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CONSTRUCTION OF THE TEST STAND FOR TESTING THE SEAT BACK OF BOAT AND YACHT ARMCHAIRS BASED ON THE ABYC STANDARDS

Key words: ABYC standards, seat test, boat seat, yacht armchair.

Abstract: Polish standards do not specify the research of yacht and boat armchairs that should be carried out before the introduction of a new armchair construction to the sales market. The only available standard that describes the method of testing boat and yacht armchairs is the "ABYC H-31 – Seat Structures" standard. The tests included in this standard are divided into several types of tests. The tests concern, among others, back and bottom seat tests. The article presents the requirements and methodology of testing the backs of armchairs intended for boats and yachts. The requirements are discussed based on the ABYC-H31 standards. The construction of a test stand for testing armchair backs is also presented. The article also contains exemplary results of the study of the armchair back of one of the prototype solutions of yacht armchair.

Konstrukcja stanowiska do testowania oparć foteli na łodzie i jachty w oparciu o standardy ABYC

Słowa kluczowe: standard ABYC, test siedzenia, siedzenie do łodzi, fotel do jachtu.

Streszczenie: Polskie standardy nie określają badań foteli, które należy przeprowadzić przed wprowadzeniem nowej konstrukcji fotela do jachtów i łodzi na rynek sprzedaży. Jedynym dostępnym, który opisuje sposób badania foteli przeznaczonych do łodzi i jachtów, jest standard „ABYC H-31 – Seat Structures". Badania zawarte w tym standardzie podzielone są na kilka rodzajów testów. Badania dotyczą między innymi testów oparcia oraz siedziska. W artykule przedstawiono wymagania oraz metodykę badań oparć foteli przeznaczonych na łodzie i jachty. Wymagania omówiono w oparciu o standardy ABYC –H31. Przedstawiono także konstrukcję stanowiska badawczego umożliwiającego przeprowadzenie badań oparcia omawianych foteli. Praca zawiera również przykładowe wyniki badań oparcia jednego z prototypowych rozwiązań foteli jachtowych.

Introduction

Seating stands are commonly found in everyday life places and fulfil various functions. They can be used in waiting rooms, parks, restaurants, and offices. These seats are not burdened with strict standards. They must be primarily comfortable and ergonomic, and the only load they carry is due to the weight of the people who sitting on them.

Other requirements are assigned to seats located in various means of transport, where they are not only responsible for comfort, but primarily for safety while traveling. They must not only protect life, but also mitigate the consequences of dangerous accelerations during accidents. Therefore, it is necessary to model these events and test the seats for safety reasons.

Depending on the type of transport means, there are different standards and regulations of seat tests. Seats mounted in cars are subject to tests during their approval. The main test procedures and requirements are described in Regulations Nos. 14 and 17 of the United Nations Economic Commission for Europe (UNECE) [1, 2]. Strength and displacement under belt anchoring, seat back construction, and headrest are subject to testing. The ability to absorb the impact energy through the seat components is also verified. The standards include dynamic tests and equivalent static tests. Due to overloads occurring during car accidents, the values of forces applied to the seat structure during certification tests can be as high as 33 kN. In addition to the durability, car seats must meet a number of geometrical and ergonomic requirements [3, 4].

Seats used in the railways are subject to the standards of International Union of Railways UIC. UIC 566 and 567 [5, 6] refer to the loads of passenger coach and their equipment. These standards present methods of calculating forces and the place of their application to the elements of the seat bottoms, seat backs, headrests, armrests, and handles for standing or walking passengers. The values of forces used for testing railway seats are much smaller than in the case of cars and amount to 1.5 kN. Geometric and ergonomic requirements are discussed in detail. UIC standards require non-flammable seats, which results in the need to choose the right materials.

Polish standards do not determine the seat tests that should be carried out before homologation of a new chair construction for use on boats or yachts. The only available standard that describes the method of testing armchairs is ABYC H-31 – Seat Structures [7]. ABYC (American Boat & Yacht Council) is the member organization that develops voluntary global safety standards for the design, construction, maintenance, and repair of recreational boats. The seat tests described in this standard are divided into two types of tests. First of these describes the research method of seat back. The second one concerns the mechanical strength method of seat bottom.

The topic of seats in means of water transport was also taken in paper [8], where the shape of the seat was optimized. Boat chairs are not exposed to the impact of high acceleration, because it is intended to be mounted in sailing boats. It results directly from the dynamics of the target object. The design has focused on comfort of traveling, because the position of the helmsman during the cruise is almost always enforced. It depends mainly on the tilting of the boat due to the impact of waves and gusts of wind. The result of the work was to design a round shape of the boat seat. The result of the described considerations was based on the original model presented in the article. It was not taken from any standard or directive.

An example of a test stand for seats intended to boats and yachts has been presented in the article [9]. Its main elements are two columns being linear bearings. Between them is mounted a mobile structure on which the seat is placed. Research using the human phantom relied on free dropping of the structure with the manikin while measuring the acceleration as a function of time. The described tests are not performed to determine the stiffness of backrests or seats. They have to determine its ability to vibration damping, which it's a natural frequency and does not exceed the frequency considered uncomfortable for a human being [10].

This paper includes the classification of seats designed for boats and yachts. It also presents a test stand for boat seating. It should be noted that the presented test stand was designed to meet the requirements of the standard [7]. In the research part of the article exemplary results of prototype of armchair boat are presented.

1. Research object

The object of the study was a seat back of armchair prototype for exclusive yachts and boats. The research was carried out on a station designed and built for this purpose. The research was based on the ABYC H-31 – Seat Structures standard [7].

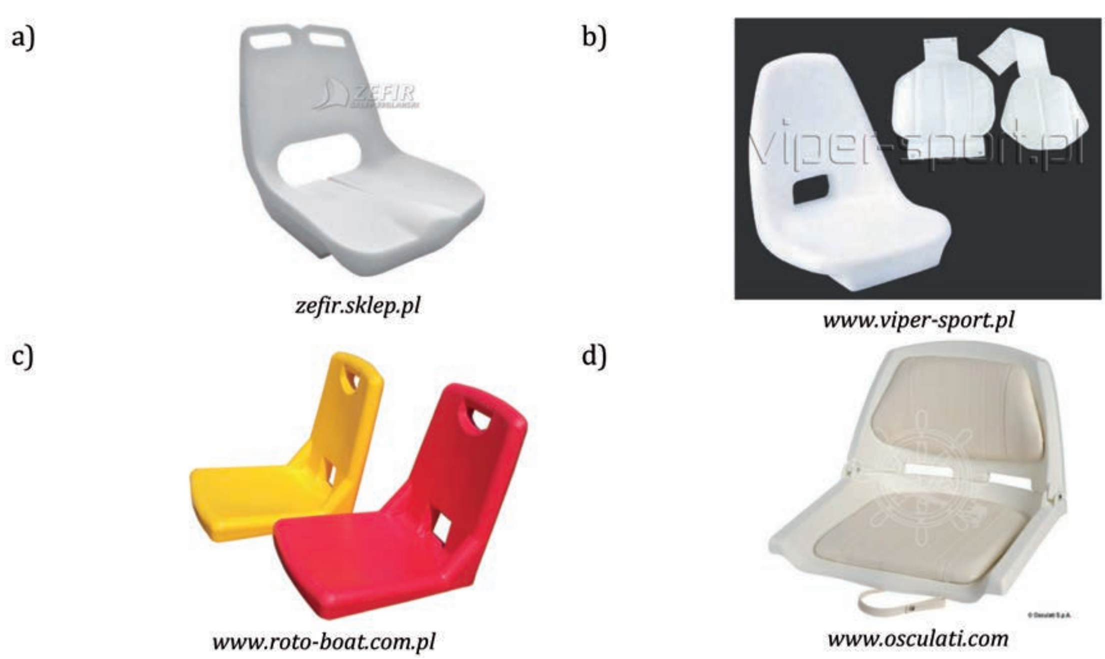

Fig. 1. Examples of standard seats

Armchairs intended for boats and yachts are divided into two groups. The first group are standard low-budget armchairs, while the second group consist of armchairs intended for luxury boats and yachts. Standard armchairs are usually made from PVC plastic (e.g., Fig. 1a,b). There is possibility to buy removable upholstery for some armchairs (e.g., Fig. 1b). This type of armchair is often made from polyethylene (e.g., Fig. 1c,d).

The second group of seats, luxurious armchairs, are becoming more and more popular. They are very often made for individual orders. The customer chooses the type or colour of the material intended for the upholstery and the material from which the bearing structure of the chair is to be made. Usually, luxurious armchairs were made of laminate and stiffened with plywood [11]. Such constructions are still used on the European market. According to the current ABYC standard, certain groups of materials have been eliminated on the American market. Wooden or wood-like elements should be characterized by high resistance to moisture absorption and thus to fungal growth. Steel elements should be made from stainless steel not smaller than 300 series (designation in accordance with the American Standard). In addition to stainless steel [12], the use of aluminium, often powder coated, is also common [13, 14]. Examples of armchairs from the luxury group are shown in Fig. 2.

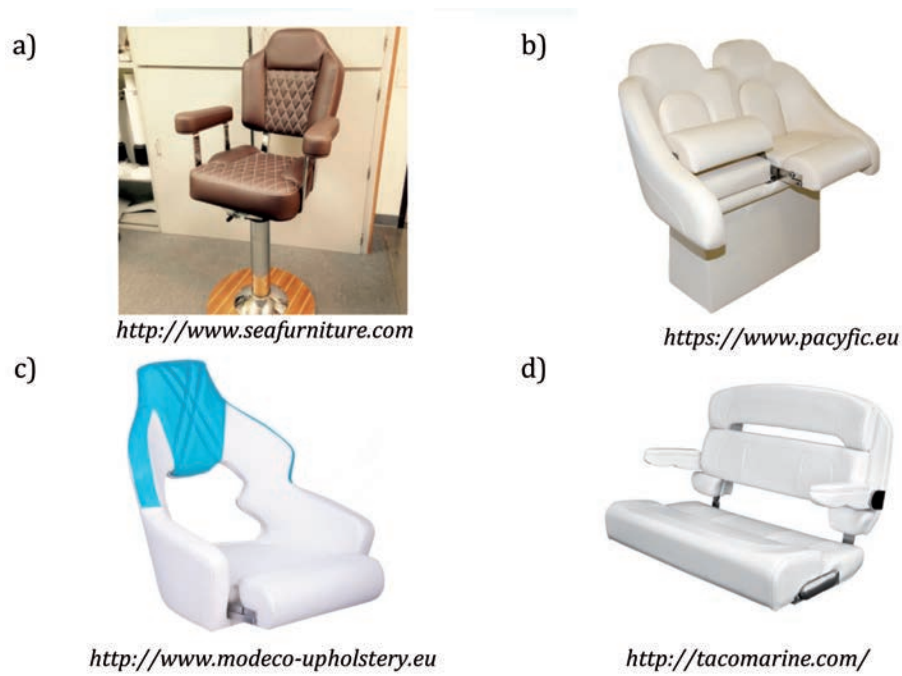

Fig. 2. Examples of armchairs from the luxury group

2. The research program

The research program was based on the standard [7]. This standard divides seats into two types. Type A are seats are intended for boats moving at any speed, and Type B seats are intended for boats not exceeding 5 mph. When it comes to seat back tests, according to standard, these tests are the same for both types of seats.

According the ABYC standard, the static load in the seat pull back test is applied at a height of 16 inches (406.4 mm) from the seat bottoms. If the seat back is less than 16 inches, as would be the case of backless seats such as bar stools and some leaning posts, the load is applied at the highest part of the seat back. The seat pull back test is divided into two stages (Fig. 3):

– F-1 – this stage concerns the first static load applied at 40" (406.4 mm) from the seat bottoms and perpendicular (plus or minus 10 degrees) to seat back. The load of F1 = 668N is applied for 5 minutes. After this time, the seat back should not be tilted to an angle greater than 30°. However, after removing the load, the permanent deformation of the backrest should not exceed 10°.
– F-2 – this stage concerns the second static load applied at 40" from the seat bottoms and perpendicular (plus or minus 10 degrees) to seat back. The load of F2 = 1126 N is applied for the next 5 minutes. After this time, the seat back should not be tilted to an angle greater than 50°. Any damage to the chair during this test, which may endanger the life or health of the person sitting on it, eliminates the possibility of selling a chair.

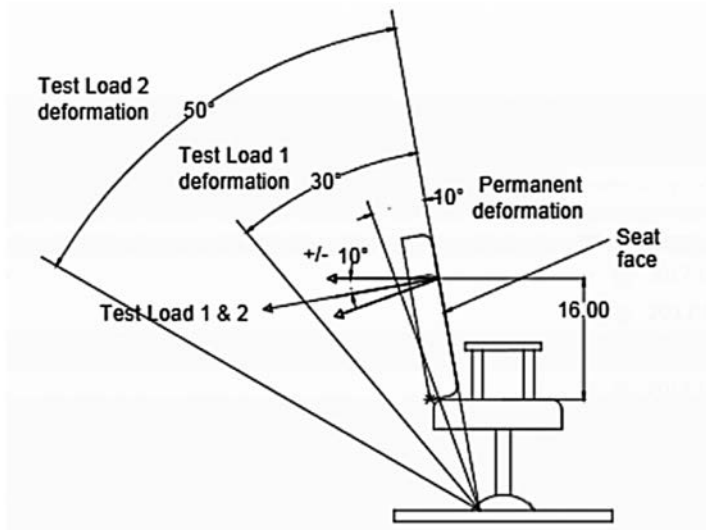

Fig. 3. The seat back testing scheme based on the ABYC standard

The ABYC standard for seat testing also includes a seat bottom test consisting of a dynamic test and a static test. The dynamic test consists of dropping the bag twice with a diameter of 407 mm (± 25.4 mm) and weight of 182 kg on the seat bottom. The bag must be dropped from a height of 305 mm of above the seat bottom. The bag can be filled with grit, sand, or other bulk material. While the static test involves placing on the seat bottom the same bag as in the dynamic test. The result of the test is considered positive when, after five minutes, there will be no damage to the chair, which may endanger the life or health of the person sitting on it.

Standard [7] also includes requirements for testing armrests and footrests. However, due to the scope of the discussed work, the scope of these studies was omitted.

3. Test stand

For the experimental tests of the seat back (F-1 and F-2 tests), a stand was prepared, and a diagram of it is shown in Figure 4. The seat bottom (1) was attached to the rigid base (2) with four screws. To seat back (3), at 406.4 mm, a force gauge (4) was mounted using a ball joint. The other end of the dynamometer was connected via a second ball joint to the piston of the electric linear actuator (5). The actuator was mounted using a bolt connection to the bracket (6). An inductive displacement sensor (8) was mounted on the bracket (7), whose plunger was supported on the back surface of the seat back at a height h. Both brackets (6) and (7) were bolted to a rigid base (2). Data from the force meter and displacement sensor was recorded on the computer (9). The linear actuator was powered by a power supply (10). After applying the force L, the back surface of the seat back assumes a position marked with a dashed line.

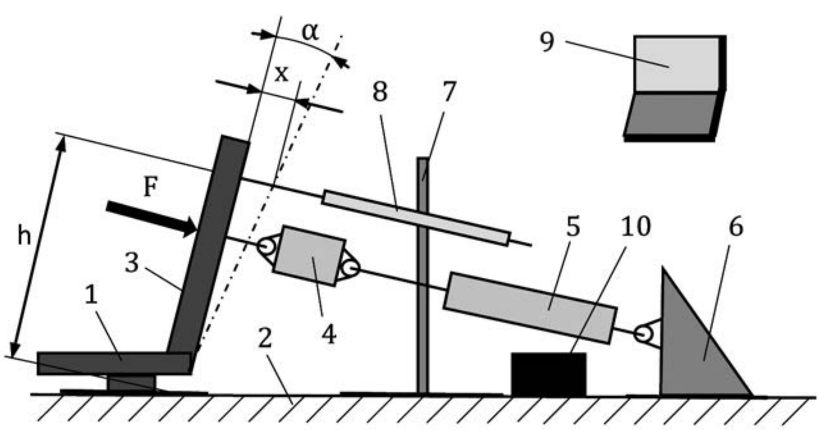

Fig. 4. Diagram of the test stand and the method of measuring the deformation angle of the seat back

On the basis of the measured displacement value x, the angle of deflection of the seat back α, at the force value F, was determined using the following formula:

$$\alpha = a\tan\left(\frac{h}{x}\right) \tag{1}$$

According to the recommendations included in the ABYC standard, the seat was first loaded with F1 ≈ 668N force for 5 min (F-1 test), then it was unloaded. Then, the second test was carried out (test F-2). The seat was loaded with F2 ≈ 1126 N for a further 5 min, and then it was unloaded. The results of the F-1 and F-2 tests are shown in the graph (Fig. 5). Visible force peaks were associated with equalizing forces to the values of F1 and F2.

During the five-minute F-1 test, the seat was loaded with F1 force, and a mean displacement at the measuring point of 2.51 cm was recorded. This corresponds to the value of the deflection angle of the seat back by 2.88 degrees. After unloading, the seat back almost returned to its position before loading the force F1. The average displacement of the seat back after unloading was less than 0.30 cm, which corresponded to the deflection angle 0.35°.

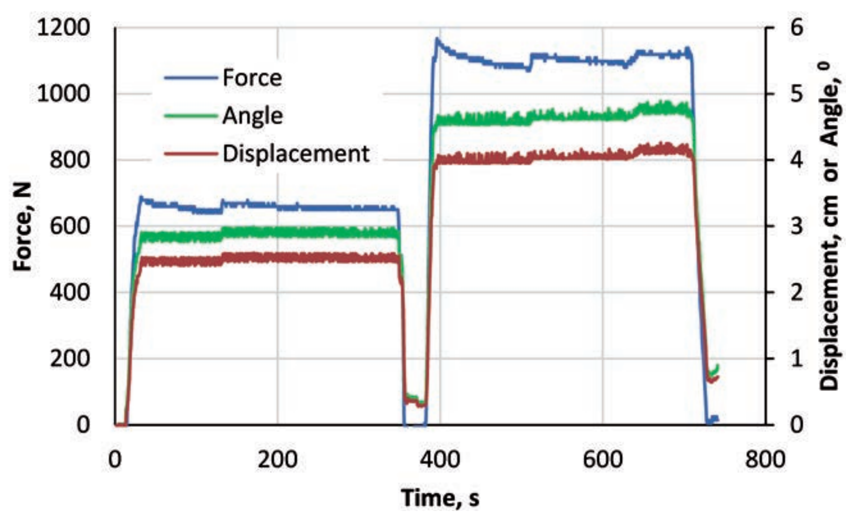

Fig. 5. Graph of force, displacement, and seat back deflection angle during the F-1 and F-2 tests.
Source: Authors

During the five-minute next load of the seat with the force F2, the average recorded displacement of the seat back was 3.98 cm (the maximum value during the test was 4.22 cm). This corresponds to the value of the deflection angle of the seat back by 4.57° (the maximum value during the test was 4.84°). After unloading the back seat, its permanent displacement was recorded at the level of about 0.69 cm. This corresponds to permanent deflection of seat back by 0.79°.

4. The results analysis and summary

The designed and made test stand enables testing the prototype of an armchair intended for boats and yachts according to the ABYC standard. Experimental tests of the armchair prototype were carried out on the made test stand. Table 1 presents the results of the F-1 and F-2 tests, which are relevant for the compliance of the armchair prototype with the ABYC standard.

Table 1. Comparison of the seat back inclination angle results

Test type		The seat back inclination angle, °		Percentage of the experimental inclination angle of the seat back in relation to the maximum value of ABYC $= \frac{Col.\,3}{Col.\,4} * 100\%$
		Experimental test	Limit values in ABYC standard	
1	2	3	4	5
F-1	Load	2.88	30	9.60
	Unload	0.35	10	3.5
F-2	Load	4.57	50	9.14
	Unload	0.79	–	–

The obtained experimental results from the performed F-1 and F-2 tests confirm the compliance of the armchair prototype with the ABYC standard. During the load applied for the F-1 and F-2 tests, the seat back deformation was less than 10% of the deformation acceptable in the AYBC standard. That means that the armchair prototype can be subjected to optimization of geometric and/or material features. In addition, during and after the tests, no damage was discovered that could pose a threat to the health and life of those using these seats.

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