Information Note and Review on Boat Surface Treatment in the Context of Appendix R2 – Bye-laws to Rule 29 – Boats and Equipment

world rowing equipment and technology commission

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1. Summary

This document reviews the topic of boat surface treatment in rowing and explains it in the context of Appendix R2 to Rule 29 on boats and equipment. Its main purpose is to distinguish between normal boat maintenance, which is part of keeping a hull in good condition, and surface treatments that may change the behaviour of water along the hull and could therefore create an unfair advantage. The paper combines basic hydrodynamic principles, laboratory test results and regulatory considerations in order to support a practical and understandable interpretation of the rule.

From a performance point of view, the key message is simple: a rowing boat is fastest when its hull is clean, smooth and free from scratches, deposits or dirt. Water flowing along a rowing boat creates friction, and this friction represents a major part of total resistance. Small surface damage can increase this resistance, while careful cleaning and, where appropriate, mechanical polishing can help restore the boat to its original smooth state. By contrast, ordinary commercial waxes or so-called performance coatings do not appear to create a special hydrodynamic benefit beyond a normal smooth hull.

The laboratory study discussed in this document examined six products that are commonly used in the rowing and marine environment. Two were marketed as coatings or drag-reducing finishers, and four were typical polishing products. The tests did not show any measurable drag reduction for any of the products when compared with a smooth untreated reference surface. However, the study did show that scratched surfaces create more friction and that polishing products can help bring a damaged surface back closer to its original condition. The practical significance is that maintenance can prevent performance loss, but the tested products did not provide evidence of extra speed beyond a properly maintained hull.

For the interpretation of Appendix R2, this leads to a clear distinction. Mechanical polishing or buffing that only removes minor imperfections and restores the original hull surface can be understood as maintenance. Products or treatments that leave behind a foreign substance, coating, lubricant or specially modified surface should be treated differently, because they go beyond restoration and may alter the water flow at the hull surface. The overall conclusion of this note is therefore that athletes and teams should focus on lawful maintenance of the original hull quality, while products claiming performance enhancement should be assessed with caution in light of both the rule and the available scientific evidence.

2. Basics on Fluid Dynamics and Surface Effects in Rowing Boats

2.1. Summary

This chapter explains why the condition of a rowing boat's hull matters for performance. It shows that frictional drag makes up a large share of total resistance and that this drag depends strongly on the behaviour of the boundary layer along the boat surface. A clean, smooth hull helps keep this friction low, while scratches, deposits and other surface irregularities can disturb the flow and increase resistance.

The chapter also clarifies that normal cleaning and careful mechanical polishing are best understood as maintenance, because they restore the original hydrodynamically smooth surface rather than creating a new performance-enhancing layer. By contrast, special coatings, lubricants or water-repellent treatments are discussed with caution, because scientific evidence does not show a meaningful drag-reducing benefit for ordinary commercial products, while some advanced surface technologies would go beyond simple maintenance and raise regulatory concerns.

2.2. The flow around rowing boats and the "basic knowledge" of fluid dynamics.

Rowing boats experience a set of water resistances when they are running through the water. The total resistance or drag can be decomposed into three main contributors, namely (1) pressure drag, (2) wave drag and (3) frictional drag. First, the pressure drag is also known as the shape drag, which represents the energy needed to move water aside such that the boat can move through that specific volume of water. The pressure drag is reduced when objects are "more streamlined". Second, the wave drag is associated with the energy needed for the formation of induced waves. Third, the frictional drag is attributed to the forces of the water flowing along the surface of a rowing boat. The water is "shearing"/"rubbing" along the boat surface, which generate turbulence of the water flow near the boat surface. Rowing boats are relatively long and narrow, which indicate an optimal shape regarding a minimal pressure and wave drag. It is estimated that 70-90% of the total water resistance can be dedicated to the frictional drag.

2.3. Laminar & Turbulent flows

The total pack of the stacked layers of the flow close to the surface is called the boundary layer of the flow, where the first layer close to the surface is called the "viscous sub-layer". A zero-slip boundary condition applies for turbulent flows over a solid/rigid boundary (like a boat surface), which means that the first watermolecules in contact with the surface will adopt its identical velocity. For rowing, the first watermolecules will travel with a velocity similar to the boat speed. Then, the first watermolecules sets the next layer in motion by the shear forces and mixing. The rate of shear and mixing where energy/momentum is transferred to the next layer, is highly dependent on the type of flow: laminar or turbulent.

1.1.1. Laminar Flow

Laminar flow can be considered as a "layered flow", where the water runs smoothly and in straight streamlines. There is no to little interaction between the adjacent layers. Laminar flow is characterized by relatively low Reynolds numbers, which indicate that the viscous forces are much larger than the kinematic forces (due to velocity). Although fully laminar flow is theoretically possible, it is relatively rare in practice and real-world application.

1.1.2. Turbulent Flow

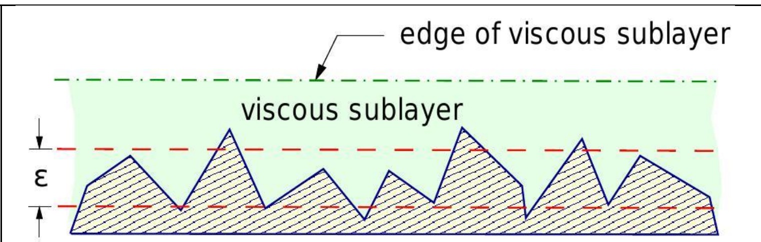
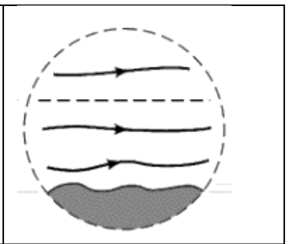
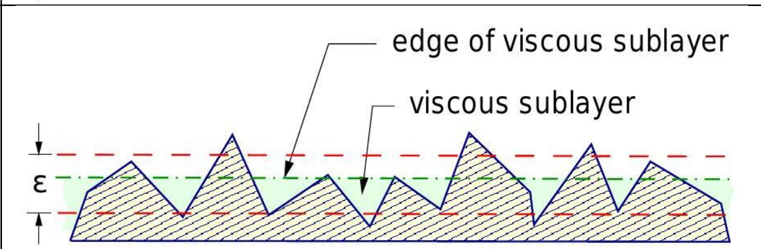
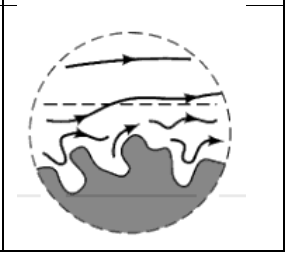
Turbulent flows can also be considered as a layer-structured flow, but the flow is characterized by the chaotic interaction between the stacked layers, which results in the formation of vortices/swirls and significant mixing of the fluid/water. In general, the intensity of "mixing" determines the level of turbulence. A higher level of turbulence is associated with more friction drag. In contrast to laminar flow, turbulent flow will have a high Reynolds numbers, in which the kinematic forces are much higher than the viscous damping of the fluid. Turbulent flow is highly irregular and almost impossible to predict or measure in detail.

2.4. Boat surfaces and surface irregularities

Boats are often being cleaned before racing, such that dirt, oil, scratches, calcic deposition and other surface irregularities are removed and the boat surface becomes more smooth. The boat surface from the factory is considered “hydrodynamically smooth”, which means that the surface roughness is below the threshold where the flow could sense surface irregularities. This threshold is determined by the first layer of the turbulent flow very close to the wall (i.e. boat surface), which is the aforementioned “viscous sub-layer”. The thickness of this “sub-layer” is an important flow parameter in relation to surface roughness. It becomes more thin when the flow velocity increases in relation to the boat surface. In general, a higher boat velocity leads to a thinner “sub-layer” and visa versa.

The boat surface is considered to be “hydrodynamically smooth” when the roughness elements are smaller than the thickness of the “viscous sub-layer”. The surface will become rough when the surface elements starts to protrude through this “sub-layer” (see Figure below). The flow will be perturbed and induces an additional mixing of the flow. This results in an growth of the turbulent intensity level and with that an increase of the frictional drag.

For rowing, the thickness of the “viscous sub-layer” is estimated to be in the range of 10-25 μm (=10-25 x10^{-6} m). In order to put this in perspective: the human hair thickness is around 50-100 μm.

Smooth surface		
Rough surface		

2.5. Boat surface enhancement?

The frictional drag of the boat surface is theoretically minimized when the boat surface is considered to be smooth. The removal of dirt and polishing away scratches will approach the “original” state of the smooth boat surface. This can be done by washing the boat surface with soap, descaling with (diluted) vinegar and polish scratches with polish waxes (see Chapter 3).

“Simple” polish/wax products commercially available are NOT able to enhance the boat surface in relation to the turbulent flow. No scientific evidence has identified that these commercial product are able to reduce the frictional drag, such that the boat velocity can be increased. Additional friction tests of common-used products would verify this conclusion.

Nevertheless, in fundamental research and science, several drag reducing methods are investigated that are highly interested (Appendix A). Two categories of methods can be classified, namely active and passive methods to reduce frictional drag. The active methods involves the addition of polymers, micelles ("soap") or air into the water in order to change/modify the fluid properties under turbulent flow conditions. The addition of the substances or air are able to damp the velocity fluctuations in the flow in time and space, which lowers the turbulent intensity and with that the frictional drag. The method works very well for internal flows (like pipelines), but are complex to apply for external flows (like boats).

The passive methods involves modified/special surfaces, that change the general interaction with the boundary layer in comparison with a "normal" smooth surface. Three types of surfaces are in the spotlight, namely riblets surfaces ("shark skin"), compliant surfaces ("dolphin skin") and superhydrophobic surfaces ("lotus effect").

The best-known are the riblets surfaces (Rule Book: riblets are forbidden), which are able to reduce the frictional drag up to 10% under laboratory conditions. The grooves in streamwise direction suppress the spanwise mixing and with that reduce the frictional drag. In practice, riblets surfaces are able to reduce the frictional drag up to max 2-5%, for internal as well as external flows. For rowing, the dimensions of the riblets need to be in the order of magnitude 50-100µm, which can be sensed by the nail of the finger.

The compliant surfaces are theoretically able to reduce the frictional drag, but a series of scientific research over the years have shown the (im)possibilities of compliant materials effecting the drag reducing ability, resulting in a series of contradictions and controversies. The application of compliant materials to boats in order to reduce the frictional drag has been considered to be highly complex and not applicable.

The superhydrophobic surfaces are worth to highlight. Superhydrophobic surfaces are micro/nanostructured surface coated with a hydrophobic component. Water droplets on these surfaces have nearly a spherical shape, indicating wetting contact angles towards 180^{o} ($>155^{o}$). Trapped air in the micro/nano-structures preserves the non-wetting character of the surface, where water is moving on a layer of air. This extreme non-wetting system change the zero-slip boundary condition, such that the fluid is able to "slip" over the surface, minimizing the transfer of energy between layers (=less mixing) and consequently reduces the frictional drag. Slip length in the order of 10-100µm is needed to be effective. Nevertheless, when these surfaces are exposed to a turbulent flow over time, trapped air is removed/withdrawn from the highly water-repellant structure and the non-wetting character gets lost. Second, state-of-the-art laboratory equipment is necessary to produce these micro/nanostructured surfaces, and only small quantities of surface area can be produced at the time. This makes the application of superhydrophobic surfaces in practice very difficult and with high costs.

Many commercial products claim to reduce the frictional drag. These products are able to enhance the water-repellent character of the surface, where the wetting contact angle may increase up to max. 150°. Nevertheless, the achieved slip length is less than 1µm and will have **no effect** on frictional drag reduction. These product are for sure able to keep the boat surface more clean for a longer period of boat usage, but the same is being accomplished by washing and/or de-scaling the boat surface, for example before racing. Furthermore, these products are often waxes or liquids that contains nano/micro-particles with a water-repellent character, carried by a volatile solvent. These substances may pose a serious risk to humans and nature (see Chapter 4).

2.6. Maintaining the initial boat surface quality

Polishing is a mechanical surface-finishing process intended to reduce local surface irregularities such as fine scratches, oxidation marks and small deposits. From a technical point of view, polishing is essentially a very fine form of sanding: microscopic amounts of the outer surface are removed by abrasive particles in order to level peaks and smooth the finish. In that sense, a polishing compound can be described as "sandpaper without paper" — the abrasive material is not fixed to a sheet, but is suspended in a paste or liquid carrier and worked over the surface with a cloth or polishing pad.

Accordingly, proper polishing does not intentionally leave anything on the boat that changes the hydrodynamic surface by adding a foreign layer or special material. After polishing, any remaining compound is wiped off and the result is simply the underlying boat surface in a smoother condition than before. The process therefore differs fundamentally from the application of coatings, waxes, lubricants or other substances that are designed to remain on the hull. Polishing is best understood as maintenance of the original surface quality through controlled abrasive removal, not as the addition of a new surface treatment. In that sense, polishing is consistent with Appendix R2 where it serves only to restore the original hull surface and does not add a foreign substance or special surface structure to the boat.

3. Laboratory testing of selected boat care products

3.1.Summary

An independent laboratory study was commissioned by World Rowing to examine whether commonly used boat care products can reduce friction on rowing boat hulls during racing conditions. The main purpose was to test claims often made for certain coatings and polishes and to determine whether these products provide any measurable performance advantage on the water. The study focused on frictional resistance, which is the part of water resistance created as water moves along the hull surface.

The overall finding was clear: none of the six tested products produced a measurable reduction in drag when compared with an untreated smooth reference surface. In other words, the study did not confirm that these products make a already smooth racing hull faster. What the tests did show, however, is that surface condition matters. A scratched or damaged surface creates more friction, while polishing products can help bring such a surface back closer to its original smooth condition.

3.2.List of tested products

The laboratory examined six products that are known in the rowing and marine community. Two of them were marketed mainly as surface coatings or finishers that claim to improve glide or reduce drag. Four others were products typically used for polishing, meaning their main purpose is to clean up scratches, oxidation or other minor surface imperfections rather than to create a special high-performance layer.

- Aquaspeed Nanoprom
- McLube Hullkote
- 3M Perfect-It Gelcoat Medium Cutting Compound & Wax
- Polarshine 10 Polishing Compound (Mirka)
- Yachticon Premium Polish Teflon Polish
- Autoglym Super Resin Polish

In simple terms, the first two products were tested as products that are supposed to stay on the surface and improve performance. The other four were considered maintenance products that may improve the condition of a damaged surface by smoothing it again. This distinction is important, because the study did not only ask whether a product can be applied, but whether it creates a real performance gain compared with a normal smooth hull.

3.3. Test set-up

The testing was carried out at Delft University of Technology using a laboratory device designed to measure friction very accurately under controlled conditions. Instead of testing complete rowing boats on open water, the researchers used a set-up that reproduces the type of surface stress a rowing hull experiences at racing speeds. This approach allows small differences to be measured more reliably than they usually could be on the water.

Each product was compared against a reference surface. For the coating-type products, the reference was a clean, very smooth surface. For the polishing products, the researchers first created a clearly scratched surface and measured it before and after treatment. This made it possible to separate two different questions: whether a product can make a smooth surface even better, and whether it can help recover performance after the surface has been damaged.

The tests focused on the range of conditions that are relevant for rowing competition. The detailed physical calculations behind this are not essential for the practical message of the study: the laboratory was set up to reflect realistic rowing conditions and to see whether these products change the resistance of the hull in a meaningful way.

3.4. Results

The results showed no measurable drag reduction for any of the six tested products when compared with the smooth reference surface. This includes the products that were specifically marketed with performance claims. Within the accuracy of the measurements, the laboratory did not find evidence that these products make a already smooth rowing hull faster.

A different picture appeared when the surface had been scratched. In that case, the damaged surface produced more friction than the smooth reference surface. According to the study, the increase could be up to about 4% under the tested conditions. The polishing products were then able, at least partly, to bring the surface back toward its original state. This means the value of such products lies mainly in maintenance and repair of surface quality, not in creating extra speed beyond what a smooth hull already offers.

The report also notes that some products may still help in other ways, for example by keeping the surface cleaner for longer or by making later cleaning easier. However, those possible benefits were not the focus of the study. The research was limited to frictional resistance and did not assess health, safety or environmental effects of the chemical ingredients.

3.5. Conclusion

- No tested product provided a measurable benefit beyond the performance of a clean, smooth reference surface.
- Products that advertise drag reduction or contain water-repellent ingredients did not show an advantage in the laboratory tests.
- Polishing can still be useful as a maintenance method, because it may reduce scratches and help restore the hull to a smooth condition.

The study supports a simple and practical conclusion: for rowing performance, a clean and smooth hull matters, but none of the tested commercial products improved performance beyond that baseline. Claims that a coating or polish can create a special speed advantage were not confirmed by the laboratory results.

For everyday practice, this means that athletes and teams should focus primarily on keeping the hull in good condition, removing dirt and preventing or repairing scratches. Polishing may be useful as part of normal maintenance when it restores surface quality. Based on this study, the key message is not that products make boats faster, but that good maintenance helps avoid unnecessary losses caused by surface damage.

4. Health & Environmental effects

4.1. The Environmental Impact of Boat Polish on Aquatic Ecosystems

Boat polish is widely used to enhance the appearance of vessels, protect hull surfaces from corrosion, and extend the lifespan of materials such as fiberglass and metal. While these products provide aesthetic and functional benefits to boat owners, they can pose significant risks to aquatic environments. Many boat polishes contain chemical compounds that, when washed into lakes, rivers, and oceans, can harm water quality, aquatic organisms, and entire ecosystems. Understanding how boat polish affects the environment is essential for promoting safer boating practices and protecting fragile aquatic habitats.

4.2. Chemical Composition of Boat Polish

Boat polishes often contain a mixture of petroleum-based solvents, synthetic waxes, silicones, abrasives, and surfactants. Some products also include additives such as fragrances, dyes, and preservatives. These chemicals are designed to resist water and environmental wear, which makes them particularly persistent once they enter aquatic systems. When boat owners apply polish, residues can be rinsed off during cleaning, rainfall, or normal operation of the vessel, allowing these substances to flow directly into surrounding waters.

Certain ingredients in boat polish, such as volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs), are known environmental contaminants. VOCs can contribute to air and water pollution, while PAHs are toxic compounds that can accumulate in sediments and living organisms. Because many waterways near marinas experience frequent boat traffic, the repeated introduction of these chemicals can lead to long-term environmental contamination.

4.3. Water Pollution and Toxicity

One of the primary ways boat polish harms aquatic environments is through water pollution. When polish residues enter the water, they can create a thin film on the surface that interferes with oxygen exchange between the air and the water. Reduced oxygen levels can stress fish and invertebrates, particularly in enclosed or slow-moving bodies of water such as marinas, lakes, and bays.

Some chemicals found in boat polish are directly toxic to aquatic life. Fish, amphibians, and invertebrates may absorb these substances through their gills, skin, or digestive systems. Even low concentrations of toxic compounds can disrupt normal biological functions, affecting growth, reproduction, and immune responses. In severe cases, exposure can result in illness or death, especially for sensitive species or early life stages such as fish larvae and eggs.

4.4.Bioaccumulation and Food Web Disruption

Another significant concern is bioaccumulation, the process by which toxic substances build up in the tissues of living organisms over time. When small aquatic organisms absorb chemicals from boat polish, those chemicals can become more concentrated as predators consume contaminated prey. This process, known as biomagnification, can result in high toxin levels in larger fish, birds, and mammals.

Bioaccumulation not only threatens wildlife but can also impact human health. People who consume fish or shellfish from polluted waters may be exposed to harmful chemicals that have accumulated in the food chain. This creates broader environmental and public health concerns, particularly in communities that rely on local waterways for food, recreation, or economic activity.

4.5.Effects on Aquatic Plants and Habitats

Boat polish can also negatively affect aquatic plants and habitats. Substances that form surface films or increase water turbidity can reduce the amount of sunlight penetrating the water. Aquatic plants, including algae and seagrasses, rely on sunlight for photosynthesis. Reduced light availability can limit plant growth, leading to decreased oxygen production and habitat degradation.

Healthy aquatic plants play a critical role in stabilizing sediments, providing shelter for organisms, and maintaining overall ecosystem balance. When these plants are damaged or die off due to chemical pollution, the effects can ripple throughout the ecosystem. Loss of vegetation can increase erosion, reduce biodiversity, and make aquatic environments more vulnerable to additional stressors such as climate change and invasive species.

4.6.Impact on Sediments and Long-Term Environmental Damage

Many chemicals in boat polish eventually settle into bottom sediments, where they can persist for long periods. Sediment contamination poses a long-term threat because pollutants can be slowly released back into the water column or taken up by bottom-dwelling organisms. Disturbances such as dredging, storms, or increased boat activity can resuspend contaminated sediments, reintroducing harmful substances into the ecosystem.

Long-term sediment pollution can make environmental recovery difficult even after the use of harmful products is reduced. This persistence underscores the importance of prevention, as cleaning up contaminated sediments is often costly, complex, and disruptive to aquatic habitats.

4.7.Reducing Environmental Harm

Although boat polish can harm aquatic environments, there are steps that can be taken to reduce its impact. Environmentally friendly alternatives, such as biodegradable or water-based polishes, are increasingly available. These products are designed to minimize toxicity and break down more easily in the environment.

Boaters can also adopt better practices, such as polishing boats away from the water, using drop cloths to catch runoff, and avoiding overuse of chemical products. Marinas can support environmental protection by providing designated wash areas with proper waste collection and treatment systems. Education and awareness play a crucial role in encouraging responsible behaviour and reducing pollution from recreational boating.

4.8.Conclusion

Boat polish, while beneficial for maintaining and protecting watercraft, can pose serious risks to aquatic environments. The chemicals it contains can pollute water, harm aquatic organisms, disrupt food webs, and cause long-term damage to sediments and habitats. These impacts highlight the need for greater awareness, responsible product use, and the adoption of safer alternatives. By making informed choices and implementing environmentally conscious practices, boat owners and marina operators can help protect aquatic ecosystems for future generations.

5. How are other federations handling the boat surface topic

5.1. World Sailing (ISAF)

2025-2024 Racing Rules of Sailing

PART 4 OTHER REQUIREMENTS WHEN RACING

SECTION B EQUIPMENT-RELATED REQUIREMENTS

53 SKIN FRICTION

A boat shall not eject or release a substance, such as a polymer, or have specially textured surfaces that could improve the character of the flow of water inside the boundary layer.

5.2. International Canoe Federation (ICF)

CHAPTER 3 - ATHLETE EQUIPMENT

3.2 CONSTRUCTION

3.2.6 - No foreign substance may be added to the surface of the boats which can give the athlete an unfair advantage. The use of hull lubricants is not permitted.

6. What is allowed under 2026 edition of App R2 – Bye laws to R29

Under Appendix R2, **only mechanical polishing or buffing is allowed** where the process serves solely **to restore the original hull surface by removing minor surface irregularities** through abrasion. In this context, polishing is treated as a maintenance process and not as the application of a product intended to remain on the boat. Accordingly, products may only be used where their function is purely abrasive and any residue is completely removed after the process. Combination products that also contain waxes, sealants, lubricants, hydrophobic agents or any other substances intended to be added onto, deposited on, or left behind on the boat surface should not be considered permitted, because they go beyond mechanical polishing and result in the application of a foreign substance to the hull.

Conclusion:

Any polishing / buffing product that contains additional substances like waxes, PTFE or similar shall NOT be used.

List with specific products / substances will follow

7. Recommendations

Polishing:

- Use polishing or buffing only where needed to maintain a smooth surface or to restore it after repairs.
- Keep the amount of polishing paste to a minimum.
- Rinse or wash the boat before first use after polishing so that no residue remains on the hull or enters the water during rowing.
- Take special care when polishing outdoors, because dried polishing residue can disperse into the environment if it is not properly contained and removed.

Wet sanding

- wet sanding is not recommended, even if it is not expressly forbidden.
- Wet sanding has no proven positive performance effect, but it does create ecological impact through the release of fine particles (microplastic) and sanding residues.
- Be aware that every sanding process removes a thin layer of the boat's top coat and therefore reduces the service life of the hull over time.

8. Testing of boat surface

A concept to measure the boat surface for substances is currently being tested.

Step 1 is to proof the idea that is already being used by another sports federation can also be applied to our case by doing some first reference measurements.

If successful we can go into the discussion of procedures and enter a into a systematic series of tests to define references and verification with various products and substances.

Last step would then be to make a rule proposal and budget request for the test equipment.