# Performance of Elastomers in Marine Bearings for Seawater Environments

## Introduction

Marine bearings that operate with seawater lubrication (e.g. ship stern tube bearings, rudder bearings, pump bearings) often rely on **elastomeric materials** for their linings or components. Elastomers provide flexibility, shock absorption, and low friction in these applications, but they must withstand the harsh conditions of saltwater service. Key performance factors include resistance to **saltwater corrosion** (chemical degradation by salt and seawater), **mechanical wear** under sliding contact, **hydrolysis** (chemical breakdown by water), **swelling** from water absorption, **biofouling** or microbial growth, and overall long-term **durability**. Common elastomers used in marine bearings are:

- **Nitrile Butadiene Rubber (NBR)** – a synthetic rubber known for oil resistance and toughness.
- **Hydrogenated Nitrile Butadiene Rubber (HNBR)** – a saturated NBR with improved heat/ozone resistance.
- **Polychloroprene (CR, Neoprene)** – an all-purpose marine rubber with good weather resistance.
- **EPDM (Ethylene Propylene Diene Monomer)** – excellent water and ozone resistance rubber.
- **Polyurethane (PU) Elastomers** – high-strength elastic polymers with outstanding wear resistance.
- **Fluoroelastomers (FKM, e.g. Viton)** – fluoro-carbon rubbers with exceptional chemical and heat resistance.

This report compares the performance of these elastomers in seawater, citing laboratory test data, real-world usage (case studies), and marine standards. It highlights which materials are best suited for **water-lubricated marine bearings** and why, providing a summary comparison table of properties in saltwater environments.

## Key Performance Requirements in Seawater

Elastomers in seawater-exposed bearings must meet several critical requirements:

- **Saltwater and Corrosion Resistance:** The material should not chemically degrade or corrode in brine. Saltwater is a mix of ions (chlorides, sulfates) that can accelerate polymer degradation if the elastomer is not inert. For example, EPDM and FKM elastomers are noted for *excellent* resistance to saltwater and UV/Ozone attack, making them ideal for long-term exposure (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket) (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). Neoprene and NBR offer more moderate saltwater durability – they resist short-term exposure, but can age or stiffen over long periods in seawater if not formulated for marine use (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...) (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...).
- **Mechanical Wear Resistance:** Marine bearings operate with a thin film of water for lubrication, so elastomers must endure sliding contact with shafts (often steel) plus any abrasive particles in the water. High **abrasion resistance** and low friction are essential to minimize wear. Nitrile rubber (NBR) has *exceptional abrasion resistance*, tolerating friction without tearing (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). Neoprene is also known for *high resistance to wear and tear* in frictional applications (Best Rubber Types for Marine Use – EPDM, Neoprene & Silicone). EPDM and HNBR are considered tough and tear-resistant as well (HNBR typically exceeds NBR in tensile and tear strength) (HNBR vs. NBR | R.E. Purvis). Polyurethane

- elastomers excel in this area – they exhibit **superior abrasion resistance** and load-bearing capacity compared to conventional rubbers (Best Urethane for Maritime Industry Uses | PSI). In practice, water-lubricated bearings made of nitrile rubber or PU can operate for many years; for instance, **Thordon** polymer bearings (a proprietary polyurethane-based material) carry a 15-year wear life guarantee in seawater service (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss). Wear mechanisms observed in NBR stern tube bearings include adhesive and tearing wear if the rubber is aged or starved of lubricant (Study on wear behaviour and wear model of nitrile butadiene rubber under water lubricated conditions | Request PDF), prompting the use of fillers (like PTFE or graphite) to reduce friction (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss).

- **Hydrolysis and Water Degradation: Hydrolysis** is the chemical breakdown of polymer chains by water. Most traditional rubbers (NBR, HNBR, CR, EPDM, FKM) have saturated or stable backbones that are not prone to hydrolysis in water. Polyurethane, however, can be susceptible to hydrolysis *if* it's the polyester-based type. Marine-grade PUs use polyether polyols to achieve high hydrolysis resistance (Accelerated ageing of polyurethanes for marine applications). Studies show that polyether-based polyurethane can survive decades in seawater with minimal property loss: one accelerated aging test extrapolated **>100 years** for 50% tensile strength loss at ambient sea temperatures, and actual samples had no tensile loss after 5 years of natural seawater immersion (Accelerated ageing of polyurethanes for marine applications). This demonstrates that with proper formulation, PU elastomers remain hydrolytically stable in marine conditions. On the other hand, early-generation **thermoplastic PUs** sometimes showed hydrolysis swelling and hysteresis failure under high loads (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing) – highlighting the need for selecting stable formulations. Overall, all listed elastomers (aside from poorly formulated PU) have excellent resistance to hydrolysis in seawater.

- **Swelling and Water Uptake:** Elastomers can absorb water and swell, which may alter bearing clearances. An ideal marine bearing material has low water absorption. **EPDM** is noted to *“not swell or react to water,”* maintaining a tight seal without softening (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). Nitrile and Neoprene have *good* water resistance as well – NBR has a closed-cell structure that prevents it from becoming waterlogged (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta), and neoprene is inherently water-resistant (wetsuits are made of neoprene). In quantitative terms, advanced composite bearing materials can achieve water absorption <0.5% by weight (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). Traditional vulcanized rubbers might absorb slightly more (on the order of a few percent or less), but it’s controlled by proper compounding. **NBR, Neoprene, and HNBR** generally exhibit low to moderate swelling in water (far less than their swell in oils). **FKM** and **EPDM** exhibit **negligible swelling in seawater** – these polymers remain dimensionally stable even after long immersion (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). Low swell is important to prevent loosening or delamination of a bearing’s rubber lining; hence marine standards often specify maximum swell limits (ASTM D471 water immersion tests are used to verify this).

- **Biofouling and Microbial Resistance:** Marine environments are biologically active – algae, barnacles, and microorganisms can colonize surfaces. Elastomeric bearings are usually *internal* to shaft assemblies and continuously flushed with water, so macro-fouling (barnacles) is less of a concern. However, **microbial attack** can occur: certain bacteria can metabolize compounds in rubber, especially if the material contains plasticizers or natural rubber content. **Polyurethane** is often chosen in offshore applications partly for its resistance to microbial growth and **bio-degradation** (Best Urethane for Maritime Industry Uses | PSI). Fluoroelastomers are highly inert (little sustenance for microbes). EPDM and CR are formulated with biocide additives in some cases to prevent microbial slime or mold. In general, elastomers like

- EPDM, neoprene, NBR, and PU have been successfully used in seawater for years without significant biofouling issues – they do not corrode like metals, and any slimy growth on a bearing is usually washed away during operation. That said, **polyurethane** and **FKM** are considered especially *resistant to microbial and fungal attack*, maintaining integrity in long-term immersion (Best Urethane for Maritime Industry Uses | PSI).

- **Overall Durability (Aging & Fatigue):** Combining the above factors, the elastomer must retain its properties over thousands of hours of operation. This means resisting oxidative aging, fatigue cracking, and thermal degradation. **HNBR** and **FKM** are standout performers in terms of resistance to heat, oxidation, and ozone – HNBR can tolerate up to ~150°C and heavy oxidative stress (HNBR vs. NBR | R.E. Purvis) (HNBR vs. NBR | R.E. Purvis), and FKM even up to 200°C, whereas standard NBR or CR begin to degrade at lower temperatures. In marine bearings, operating temperatures are usually moderate (sea water is a coolant), so ozone/UV aging is a bigger concern during idle periods or shore storage. Neoprene and EPDM are formulated to handle ozone and UV (EPDM excels in this regard) (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). **NBR** is the one that *by itself* has poorer ozone resistance, but in practice additives (antiozonants) are used, or the bearing is designed such that the rubber is not exposed to air when not in use. The U.S. Navy has extensively tested rubber bearing longevity – one study noted natural rubber and neoprene bearings maintain stable stiffness after 2 years in artificial seawater (Accelerated ageing of polyurethanes for marine applications). Modern nitrile-based bearings (like the Johnson Cutless®) have decades-long service records. In fact, **over 90% of U.S. Navy surface ships and submarines use nitrile rubber water-lubricated bearings**, a testament to their durability in harsh conditions (Duramax Marine: About Us).

In summary, the ideal marine bearing elastomer is one that *resists saltwater chemical attack, exhibits low wear under water lubrication, does not hydrolyze or swell significantly, and endures long-term aging* without embrittlement. The following sections compare how each common elastomer meets these criteria, with references to test data and use cases.

# Comparison of Common Elastomers in Marine Bearing Service

## Nitrile Rubber (NBR)

- *NBR **is a copolymer of butadiene and acrylonitrile, known for its toughness and oil resistance. It has a long history in marine bearings – for example, nitrile linings in** Cutless** bearings became the standard for water-lubricated propeller shafts in the late 20th century (Water-lubricated sterntube bearings combat oil loss). Key properties of NBR in seawater environments:

- **Saltwater Resistance:** Nitrile handles water exposure well. It is *highly resistant to water-based corrosion* and does not disintegrate or "waterlog" in seawater (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). Chemically, NBR is less resistant to ozone and oxygen than some other rubbers, but underwater (out of sunlight/air) this is less of an issue. In practice, NBR-bearing compounds include antioxidants to improve sea aging. They also often incorporate plasticizers and waxes that bloom to the surface, providing a degree of ozone protection when the bearing is exposed to air.

- **Mechanical Wear:** NBR exhibits **excellent abrasion and wear resistance**. It resists frictional wear and tearing, which is critical for shaft bearings (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). NBR's toughness and ability to embed small particles (due to its softness) help it survive dirty seawater lubrication. Its **vibration damping** capacity is also excellent (Tribological modification of hydrogenated nitrile rubber ...), protecting shafts from shock. One study on nitrile rubber stern tube bearings showed that unaged NBR has low friction and wear, but after long-term thermal

- aging its tear strength reduces, leading to higher wear rates (Study on wear behaviour and wear model of nitrile butadiene rubber under water lubricated conditions | Request PDF). This underscores the need to keep operating temperatures moderate. Overall, with water lubrication, NBR's main wear mechanism is mild adhesive wear – usually manifesting as a smooth polished surface. If starved of water, it can suffer adhesive tearing. To mitigate startup friction ("stiction"), proprietary NBR compounds incorporate lubricating fillers: e.g. one advanced material blends PTFE and graphite into nitrile to cut the friction coefficient to about **50% of the limit set by MIL-DTL-17901C** (a military spec for rubber bearings) (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss) (A new rubber/UHMWPE alloy for water-lubricated stern bearings ...).

- **Hydrolysis Resistance:** Nitrile rubber has a carbon-carbon backbone (with cyano groups) and does not undergo hydrolysis. It remains stable in long-term water immersion. Long-term aging of NBR in seawater tends to cause **oxidative hardening** (if oxygen is present) rather than hydrolytic breakdown. As such, hydrolysis is not a concern for NBR – many NBR parts (like seals, hoses) operate in water for years without issue.

- **Swelling:** NBR compounds exhibit *low water absorption*. They are often rated "Good" in water swell tests (Material Properties for Rubber Compounds). One source notes nitrile's effective barrier against water absorption, due to its polymer structure (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). In practical terms, an NBR bearing may swell a small amount in the first days of immersion (perhaps on the order of <2% volume), then reach equilibrium. This small swell can actually tighten the fit in the bearing housing slightly, which is often accounted for in design clearances. Importantly, NBR's swell in **oil** is high (if any oil enters the seawater system, NBR will absorb it); but in pure water, swell remains minimal.

- **Biofouling:** As an organic rubber, NBR can in theory be slowly broken down by certain bacteria or fungi. However, field experience shows this is not a significant failure mode. NBR bearings are typically in

- continuous motion when the ship operates, preventing organism buildup. Additionally, many NBR marine compounds include anti-fungal additives. Thus, NBR is considered **moderately resistant** to biofouling – not as inherently inert as FKM, but generally not problematic.

- **Durability and Usage:** NBR's track record is excellent. It is a **go-to material for water-lubricated bearings**, used in countless ships. The U.S. Navy's adoption (90% of surface fleet) attests to its reliability (Duramax Marine: About Us). Commercial products like **Duramax Johnson Cutless** bearings have used a proprietary oil-resistant NBR formulation for decades (Johnson Cutless water-lubricated rubber bearings - Duramax Marine). These bearings routinely achieve long service life, provided alignment and lubrication are maintained. One consideration is that NBR has an upper temperature limit (~90°C to 100°C in water) – beyond this, it hardens. In normal seawater service (often <40°C), this is fine. In summary, NBR is a **balanced choice**: tough, proven, and forgiving, making it one of the best all-around elastomers for marine bearings.

## Hydrogenated Nitrile Rubber (HNBR)

- *HNBR** is a hydrogenated version of NBR, wherein the butadiene segments are saturated. This greatly improves its resistance to heat, ozone, and oxidation. HNBR is essentially a high-performance NBR, and it has seen use in demanding seals and newer bearing designs:

- **Saltwater & Chemical Resistance:** By virtue of saturation, HNBR is **even more resistant to seawater aging** than NBR. It has excellent resistance to ozone and oxygen attack (HNBR vs. NBR | R.E. Purvis), which means that in a marine environment (where ozone/UV exposure can occur intermittently), HNBR will not crack or degrade. Its saltwater compatibility is on par with NBR (no issues with brine). HNBR also withstands a broader range of chemicals; for example, it's resistant to mild oxidizing agents that might be present in seawater or marine growth.

- **Mechanical Wear:** HNBR offers **enhanced mechanical properties** over standard nitrile – higher tensile strength, better elongation, and often superior abrasion resistance (HNBR vs. NBR | R.E. Purvis). In terms of wear, this translates to potentially longer bearing life and better handling of edge loading or misalignment without tearing. Research has specifically looked at HNBR for water-lubricated bearings: one study prepared **HNBR nanocomposites** (with dispersed ultrahigh molecular weight PE, graphite, etc.) to reduce friction. It found HNBR's tribological performance can indeed be tuned, and baseline HNBR already solved some friction/wear problems seen in NBR (Tribological modification of hydrogenated nitrile rubber nanocomposites for water-lubricated bearing of ship stern shaft | CoLab). HNBR's improved *thermal stability* also means it maintains its elasticity at higher operating temperatures, avoiding the hardening that aged NBR experiences (HNBR vs. NBR | R.E. Purvis). This is beneficial if a bearing runs warm (e.g. near an engine room).
- **Hydrolysis:** Like NBR, HNBR is not prone to hydrolysis (no hydrolysable groups). Its water immersion stability is excellent. Any long-term changes would be due to oxidation (which HNBR resists well).
- **Swelling:** Water swell for HNBR is very low – similar to NBR. There is little published specific data, but since HNBR is often used in oilfield seals due to low swell in fluids, one can infer it remains dimensionally stable in seawater. HNBR O-rings and seals are used in subsea equipment where water absorption must be minimal.
- **Biofouling:** HNBR being a synthetic rubber with no unsaturation is somewhat less attractive to microbes than NBR. It can still be attacked over very long timescales by specialized bacteria, but in general it's **resistant**. No special concerns beyond those for NBR.
- **Applications & Notes:** HNBR is more expensive than NBR, so its use in large marine bearings is not as common. However, it finds use in **high-performance applications** – for instance, HNBR O-rings in marine hydraulic systems, or specialized bearing designs where higher temperature capability is needed. It's also explored in research

- prototypes for improved stern tube bearings. In summary, HNBR can be considered **“NBR-plus”** – offering greater longevity (due to heat/ozone resistance) and potentially lower wear, at a higher material cost (HNBR vs. NBR | R.E. Purvis). For extremely harsh conditions or extended maintenance intervals, HNBR is a top contender.

## Chloroprene Rubber (Neoprene, CR)

- *Neoprene** (CR) is one of the earliest synthetic rubbers and has been used in marine environments for decades. It is well known for its weather resistance (hence use in wetsuits, cable jackets, etc.). In marine bearings and seals, neoprene’s performance can be summarized as follows:

- **Saltwater Resistance:** Neoprene has **good resistance to seawater**, though not quite at the level of EPDM or FKM. It will tolerate constant saltwater exposure and is often used in marine **gaskets and seals** for this reason (What Gasket Is Used For Seawater? | ARTG - AR Thomson Group). Over a very long time, or at elevated temperature, neoprene can undergo hydrolytic dechlorination or absorb some water, leading to softening. One source notes that neoprene’s performance *“deteriorates over extended exposure”* to saltwater, making it less durable long-term than EPDM or Viton (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). Practically, neoprene items in seawater (like a neoprene diving suit or a pump gasket) last many years, but a neoprene bearing might not match the decades-long life of EPDM in the same setting. Still, it is considered **moderately resistant** to saltwater – certainly suitable for short or medium-term exposure and intermittent use.

- **Mechanical Wear:** Neoprene is a fairly tough elastomer. It has **high abrasion resistance and tear strength**, often comparable to NBR. It is known to endure flexing and friction; for instance, flexible impeller pumps on boats commonly use neoprene impellers because they must survive continuous rubbing inside a pump housing. Neoprene is described as *“rugged… with excellent resistance to rips and abrasions”*,

- nearly on par with EPDM (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). It also handles impact and vibration well (it was historically used in bridge bearings and engine mounts due to these qualities). For a marine bearing, a neoprene lining would exhibit low wear as long as lubrication is sufficient. Its coefficient of friction is slightly higher than nitrile's, but still low in water. Overall, CR provides **very good wear performance** in marine applications, which is why it's used for things like dock fender pads and pipeline pigs.

- **Hydrolysis:** Neoprene has chlorine in its polymer chain, but it is stable in water. It does not hydrolyze in the classic sense; water alone doesn't break the polymer. In heavily chlorinated water or in the presence of certain metals, neoprene can decompose slowly. However, standard seawater does not usually cause significant hydrolytic damage to CR. Laboratory seawater-aging of neoprene shows primarily **oxidative** or **extractive** changes (e.g. some additives leaching out) rather than chain scission. So hydrolysis is **not a major concern** for neoprene.

- **Swelling:** Neoprene's water absorption is low. It is a relatively polar rubber and does not swell much in polar fluids like water. Qualitatively, it's rated as *"Good" water resistance* (similar to NBR) (Material Properties for Rubber Compounds). Thus, swelling in seawater is minor. Swell might be slightly more than EPDM's (which is negligible), but neoprene gaskets maintain shape well in seawater service. This makes neoprene suitable for seals that must keep their dimensions (it *"maintains a tight seal without leaching"* too much, though EPDM is superior in that regard) (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket).

- **Biofouling:** Because neoprene contains chlorine, it is somewhat less prone to microbial attack – the chlorine imparts a mild biocidal property. Neoprene was actually used as a lining in some oceanographic cables specifically to resist marine organism growth. That said, it's still an organic polymer and can get surface biofilms. It is **moderately resistant** to biofouling. Generally, neoprene parts in the ocean get slimy but do not degrade structurally from organisms.

- **Durability:** Neoprene stands up well to **weathering** – it's famously ozone and UV resistant (though HNBR and EPDM are even better in ozone). It also stays flexible in cold seas (serviceable down to about -40°C). These traits make it a common marine engineering material. However, in a direct comparison, **EPDM and FKM are noted to outlast neoprene** in long-term saltwater exposure (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...) (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). Thus, neoprene might be chosen for moderate-duty or lower-cost applications, or where some oil resistance is needed in addition to water resistance (neoprene is resistant to oil to a degree, unlike EPDM). For example, **neoprene is used in some older generation cutlass bearings and in marine pump bearings**, and it performs adequately, though many designs have shifted to nitrile or polyurethane for better longevity. In summary, CR is a **versatile marine elastomer** – durable in diverse conditions, but not the very top performer in any single category (it is outclassed by EPDM in pure seawater and by NBR in oil-heavy environments). It remains a solid choice for general marine use due to its balanced profile of water, oil, and weather resistance.

## EPDM Rubber

- *EPDM** (ethylene propylene diene monomer) is a synthetic rubber with an unsaturated backbone, renowned for its exceptional weather and water resistance. In marine environments, EPDM often shines as an ideal material for seals and even bearing elements when oil exposure is not a factor:

- **Saltwater Resistance:** EPDM is often cited as *"the most water-resistant"* elastomer (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). It **does not break down in saltwater**, showing excellent resistance to seawater, chlorides, and marine biological fluids (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). This rubber can tolerate continuous immersion in brine with virtually no chemical degradation – no significant swelling,

- embrittlement, or loss of properties. Its resistance extends to **UV, ozone, and weathering**, which is important for parts that may be partially exposed (e.g. a rudder bearing at the waterline). Thanks to these properties, EPDM is used extensively in marine hatch seals, cable jacketing, and pipe gaskets where long-term saltwater exposure occurs (Best Rubber Types for Marine Use – EPDM, Neoprene & Silicone). In short, EPDM's saltwater/chemical stability is **excellent** (comparable to fluoroelastomers in water, though EPDM cannot handle oils or fuels).

- **Mechanical Wear:** EPDM is a **highly elastic and flexible** rubber, maintaining flexibility even in cold seawater (Best Rubber Types for Marine Use – EPDM, Neoprene & Silicone). It has good tear and abrasion resistance, though typically a bit lower than NBR or CR in absolute terms. Filled EPDM compounds (with carbon black) can be quite tough – EPDM is used in automotive weatherstrips that see abrasion. In marine bearing context, EPDM can function well, especially in low-pressure, high-flex applications. For example, some water-lubricated bushings or pump bearings use EPDM because it can handle sandy water abrasion reasonably and won't degrade from the water itself. Under high loads, EPDM's relatively lower hardness (usually ~50-70 Shore A in marine grades) means it may wear slightly faster than a harder polyurethane or nitrile. Nonetheless, one source notes EPDM and Neoprene are both "rugged elastomers" with *excellent resistance to rips and abrasions* (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). EPDM's wear performance can be considered **good** – not the very highest, but sufficient for many bearing needs, particularly when its chemical stability is a priority. It also has a low coefficient of friction when wet. If very high abrasion resistance is needed, typically a harder compound or another material might be chosen over EPDM.

- **Hydrolysis:** EPDM is completely **unaffected by hydrolysis**. Its polymer backbone is fully saturated (ethylene-propylene) and very stable in water. In fact, EPDM is often used as a liner in potable water systems for this reason. Aging of EPDM in hot water tends to cause some **oxidation (hardening)** rather than chain scission. A study of EPDM in hot artificial seawater showed decreases in tensile strength

- and elongation over time at elevated temperatures, primarily due to thermal aging, not direct chemical attack by water (Experimental Evaluation of Aging Characteristics of EPDM as a ...MT.1943-5533.0003242#:~:text=Experimental%20Evaluation%20of%20Aging%20Characteristics,aging%20time%2C%20whereas%20the)). Still, EPDM performs better than most other rubbers under such conditions. So hydrolytic degradation is **not a concern**.

- **Swelling:** EPDM exhibits **negligible water swelling**. It can maintain a seal or fitted shape over years of water contact. As noted, *"EPDM doesn't swell or react to water"*, retaining a tight seal (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). In quantitative terms, EPDM's water absorption can be extremely low (often *<0.1-0.5%* in tests) (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). For instance, an EPDM O-ring left in seawater will typically show practically no volume change. This property is a huge advantage for maintaining bearing clearances and avoiding any loosening of a rubber lining. EPDM does absorb *oils* readily (which is why it's not used with oils), but in pure seawater systems this is not an issue.

- **Biofouling:** EPDM's inertness extends to biological attack. It does not contain ingredients that microbes find easily digestible (like plasticizers or unsaturated bonds). As a result, EPDM is **resistant to microbiological degradation** and fungal growth. It's even used in sanitary applications due to this. In a marine context, one might see a thin biofilm on an EPDM surface over time, but the rubber itself remains undamaged. EPDM's excellent ozone resistance also means no micro-cracks form that could harbor organisms. Therefore, EPDM is considered to have **good biofouling resistance** – effectively, it just doesn't provide a foothold for significant fouling, especially when regularly in motion.

- **Durability and Use in Bearings:** The combination of water/ozone resistance and low swell makes EPDM extremely **durable** in marine environments. It is often the material of choice for **long-life seals, hoses, and bellows** on ships (Best Rubber Types for Marine Use –

- EPDM, Neoprene & Silicone). For use in bearings, EPDM is used when oil ingress is not expected (since oil would cause EPDM to swell and fail). A good example is **hydroelectric turbine bearings** and marine pump bearings that use water as the only lubricant – EPDM can be formulated for these to provide years of service. Some commercial water-lubricated bearings have indeed used EPDM or EPDM-blend staves for clean water applications (freshwater or seawater). The limiting factor is that EPDM might not handle gritty water as well as nitrile or polyurethane, due to slightly lower abrasion resistance. Nonetheless, in a **pure seawater, low-abrasive environment, EPDM is arguably one of the best-suited elastomers** thanks to its stability. It offers a very long service life with minimal degradation, meeting marine standards for aging. Cost-wise, EPDM is also economical (often cheaper than neoprene) (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). In conclusion, EPDM is ideal for *seawater-exposed elastomer components* that need to last – its only caveat being incompatibility with hydrocarbons and perhaps not the top choice for extreme wear situations.

## Polyurethane Elastomers (PU)

- *Polyurethane **elastomers are a distinct class of polymers formed by reacting polyols and isocyanates, resulting in a versatile material whose properties can range from rubbery to very hard. In marine bearings,** cast polyurethane** materials (often thermosetting polyurethanes) have gained prominence because of their outstanding load-bearing and wear characteristics. Key points on PU in seawater:

- **Saltwater Resistance:** Polyurethane is highly **resistant to saltwater and seawater chemicals**, especially if formulated for marine use. It does not rust or corrode, and properly cured PU has excellent chemical stability in water. Urethane coatings are even used to protect steel in marine environments due to their water resistance. A marine industry source notes that *“urethane parts are resistant to salt*

- *water and water absorption"* and do not oxidize or break down even after long exposure (Best Urethane for Maritime Industry Uses | PSI). This assumes a polyether-based PU; as mentioned, polyester-based PUs could hydrolyze (covered below). Generally, PU elastomers handle the inorganic salts in seawater with no deleterious effect. They also tolerate the organic components of seawater (like bacteria, algae) without chemical reaction. Thus, saltwater does not cause **corrosion or material loss** in PU – making it very suitable for long-term immersion.
- **Mechanical Wear: Abrasion resistance is where PU truly excels**. Polyurethanes can combine high elasticity with high hardness, leading to a material that resists cutting, grinding, or abrasion far better than conventional rubber. In fact, PUs are widely used for **marine dredging pump liners, cable protectors, and vessel fender pads** precisely because of this superior wear performance. In bearing applications, proprietary PU-based polymers (such as *Thordon SXL*, *ThorPlas*, etc.) have demonstrated much longer wear life than rubber. For example, Thordon's seawater-lubricated bearings (polymeric alloy) routinely outperform traditional nitrile rubber in lifespan (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss). A polyurethane's **tensile and tear strengths** are typically higher than those of NBR/EPDM, allowing it to carry high loads without failure. Laboratory wear tests show PUs can operate at higher unit pressures and speeds in water before wear rates accelerate (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). Additionally, PUs often have internal lubricants or can embed solid lubricants to further reduce friction (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). Manufacturers highlight that cast PUs have *"superior abrasion and impact resistance, and great vibration damping"* in marine service (Best Urethane for Maritime Industry Uses | PSI) (Best Urethane for Maritime Industry Uses | PSI). In summary, a well-chosen PU elastomer provides **outstanding wear resistance** for water-lubricated bearings – often the best of all the elastomer options.
- **Hydrolysis Resistance:** The main caution with polyurethane is **hydrolysis** – the soft segments in PU (ester or ether linkages) can be

- vulnerable to water attack. **Polyester-based** urethanes will degrade in warm, wet conditions over time (water breaks the ester bonds, causing the material to soften and lose strength). **Polyether-based** urethanes are **much more hydrolysis-resistant**, as ether linkages are more stable. Marine-grade PUs use polyether chemistry or incorporate hydrolysis stabilizers. Research has quantified this: polyester urethanes immersed in seawater for a year can lose significant tensile strength, whereas polyether urethanes retain most of their strength (Accelerated ageing of polyurethanes for marine applications). One study of two PU formulations in artificial seawater (40 Shore A and 90 Shore A hardness) found that while accelerated hot-water aging indicated some hydrolysis, extrapolation suggested **>100 year life at 20°C**, and actual 5-year sea immersion caused **0% strength loss** (Accelerated ageing of polyurethanes for marine applications). This is a strong validation that **modern marine PUs can be effectively immune to hydrolysis** in normal temperature conditions. However, if a polyurethane-bearing is used in higher-temperature service (near hot engines or in tropical waters >50°C), one must ensure the grade is hydrolysis-resistant to avoid gradual softening. Some manufacturers of composite bearings explicitly state that their product *"will not suffer from ... swelling from hydrolysis"* unlike "unstable thermoplastic polyurethane" alternatives (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). That statement likely targets older PU designs – it underscores the importance of selecting a stable, possibly thermoset PU formulation. In conclusion, hydrolysis can be a **non-issue** for PU in marine service if the correct formulation is used (polyether or fully cured thermoset), whereas a poorly selected PU could fail by hydrolysis. Industry practice now largely mitigates this risk.
- **Swelling:** Water absorption in a quality polyurethane is very low. Some PUs are even used for submarine cable jackets that cannot swell. One composite stern tube bearing (Duramax DuraBlue) notes an absorption rate of **≤0.09%** and essentially no swelling in seawater (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). Polyurethanes generally have slightly higher water absorption

- than EPDM or FKM, but we are talking fractions of a percent. Importantly, any slight swell that does occur in a PU is usually accommodated by design clearances. PU doesn't swell like a sponge; rather, it might take in a small amount of water and reach equilibrium. For practical purposes, **swelling is virtually negligible** for marine-grade PUs (especially compared to their thermal expansion or other tolerances). This is one reason PU bearings maintain their interference fit in housings reliably (some older rubber bearings could loosen if they swelled too much or if the backing shell and lining had different expansion rates – PU avoids that issue).
- **Biofouling:** Polyurethane is **resistant to biological attack**. As noted in a polyurethane supplier's marine use case, *"urethane elastomers resist hydrolysis and microbial attack"* in offshore applications (Best Urethane for Maritime Industry Uses | PSI). There are documented cases of microbial degradation of certain polyesters and polyethers in soil or waste water, but in seawater, PU holds up very well. Often, marine PUs are formulated with biocides or choose chemistries that inherently discourage microbial growth. Additionally, a bearing in motion is not a conducive surface for fouling. So, PU bearings do not suffer appreciable biofouling.
- **Durability and Use:** Because of their strength and water compatibility, **polyurethane-based bearings** (and composite bearings using PU matrices) have become popular for high-performance marine applications. For example, **Thordon Bearings** (a leading brand in water-lubricated bearings) uses a polymer alloy that is largely polyurethane-based, offering low friction and wear with a 15-year **wear life guarantee** in seawater service (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss). Another example is the **DMX polymer bearing** by Duramax, which is a hybrid PU alloy designed for gritty water – it showed *zero* shaft and bearing wear in tests with sand-loaded water (Duramax Marine: About Us). These illustrate that PU can outperform traditional rubber in longevity, especially in demanding conditions (high loads, contaminated water). One must be mindful of operating temperature and thermal buildup:

- very soft PUs can have higher internal hysteresis (heat generation) under cyclic loading, which could lead to thermal failure if not managed (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). But in well-engineered systems with proper water flow (cooling) and not exceeding design pressure-speed limits, PU bearings exhibit exceptional durability. They are type-approved by classification societies like ABS for use even at short bearing lengths (L/D ratios as low as 2:1) due to their high load capacity (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). In summary, polyurethane elastomers (properly formulated) are among the **best-suited materials for marine bearings** when one's priority is wear life and performance. They marry the low-swell, water-friendly nature of plastics with an elasticity similar to rubber, thus providing a unique combination of benefits. The slight trade-off is ensuring hydrolysis resistance and managing cost, but for many new ships, the performance gains outweigh these concerns.

## Fluoroelastomers (FKM, e.g. Viton)

- *Fluoroelastomers** such as Viton (a DuPont tradename for FKM) are polymers with fluorinated backbones (typically vinylidene fluoride co-polymers). They are known for outstanding chemical and temperature resistance. In marine contexts, FKM is most commonly used for O-rings, shaft seals, and valve seals, rather than bulk bearing linings. Nonetheless, evaluating FKM for seawater bearing service:

- **Saltwater Resistance:** FKM's resistance to seawater is **excellent**. It is essentially inert to water and salts – there is no swelling, no hydrolysis, and no ionic attack. Sources note that *"Viton offers excellent resistance to sea water, oils, and chemicals, making it a premium choice for critical sealing components in the marine industry"* (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...) (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). Unlike most other rubbers, FKM can also handle exposure to sour chemicals, fuels, and other fluids that might co-exist with seawater in certain machinery (e.g.

- oil in a stern tube). This broad chemical resilience means that if a bearing made of FKM were exposed to contaminated seawater (say with oil or solvents), it would likely be unfazed. Its ozone and UV resistance are also outstanding – FKM does not crack or degrade even in harsh sunlight or atmospheric conditions. In short, **no elastomer surpasses FKM in chemical and saltwater resistance**, which is why it's the go-to for high-end seals in marine and offshore environments (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...).

- **Mechanical Wear:** Fluoroelastomers are generally formulated to be fairly hard (typically 70–80 Shore A for seals). They have high tensile strength and decent elongation, but compared to a "rubbery" NBR or EPDM, FKM can feel a bit stiffer. In terms of friction and wear, FKM can perform well – Viton shaft seals run against stainless steel with low wear when lubricated. If used as a bearing liner, FKM would have low friction in water (it's quite smooth) and good wear resistance, *but* its relative lack of resilience might make it less able to embed grit or conform to misalignments. In dynamic applications that involve significant flexing, FKM is at a slight disadvantage: it has less rebound elasticity at low temperatures, so if a bearing sees shock loads, FKM might transmit more force or even crack if extremely cold. That said, at typical seawater temperatures (above, say, 5°C), this is usually not an issue. Fluoroelastomers also have high thermal stability, so they resist heat build-up and frictional heating better than most rubbers. Overall, one could rate FKM's wear capability as **good** – perhaps not *as forgiving* as nitrile or polyurethane under extreme conditions, but certainly robust enough for many sealing applications. There aren't many documented cases of FKM being used as a full bearing material (likely due to cost), but given its use in aggressive oilfield downhole tools (with high wear and chemical exposure), it's reasonable to say FKM would hold up well in a seawater bearing from a wear standpoint.

- **Hydrolysis:** FKM is immune to hydrolysis. There are no hydrolysable linkages in its heavily fluorinated carbon chain. Even superheated steam doesn't easily break down Viton (although very high-temperature steam can cause some loss of fluorine). In normal seawater, hydrolysis

- is not applicable. FKM will maintain its polymer integrity indefinitely in water.
- **Swelling:** Fluoroelastomers have extremely low swell in water (and in most fluids except certain amines). In fact, FKM is often used when seal swell must be near-zero. Thus, an FKM bearing or seal remains dimensionally stable – it won't absorb water. This property is comparable to EPDM's in water. For example, one guide compares EPDM vs Viton: both are rated *"Excellent"* for saltwater resistance, and Viton has only *moderate* flexibility in comparison (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...), but not an issue for swell. So we consider water swell **negligible** for FKM.
- **Biofouling:** The fluorinated nature of FKM makes it very inhospitable to microorganisms. They simply cannot metabolize it (it's like PTFE in that sense – extremely inert). Thus, FKM will not be biodegraded. It's also usually nonporous, so it doesn't support biofilm well. In essence, FKM has **excellent biofouling resistance** – it will remain unchanged by any kind of microbial presence.
- **Durability and Niche Use:** FKM is often described as "the most durable material" for extreme environments (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). In marine settings, it finds use in **high-performance seals** such as stern tube lip seals, pump seals, and valves that see both seawater and oil or high temperatures. For instance, in offshore drilling equipment, FKM O-rings are used where seawater, brine, and hydrocarbons mix, and they ensure reliable sealing where other elastomers would fail. However, due to cost and some mechanical limitations, FKM is *not* commonly used as the main bearing lining in large marine bearings. Its cost is many times that of NBR or EPDM, and typically a marine bearing requires a significant volume of material. Instead, one might see FKM used in smaller bushings or special cases where chemical resistance is paramount. For example, a chemical tanker's cargo pump might use FKM bushings if it handles both seawater ballast and cargo chemicals. In summary, **fluoroelastomers are over-engineered for most water-lubricated bearing needs** – they absolutely fulfill the saltwater, low-swell,

- durability requirements (even exceeding them), but their high cost and stiffness mean they’re usually reserved for critical *sealing* applications in marine systems (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). When used appropriately, they provide maintenance-free longevity even in the harshest conditions, justifying their use for critical seals and gaskets in marine engines and offshore platforms (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...).

The table below summarizes the performance of these elastomers across key properties relevant to seawater marine bearings:

## Comparison of Elastomer Properties in Seawater Bearings

| **Elastomer** | **Saltwater Resistance** | **Wear Resistance** | **Hydrolysis Stability** | **Water Swell** | **Biofouling Resistance** | **Typical Use & Notes** |

|--------------|-------------------------|--------------------|-------------------------|-----------------|--------------------|----------------|

| **Nitrile (NBR)** | Good – resists seawater (some ozone sensitivity, but underwater OK) (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). | Excellent – very high abrasion and tear resistance (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). | Excellent (no hydrolysable groups). | Low – minimal water absorption/swell (Nitrile vs. Neoprene: Which Rubber Material Is Best? | Thoams A. Caserta). | Moderate – organic rubber; long-term microbial growth possible but rare. | Widely used in ship stern tube bearings (Study on wear behaviour and wear model of nitrile butadiene rubber under water lubricated conditions | Request PDF) (90% of US Navy vessels) (Duramax Marine: About Us). Proven durability, but avoid ozone exposure during idle periods. |

| **Hydrogenated Nitrile (HNBR)** | Excellent – similar to NBR in water, plus superior ozone/aging resistance (HNBR vs. NBR | R.E. Purvis). | Excellent – improved tensile and abrasion strength vs NBR (HNBR vs. NBR | R.E. Purvis). | Excellent. | Low. | Moderate. | Used for high-performance seals/bearings; longer life in harsh conditions than NBR (HNBR vs. NBR | R.E. Purvis). Higher cost limits large-scale use. |

| **Neoprene (CR)** | Moderate – withstands saltwater, but not as long-term durable as EPDM or Viton (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...) (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). | Very Good – high resistance to wear and impact (Best Rubber Types for Marine Use – EPDM, Neoprene & Silicone). | Excellent. | Low – slight swell only. | Moderate – resists fungus; some biofilm possible. | Common in marine gaskets, hoses, *impeller* pumps. Good all-around marine durability, though EPDM/Viton last longer in continuous seawater (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). |

| **EPDM** | Excellent – outstanding saltwater, UV, and ozone resistance (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). | Good – strong against abrasion and flexing (stays flexible in cold) (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). | Excellent. | Negligible – essentially no swelling in water (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket). | Good – inert polymer, doesn't support microbial growth. | Preferred for long-life seals and water-only bearings (no oil) (Best Rubber Types for Marine Use – EPDM, Neoprene & Silicone). Extremely stable in marine environments; cannot tolerate oils/grease. |

| **Polyurethane (PU)** | Excellent – marine-grade PUs resist saltwater and chemicals (Best Urethane for Maritime Industry Uses | PSI). | **Outstanding** – superior abrasion and load capacity (Best Urethane for Maritime Industry Uses | PSI). | Variable – **must use hydrolysis-resistant** formulations (Accelerated ageing of polyurethanes for marine applications) (polyether-based); these give excellent stability (100% strength retention after 5 yrs seawater) (Accelerated ageing of polyurethanes for marine applications). | Very Low – ≤0.5% water absorption in advanced composites (Duramax Advanced Bearings: DuraBlue Composite Stern

Tube Bearing). | Very Good – resists microbial attack when formulated for marine (Best Urethane for Maritime Industry Uses | PSI). | Used in advanced water-lubricated bearings (e.g. Thordon®) for **high wear performance** (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss). Offers long service life; ensure polyether/thermoset grade to prevent hydrolysis (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). |

| **Fluoroelastomer (FKM, Viton)** | Excellent – inert to seawater, salts, oils (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). | Good – strong and stable; slightly less elastic at low temp. | Excellent. | Negligible. | Excellent – highly resistant to bio-attack (fluorinated polymer). | Used in O-rings and critical seals in marine engines & valves (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...). Extreme durability in harsh conditions (Best Rubber Materials for Sea Water Exposure –EPDM,Viton...); high cost typically precludes use as bulk bearing material. |

- *Table:** Qualitative comparison of elastomer properties for marine (seawater) bearing applications. (Ratings: Excellent ≫ Good > Moderate). References indicate source support for stated performance.

# Marine Standards and Guidelines

Marine industry standards provide guidelines and test criteria to ensure elastomeric bearing materials will perform reliably. For example, the **U.S. Navy's MIL-DTL-17901C (SH)** specification covers water-lubricated rubber bearing components. It prescribes tests like limiting friction coefficients under certain loads and speeds, and endurance tests in abrasive seawater conditions (A new rubber/UHMWPE alloy for water-lubricated stern bearings ...). New elastomer-based materials (including composites) are often benchmarked against this spec – for instance, a novel NBR/UHMWPE composite achieved only ~50% of the maximum friction allowed by MIL-DTL-17901C (A new rubber/UHMWPE alloy for water-lubricated stern bearings ...), indicating excellent performance.

Classification societies (like **DNV, ABS, Lloyd’s Register**) require that any bearing material used in critical applications (propeller shaft bearings, rudder bearings) be approved or certified. Typically, manufacturers must demonstrate that the elastomer or polymer bearing meets certain criteria: minimal swelling in seawater, adequate compressive strength, and acceptable wear rate. For instance, ABS has **type-approved** composite and elastomer bearings for stern tubes – the Duramax DuraBlue composite (a thermoset PU/fiber material) is ABS-approved for use even at short L/D ratios, having shown <0.5% water absorption and high load capability (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing) (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing).

International standards also provide testing methodologies. **ASTM D471** (rubber property – effect of liquids) is used to measure volume swell of elastomers in seawater or oil. **ASTM D570** is used for water absorption of polymer samples. Wear resistance can be evaluated by tests like ASTM D5963 (abrasion) or custom tribometers in water. **ISO 9001** quality standards are often cited by manufacturers to indicate consistent production of marine-grade elastomers (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing). While there may not be an ISO specifically dictating “marine bearing elastomer material”, ISO and ASTM standards on elastomeric bearings (for bridges, seismic isolators, etc.) are sometimes referenced for mechanical property requirements analogously.

In practice, marine design guidelines (such as from **DNV Rules for Ships**) will recommend using proven materials (e.g., nitrile rubber or approved composites) for water-lubricated bearings and to follow manufacturers’ limits on pressure and PV (pressure-velocity) factors. Maintenance guidelines stress keeping the water clean (filtered) to reduce abrasive wear (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss) and periodic inspection for any swelling or delamination. When these guidelines and standards are adhered to, elastomeric marine bearings have demonstrated excellent reliability and environmental benefits (no oil leakage).

# Conclusion

Elastomeric materials have proven indispensable for marine bearings in seawater-lubricated systems, offering a combination of resilience, shock absorption, and compatibility with water that metal bearings cannot. Among the common options, **Nitrile (NBR)** remains widely used due to its robust wear resistance, impact strength, and long track record in applications like stern tube bearings (Study on wear behaviour and wear model of nitrile butadiene rubber under water lubricated conditions | Request PDF). **Neoprene** also serves well for general-purpose marine hardware, though it's gradually overshadowed by EPDM in purely water applications. For the **best saltwater durability**, **EPDM** and **Fluoroelastomers (FKM)** stand out – these materials exhibit virtually no degradation or swelling even after years in seawater, making them ideal for long-term seals and low-stress bearings. EPDM in particular is a cost-effective choice for any water-exposed component that doesn't see oil (EPDM vs Neoprene: Pick the Best Synthetic Rubber for Your Gasket).

When it comes to **high-load, high-wear bearings**, **Polyurethane**-based elastomers have emerged as the top performers. They deliver order-of-magnitude improvements in wear life and can handle gritty or severe conditions that might abrade traditional rubber (Best Urethane for Maritime Industry Uses | PSI). Modern PU bearings, formulated to resist hydrolysis, combine excellent seawater stability with superior mechanical properties – evidenced by their adoption in critical propulsion systems (with multi-year guarantees and class approvals) (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss) (Duramax Advanced Bearings: DuraBlue Composite Stern Tube Bearing).

In summary, the **optimal elastomer for a marine bearing** depends on the specific service conditions:

- For *pure seawater, moderate speed/load* (e.g. small boat stern tubes, rudder bearings), **EPDM** offers a great balance of longevity and reliability, given its unbeatable resistance to salt, ozone, and aging.

- For *higher load or abrasive conditions*, a **marine-grade Polyurethane** or composite is often best, due to its wear resistance and strength, provided hydrolysis-stable grades are used.
- **Nitrile rubber** continues to be a sound choice for general water-lubricated bearings, especially if there's any chance of oil contamination (since NBR tolerates a bit of oil whereas EPDM would fail). It's also cost-effective and has decades of service proof. Upgrading to **HNBR** can further extend life where budget allows, thanks to its improved heat/oxidation tolerance.
- **Fluoroelastomers** are typically reserved for specialized seals but can be considered in scenarios requiring extreme chemical resistance in a marine bearing (for example, exposure to solvents or very high temperatures alongside seawater). They will provide longevity, although at a high cost.

All these elastomers, when properly engineered and tested, **meet marine standards** and contribute to safer, oil-free propulsion systems. By selecting the appropriate elastomer and following guidelines (e.g., ensuring water quality, adhering to design PV limits), marine engineers can achieve a bearing that delivers low friction, minimal wear, and long-term durability in seawater – enabling "green" lubrication systems that avoid oil pollution (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss) (Riviera - News Content Hub - Water-lubricated sterntube bearings combat oil loss). The continued evolution of materials (like nano-filled HNBR composites (Tribological modification of hydrogenated nitrile rubber nanocomposites for water-lubricated bearing of ship stern shaft | CoLab) (Tribological modification of hydrogenated nitrile rubber nanocomposites for water-lubricated bearing of ship stern shaft | CoLab) or fiber-reinforced PU matrices) promises even better performance, ensuring elastomers remain at the forefront of marine bearing technology for the foreseeable future.

- *Sources:** The information above is drawn from a combination of marine materials handbooks, industry publications, and research studies. Key references include performance data from rubber

- manufacturers and naval engineering studies (e.g., tribological tests on NBR stern tube bearings (Study on wear behaviour and wear model of nitrile butadiene rubber under water lubricated conditions | Request PDF) (Study on wear behaviour and wear model of nitrile butadiene rubber under water lubricated conditions | Request PDF), long-term seawater aging research on polyurethanes (Accelerated ageing of polyurethanes for marine applications), and marine standard documents (A new rubber/UHMWPE alloy for water-lubricated stern bearings ...)), as well as guidelines from marine classification societies and bearing OEMs. These have been cited throughout to provide evidence for each elastomer's performance claims.

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