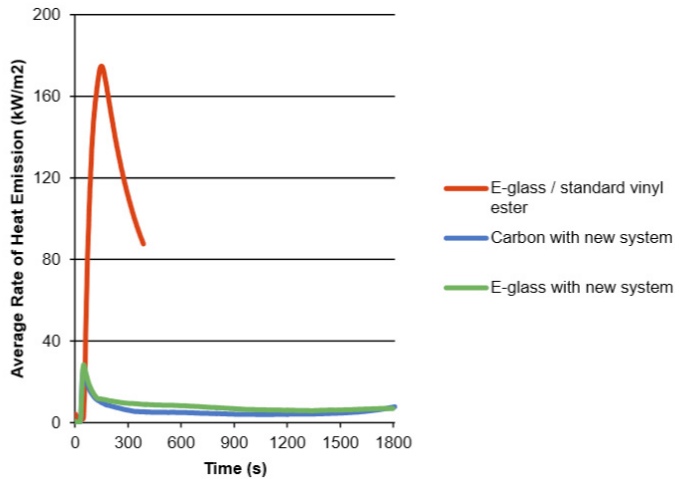


Fig. 2. Rate of Heat Emission

Source: based on Report LEO Saertex by Neptun Werft GmbH&Co.KG (Strasbourg 2014).

- c) How can this be realized? Reduction of lightship weight by:
 - implementation of known lightweight construction,
 - use of innovative materials (e.g., FRP),
 - best possible use of weight reducing measures,
 - use of energy-efficient and low emission systems and plants,
 - implementation of experiences gained with projects handled in research and development.
- d) Use of fibre reinforced plastics is state of the art.
 - FRP has been successfully used for windpower technologies, in aircraft-, road- and rail vehicle construction, as well as in various maritime industries,
 - FRP combines the advantages of extreme lightweight construction with the highest demand of strength properties by targeted utilization and combination of single components FRP can configured optimally to the requested material's properties.
- e) FRP product LEO (lightweight with extreme opportunities supplied by SAERTEX).
 - LEO can be used for innovative river cruise vessels,
 - for the LEO – the strength and fire resistance of the sandwich panels can be improved independent of each other,
 - in the event of a fire the material is toxicologically harmless and as to smoke development – uncritical.

LEO is a ready-to-use system for the production of complex composite light weight parts in infusion technology, consisting of:

- protection layer,
- fire retardant infusion resin, and
- multiaxial non-crimp-fabrics (NCF), specifically modified with fire inhibitor.

4. Reaction-to-fire behaviour

LEO passed established test procedures based on reference laminates, e.g.,

- IMO Res. A 653(16) / MSC Code 61 (67),
- FTP Code 2010 Annex 1 Part 2 (smoke and toxicity),
- FTP Code 2010 Annex 1 Part 5 (low flame spread),
- Cone Calorimeter ISO 5660, and
- NBS Smoke Box ISO 5659.

Table 1. An example of toxicity values

Smoke density (20 min)	DS.	431
Conventional Index of Toxicity (CIT)	4 min	0,0637
Measured values:	CO ₂	1,737 ppm
	CO	117 ppm
	HCN	38 ppm
	HF	0 ppm
	HCl	0 ppm
	HBr	0 ppm
	NO-NO ₂	0 ppm
SO ₂ -H ₂ S	0 ppm	

Source: based on Report LEO Saertex by Neptun Werft GmbH&Co.KG (Strasbourg 2014).

5. Reaction-to-fire test

- LEO was successfully tested according to IMO Res. A 754(18),
- insulation requirements according to IMO Res. MSC 44(65) were fulfilled,
- sandwich test panel 80 x 80 cm, approx. 6 kN/m² area load,
- sandwich test panel without insulation,
- functional integrity of test panel sustained after 60 mins of fire exposure.



Fig. 3. LEO's reaction to fire

Source: based on Report LEO Saertex by Neptun Werft GmbH&Co.KG (Strasbourg 2014).

The proposed solution is to use fiber composite FRP – composite polymer matrix. This allows for a significant reduction in the weight of the unit, reducing the burden of the gym, reduction of pollution missions. The body built using FRP composite is characterized by:

- the loss of weight while maintaining strength requirements, the fulfillment of all standards regarding flammability, toxicity, and the release of harmful substances,
- corrosion resistance,
- very low amount of smoke arising in the case of inflammation,
- replacement of 90 tonnes of steel for 40 tonnes of structures made of composite material, and
- lowering the immersion of 1cm for every 10 tonnes of weight units.

The structured body therefore has two key advantages to the one constructed in a conventional manner:

- lowering the assumed weight of 50 tonnes, and
- the reduction of immersion of 5 cm.

In the case of inland above-mentioned values, they are significant in terms of technical aspects and operational. In the case of the ships of this type, the weight is about 15,000 tonnes. The decrease by 50 tonnes is therefore noticeable. This is also closely connected with fuel consumption. For vessels navigating shallow waters, however, it is immersion that determines the areas in which the unit will be able to move. To reduce the immersion of 5 cm, we can observe an increase in the area of application of such a unit, increasing the number of days in the year when it can do its job. Steel areas – bottom, shell, and bulkhead deck (below red dividing line).

LEO sandwich panels have been investigated and tested in several EU projects:

- BESST – Breakthrough in European Ship and Shipbuilding Technologies,
- CONVINCENCE – Vulnerability Reduction Technologies for Large Maritime Composite Structures, joint European Defence Agency project.

Sun deck including the longitudinal and transverse walls and local deck's stiffenings underneath (above red dividing line).

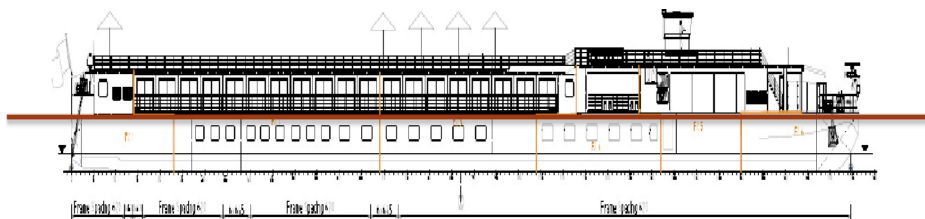


Fig. 4. FRP – areas in Inland Cruiser Vessel

Source: based on Report LEO Saertex by Neptun Werft GmbH&Co.KG (Strasbourg 2014)

Reduction of steel weight by approx. 90 tonnes
 Calculated weight of FRP-structure: approx. 40 tonnes
 Projected weight reduction: approx. 50 tonnes
 Reduction of draught: (approx. 10 t = 1cm): 5 cm

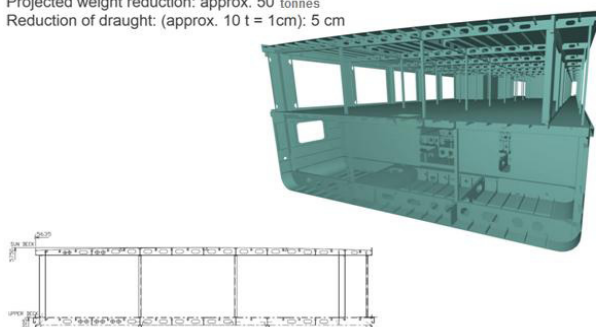


Fig. 5. FRP structure

Source: based on Report LEO Saertex by Neptun Werft GmbH&Co.KG (Strasbourg 2014).

Conclusions

Advanced materials LEO suit perfectly for marine and inland waterway vessel applications:

1. fulfills highest mechanical and strict fire / smoke / toxicity requirements (FST),
2. mechanical and FST parameters can be adjusted independently towards each other depending on individual part requirements,
3. provides high structural integrity even when exposed to fire,
4. extremely low smoke development in case of fire, and
5. non-halogen, non-toxic in case of fire.

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STOSOWANIE ZAAWANSOWANYCH MATERIAŁÓW W KONSTRUKCJACH PASAŻERSKICH STATKÓW ŚRÓDLĄDOWYCH W KONTEKŚCIE NAJNOWSZYCH WYMAGAŃ TECHNICZNYCH UNII EUROPEJSKIEJ

Słowa kluczowe: pasażerskie statki żeglugi śródlądowej, konstrukcja statku, europejskie standardy techniczne

Streszczenie: W 2015 roku Centralna Komisja Żeglugi na Renie powołała na sesji plenarnej europejski komitet ds. sporządzania wspólnych standardów w dziedzinie żeglugi śródlądowej (Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure – CESNI). Misją nowego tworu jest przygotowywanie i wdrażanie szerokiego spektrum standardów technicznych w żegludze śródlądowej, a także ujednolicanie obecnych wymogów we wszystkich państwach Unii Europejskiej. 26 listopada 2015 roku CESNI przyjęła pierwszą rezolucję – Europejska norma ustanawiająca wymagania techniczne dla statków żeglugi śródlądowej (ES-TRIN). Dokument ten przyjmuje w ujednoliconej formie wymagania dyrektywy 2006/87/UE (Dyrektywa Parlamentu Europejskiego i Rady z 12 grudnia 2006 roku ustanawiająca wymagania techniczne dla statków żeglugi śródlądowej i uchylająca dyrektywę Rady 82/714/EWG). Obecnie rezolucja ES-TRIN nie jest sama z siebie obowiązująca, do czasu, aż będzie miała odniesienie do przepisów prawnych państw UE.

Dyrektywa techniczna dopuszcza stosowanie nowoczesnych materiałów w konstrukcjach statków śródlądowych, które stanowią doskonałą alternatywę dla dotychczasowej technologii. Materiały takie jak FRP wpływają na odciążenie konstrukcji, co bezpośrednio przekłada się na obniżenie kosztów eksploatacyjnych statku, zmniejsza emisję szkodliwych substancji do atmosfery oraz w wielu przypadkach wpływa na poprawę bezpieczeństwa podczas wystąpienia sytuacji nadzwyczajnych.

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