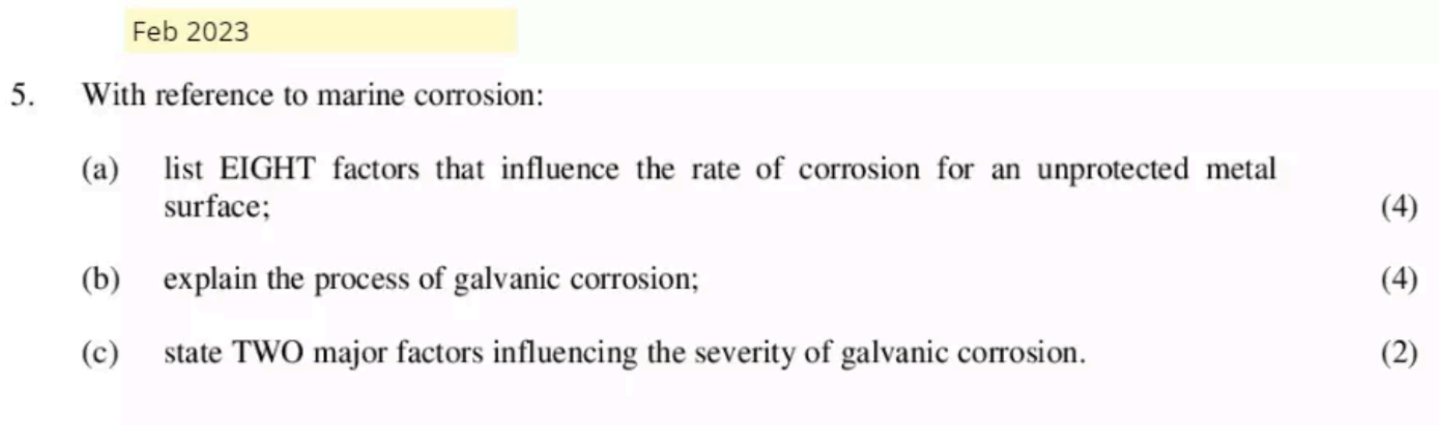
Marine Corrosion Galvanic Stress Corrosion



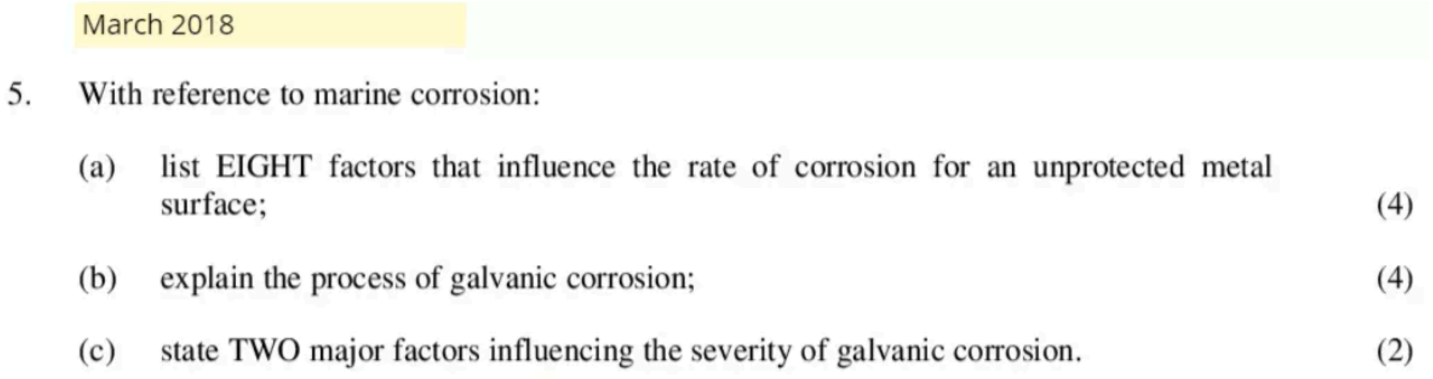
Feb 2023

5. With reference to marine corrosion:

(a) list EIGHT factors that influence the rate of corrosion for an unprotected metal surface; (4)

(b) explain the process of galvanic corrosion; (4)

(c) state TWO major factors influencing the severity of galvanic corrosion. (2)



March 2018

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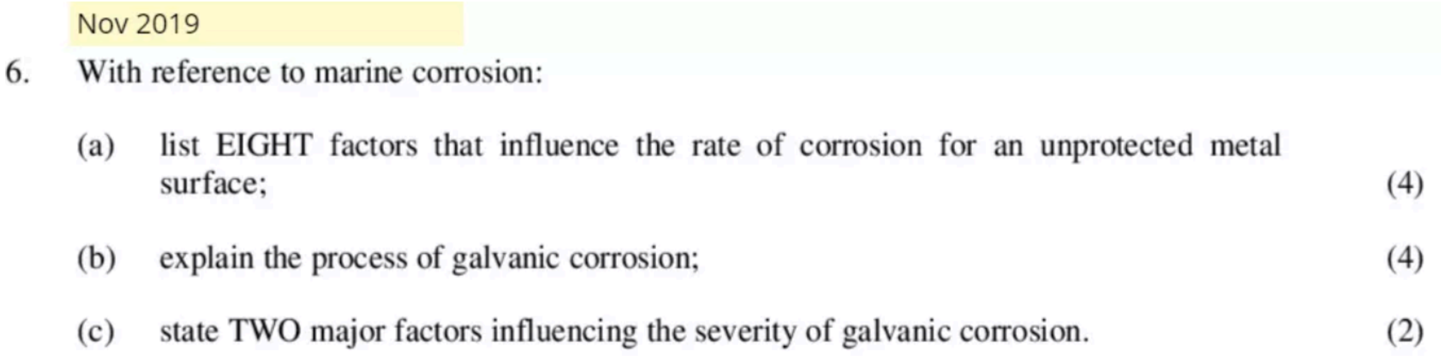

Nov 2019

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(b) explain the process of galvanic corrosion; (4)

(c) state TWO major factors influencing the severity of galvanic corrosion. (2)

(a) Eight Factors Influencing Corrosion Rate:

1. Salinity: Higher salinity in seawater leads to increased conductivity and promotes faster ionic movement, accelerating corrosion.
2. Temperature: Warmer water generally increases corrosion rates due to higher ionic mobility and chemical reaction kinetics.
3. Dissolved Oxygen: Oxygen acts as a cathodic reactant in the corrosion process, and higher dissolved oxygen levels in seawater intensify corrosion.
4. pH Level: Acidic (lower pH) environments accelerate corrosion, while alkaline (higher pH) environments can offer some protection.
5. Biological Activity: Marine organisms like barnacles and bacteria can create micro-environments that promote localized corrosion.
6. Water Flow Rate: Higher water flow can remove corrosion products and expose fresh metal to the corrosive environment, increasing the rate.
7. Metal Properties: Different metals have varying corrosion resistance based on their inherent properties and electrochemical potentials.

8. Stress and Surface Condition: Stresses and rough surfaces can act as initiation points for corrosion and accelerate the process.

(b) Galvanic Corrosion Explained:

Galvanic corrosion occurs when two dissimilar metals are in electrical contact and immersed in a conductive electrolyte, like seawater. Here's the process:

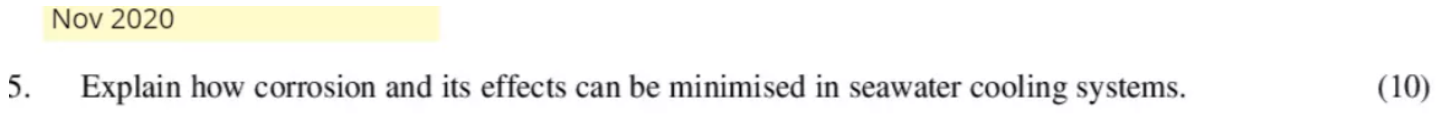
1. Potential Difference: The metals have different electrochemical potentials, creating a voltage difference between them.
2. Anode & Cathode Formation: The more active metal (lower potential) becomes the anode, where metal atoms ionize and release electrons.
3. Electron Flow: The released electrons flow through the conducting path (seawater) to the less active metal (higher potential), the cathode.
4. Cathodic Reaction: Electrons react with oxygen and water at the cathode, forming hydroxyl ions.
5. Metal Ion Movement: The metal ions from the anode migrate through the electrolyte towards the cathode.
6. Corrosion & Precipitation: At the cathode, the metal ions combine with hydroxyl ions to form insoluble metal hydroxides, which appear as corrosion products.

This cycle continues, with the anode corroding faster than it would alone, while the cathode is protected.

(c) Two Major Factors Influencing Severity of Galvanic Corrosion:

1. Potential Difference: The greater the difference in electrochemical potential between the two metals, the faster and more severe the galvanic corrosion.
2. Conductivity of the Electrolyte: Increased conductivity of the electrolyte (e.g., saltier seawater) facilitates higher electron flow and intensifies the corrosion process.

Understanding these factors and processes is crucial for mitigating marine corrosion. Using materials with similar potentials, applying protective coatings, and employing cathodic protection are some approaches used to combat this damaging phenomenon in marine environments.



Nov 2020

5. Explain how corrosion and its effects can be minimised in seawater cooling systems. (10)

Minimizing corrosion and its effects in seawater cooling systems is crucial for maintaining system integrity, efficiency, and longevity. Here are some key strategies:

Preventing Corrosion:

- Material Selection: Choosing corrosion-resistant materials like stainless steel, copper-nickel alloys, or titanium can significantly reduce corrosion rates. While initially more expensive, their long-term cost-effectiveness outweighs frequent maintenance and replacements.
- Seawater Treatment: Pre-treating seawater before it enters the system can remove harmful elements like dissolved oxygen, chlorides, and sulfates, reducing their corrosive potential. Techniques like deaeration, filtration, and chemical dosing can be employed.
- Protective Coatings: Applying specialized coatings like epoxy resins, polyurethanes, or zinc primers can create a physical barrier between the metal and the seawater, further diminishing corrosion. However, regular inspection and reapplication may be necessary.
- Cathodic Protection: Impressing a small current on the metal surface can shift its potential, making it cathodic and preventing oxidation. This can be achieved through sacrificial anodes (e.g., zinc) that corrode instead of the system components, or impressed current systems.

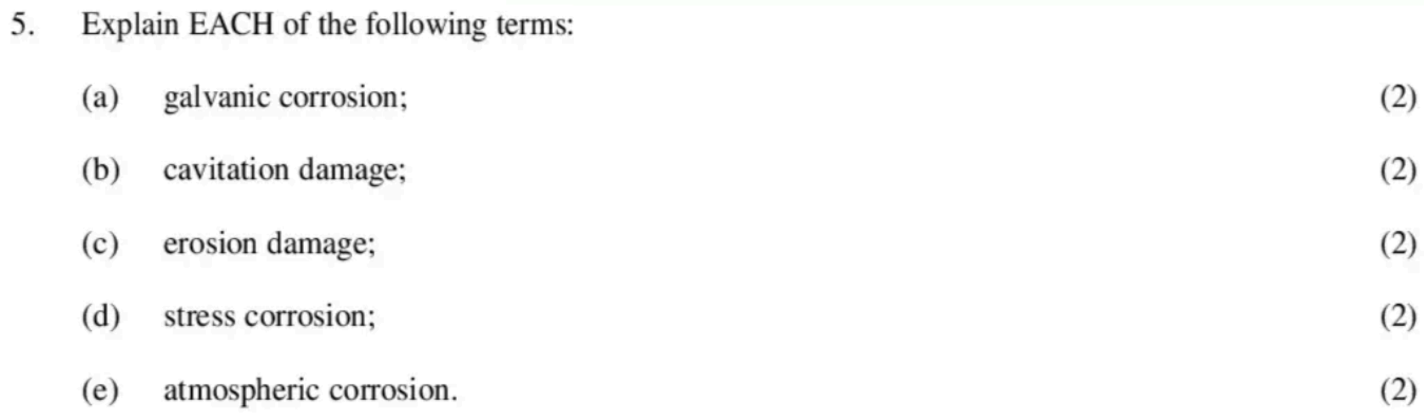
Monitoring and Mitigation:

- Regular Inspections: Regularly inspecting the system for signs of corrosion, such as pitting, scaling, or cracks, allows for early detection and intervention. Visual inspections can be supplemented with ultrasonic testing, eddy current testing, or other non-destructive techniques.
- Cleaning and Maintenance: Periodically cleaning and removing corrosion products like barnacles and biofilms can prevent them from accelerating corrosion and improve heat transfer efficiency. Chemical or mechanical cleaning methods can be utilized depending on the severity of the buildup.
- Flow Optimization: Maintaining proper flow rate through the system ensures continuous removal of corrosion products and prevents stagnant zones where corrosion can become concentrated. Optimize pump operation and pipe configurations to achieve ideal flow patterns.

Additional Measures:

- Galvanic Isolation: Avoid direct contact between dissimilar metals within the system, as it can lead to galvanic corrosion. Use insulating materials or design modifications to prevent electrical connections between incompatible metals.
- Biofouling Control: Implement biofouling control measures like chlorination or ultraviolet treatment to prevent marine organisms from colonizing the system and contributing to localized corrosion.
- Operational Adjustments: Optimizing operating parameters like temperature, pH, and pressure can further minimize corrosion rates. Consult material specifications and corrosion charts for appropriate operating ranges.

June 2019



5. Explain EACH of the following terms:

(a) galvanic corrosion; (2)

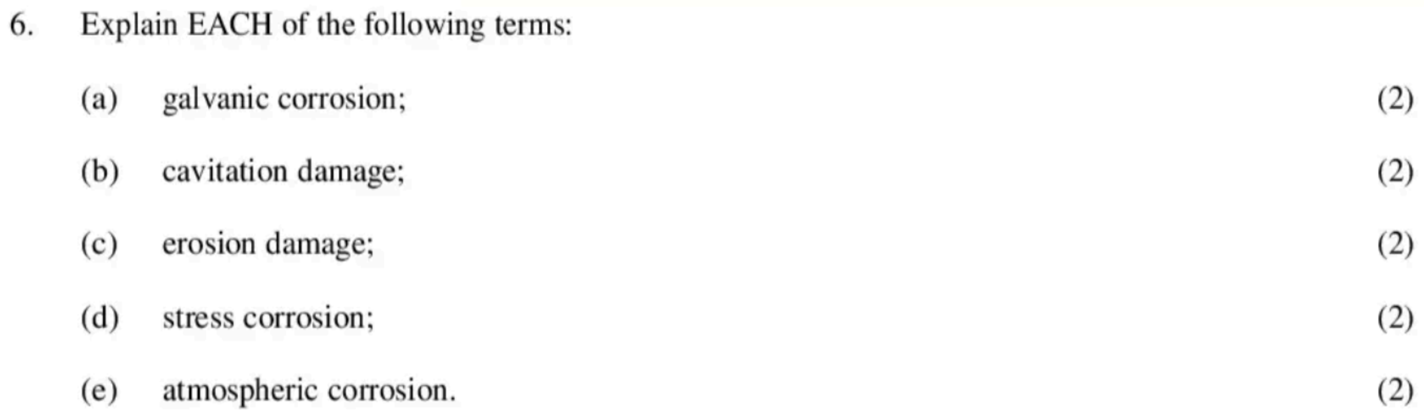
(b) cavitation damage; (2)

(c) erosion damage; (2)

(d) stress corrosion; (2)

(e) atmospheric corrosion. (2)

March 2021



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(a) galvanic corrosion; (2)

(b) cavitation damage; (2)

(c) erosion damage; (2)

(d) stress corrosion; (2)

(e) atmospheric corrosion. (2)

a) Galvanic Corrosion: Imagine a scenario where two dissimilar metals touch and are immersed in a conductive solution (electrolyte) like seawater. This seemingly innocent contact can trigger a treacherous process called galvanic corrosion. Here's what happens:

1. Dissimilar Potentials: Each metal has its own "electrical potential," like a battery, but at different levels. The more active metal (lower potential) acts as the anode, while the less active one (higher potential) becomes the cathode.
2. Electron Flow: Driven by the potential difference, electrons flow from the anode (active metal) through the electrolyte to the cathode (less active metal).
3. Metal Dissolves: At the anode, metal atoms lose electrons and dissolve into the electrolyte as ions. This is where corrosion occurs, eating away at the anode metal.
4. Cathodic Reaction: Electrons reaching the cathode react with the electrolyte (usually oxygen and water) to form harmless compounds like hydroxide ions.

This cycle continues, relentlessly corroding the anode while protecting the cathode. The severity depends on factors like the potential difference between the metals and the conductivity of the electrolyte. Avoiding direct contact between dissimilar metals, using sacrificial anodes (made of even more active metals), or applying protective coatings are some ways to combat galvanic corrosion.

(b) Cavitation Damage: Picture a fast-flowing fluid swirling around an object, creating bubbles due to pressure drops. When these bubbles collapse violently near a solid surface, the impact sends miniature shockwaves, like microscopic explosions. This phenomenon is called cavitation, and its destructive force can cause significant damage, aptly named cavitation damage.

The shockwaves erode the surface, creating pits, grooves, and rough patches. This type of damage is particularly common in propellers, turbine blades, and other components exposed to high-speed liquids. Materials with better tensile strength and resistance to fatigue are preferred to combat cavitation. Additionally, optimizing fluid flow and reducing pressure fluctuations can help mitigate the problem.

(c) Erosion Damage: Erosion in the context of materials describes the gradual removal of surface material by the abrasive action of a fluid or solid particles. Imagine sandblasting against a metal surface – that's essentially erosion damage. It can manifest as scratches, grooves, or even complete wear-through in severe cases.

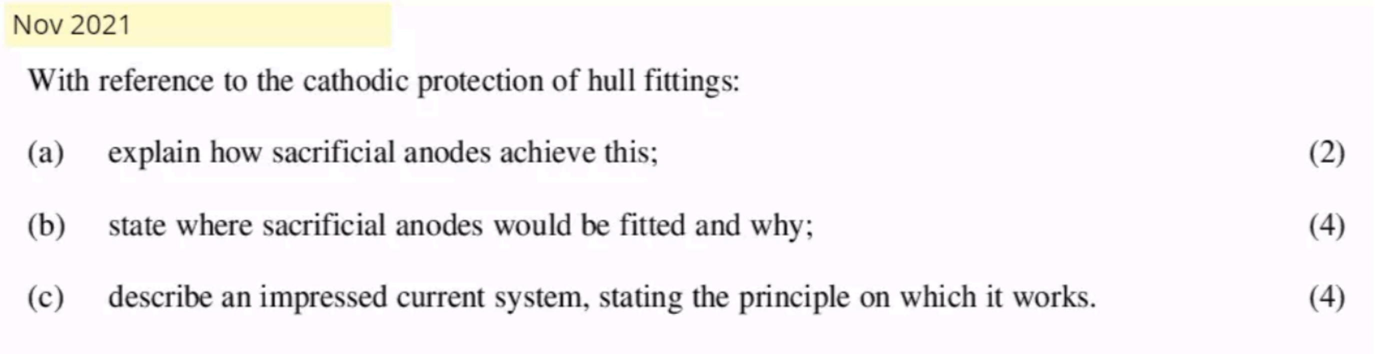
Pipelines, pumps, valves, and other components exposed to fluid flow with solid particles, like slurries or sand-laden water, are particularly susceptible to erosion damage. Choosing abrasion-resistant materials, modifying designs to reduce flow velocity and particle impact, and implementing protective coatings are crucial to prevent this type of wear and tear.

(d) Stress Corrosion: Imagine a metal under constant stress, like a bridge bearing the weight of vehicles. This stress, combined with a specific corrosive environment, can lead to a type of localized attack called stress corrosion. It's like a double whammy, where the stress weakens the metal and the corrosive environment exploits these weaknesses, leading to cracks and fractures.

Certain materials are more susceptible to stress corrosion in specific environments. For example, stainless steel under chloride stress in seawater is a classic example. Identifying potential stress factors and corrosive environments, choosing resistant materials, and employing stress-relieving techniques are essential to manage this type of damage.

(e) Atmospheric Corrosion: This is the most common type of corrosion, the one we see daily on everyday objects exposed to the elements. Rain, wind, sunlight, and pollutants in the air combine to form a constantly fluctuating corrosive environment. The process usually involves oxidation, where metal atoms react with oxygen in the air, forming oxides like rust on iron or patina on copper.

Atmospheric corrosion rates vary depending on the metal, the specific environment (coastal areas tend to be more corrosive), and protective measures like coatings or surface treatments. Regularly cleaning and maintaining surfaces, choosing corrosion-resistant materials, and applying protective coatings are effective strategies to minimize atmospheric corrosion.



Nov 2021

5. With reference to the cathodic protection of hull fittings:

(a) explain how sacrificial anodes achieve this; (2)

(b) state where sacrificial anodes would be fitted and why; (4)

(c) describe an impressed current system, stating the principle on which it works. (4)

Protecting the Underwater Warriors: Unveiling Cathodic Protection of Hull Fittings

(a) Sacrificial Anodes: Guardians of the Hull:

Imagine these gallant knights, made of zinc or aluminum, standing guard on the hull, sacrificing themselves to protect the nobler metals around them. These are sacrificial anodes, the champions of cathodic protection for hull fittings. They work by creating a galvanic cell with the steel hull:

1. Potential Difference: Sacrificial anodes have a lower electrochemical potential than the steel hull. This creates a voltage difference between them.
2. Anode & Cathode Formation: The anode becomes the anode, readily releasing electrons and dissolving into ions. The steel hull becomes the cathode, attracting electrons.
3. Electron Flow: Electrons flow from the anode through the conductive seawater to the cathode (hull).
4. Cathodic Reaction: Electrons at the cathode react with oxygen and water to form harmless compounds like hydroxide ions.

This cycle essentially shifts the corrosion away from the hull onto the sacrificial anode. As the anode corrodes, it gradually shrinks, eventually needing replacement. But during its noble sacrifice, it protects the vital hull from the ravages of corrosion.

(b) Strategic Positioning: Protecting the Vulnerable:

Like wise generals placing their troops, sacrificial anodes are strategically positioned on the hull, focusing on areas most susceptible to corrosion:

- Propeller: The spinning propeller creates turbulence, accelerating corrosion. Anodes near the propeller ensure its protection.
- Rudder and Stern: These areas experience high water flow and stress, making them vulnerable. Strategically placed anodes shield them.
- Seawater Inlets and Outlets: Where water enters and exits the hull, corrosion risk is high. Anodes protect these crucial points.
- Bilge keels: These protrusions on the hull bottom are prone to corrosion, and anodes strategically placed underneath offer protection.

By placing anodes in these vulnerable areas, we ensure the vital parts of the hull remain shielded from corrosion, extending their lifespan and safeguarding the vessel's integrity.

(c) Impressed Current Systems: Engineered Protection:

For situations where sacrificial anodes aren't sufficient, or for more precise control, an impressed current system can be employed. This system operates based on the same principle of cathodic protection but uses an external power source:

1. Reference Electrode: A reference electrode measures the hull's potential against seawater.
2. Control Unit: The control unit analyzes the potential and adjusts the current output from a DC power source.
3. Anode: A specially designed anode, often made of platinum or graphite, releases current into the seawater.
4. Electron Flow: The current flows from the anode through the seawater to the hull, making it the cathode.
5. Cathodic Reaction: Similar to sacrificial anodes, electrons on the hull react with oxygen and water to form harmless compounds.

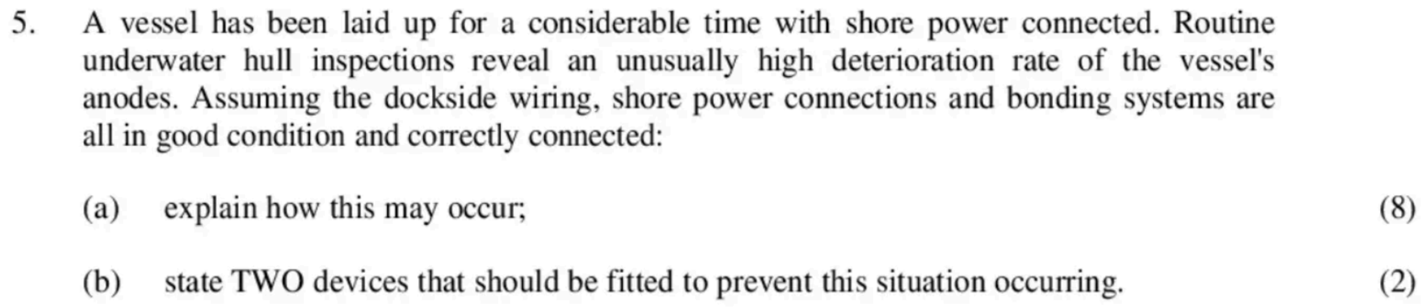
By adjusting the current output, the system can precisely control the cathodic protection over the entire hull surface. This offers advantages like:

- Tailored Protection: Adjusting the current allows for customized protection for different hull areas and materials.
- Longer Anode Life: Impressed current systems can use non-sacrificial anodes, which last much longer than sacrificial ones.
- Remote Monitoring: The system can be monitored and controlled remotely, simplifying maintenance and adjustments.

However, impressed current systems are more complex and require additional maintenance compared to sacrificial anodes. Choosing the right approach depends on the size and complexity of the vessel, specific corrosion risks, and operational requirements.

Remember, both sacrificial anodes and impressed current systems play crucial roles in protecting hull fittings from corrosion, ensuring the safety and longevity of vessels navigating the watery depths.

March 2022



5. A vessel has been laid up for a considerable time with shore power connected. Routine underwater hull inspections reveal an unusually high deterioration rate of the vessel's anodes. Assuming the dockside wiring, shore power connections and bonding systems are all in good condition and correctly connected:

(a) explain how this may occur; (8)

(b) state TWO devices that should be fitted to prevent this situation occurring. (2)

Unraveling the Mystery of Accelerated Anode Deterioration in a Laid-Up Vessel:

(a) Possible Explanations for High Anode Deterioration:

Even with seemingly perfect shore power and bonding systems, an unusually high anode deterioration rate on a laid-up vessel can occur due to several reasons:

1. Reduced Oxygen Levels: When a vessel is laid up, stagnant water near the hull can have reduced oxygen levels. This creates an environment conducive to anaerobic bacteria, which can accelerate corrosion by directly attacking the metal, leading to faster anode consumption.
2. Cathodic Disbondment: If the shore power system isn't fully isolated from the boat's internal electrical system, stray currents can flow through the hull, causing localized corrosion called cathodic disbondment. This can happen due to faulty wiring, grounding issues, or inadequate bonding connections.
3. Galvanic Interactions with Nearby Vessels: If other vessels with dissimilar hull materials are docked closely, galvanic corrosion can occur between the hulls through the conductive seawater. This can drain current from the vessel's anodes, accelerating their deterioration.
4. Improper Anode Selection or Positioning: Anodes may not be chosen for the specific water conditions or correctly positioned to offer adequate protection. For example, using zinc anodes in brackish water or placing them too far apart from the areas needing protection can lead to faster consumption.

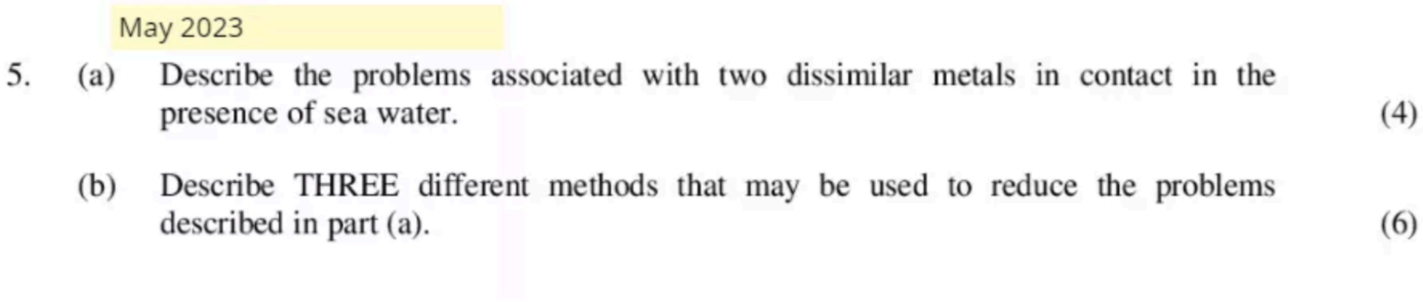
(b) Devices to Prevent Anode Deterioration:

To protect against these scenarios and prolong anode life, two primary devices should be considered:

1. Cathodic Protection Monitoring System: This system continuously monitors the current flowing between the anodes and the hull, providing early detection of any abnormal changes. It can alert for issues like reduced oxygen levels, stray currents, or insufficient protection, allowing for timely corrective action to prevent excessive anode deterioration.
2. Isolation Transformer: This device electrically isolates the vessel's internal electrical system from the shore power supply, preventing stray currents from flowing through the hull and causing unintended cathodic disbondment. This ensures the cathodic protection system operates effectively with minimal anode consumption.

By implementing these devices and regularly monitoring the situation, you can maintain optimal cathodic protection for the vessel's hull, even during lay-up periods, significantly extending the lifespan of the anodes and reducing maintenance costs.

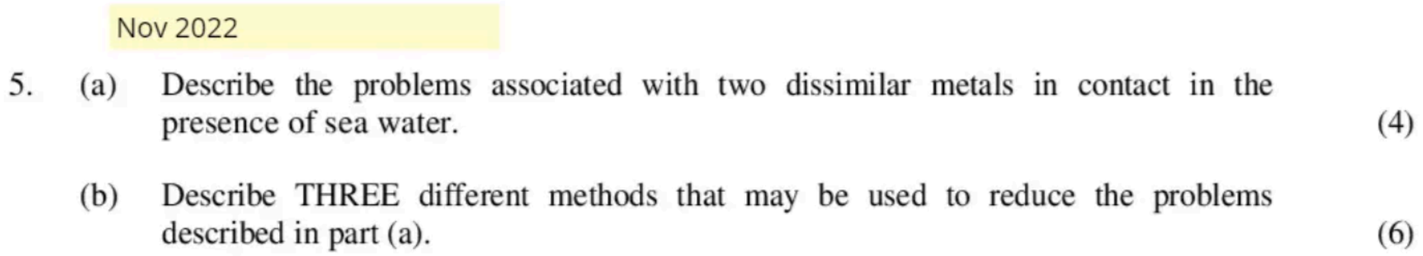
Remember, a thorough investigation into the specific circumstances and an assessment by a qualified marine electrician are crucial to accurately diagnose the cause of the accelerated anode deterioration and implement the most effective preventative measures.



May 2023

5. (a) Describe the problems associated with two dissimilar metals in contact in the presence of sea water. (4)

(b) Describe THREE different methods that may be used to reduce the problems described in part (a). (6)



Nov 2022

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(b) Describe THREE different methods that may be used to reduce the problems described in part (a). (6)

Dissimilar Metals in Seawater: A Recipe for Corrosion Trouble

(a) Problems with Dissimilar Metals in Seawater:

When two dissimilar metals come into contact in the presence of seawater, a recipe for corrosion disaster is brewed. Here's why:

1. Galvanic Corrosion: The primary culprit is galvanic corrosion. Dissimilar metals have different electrochemical potentials, meaning they possess varying tendencies to give up electrons and corrode. The more active metal (lower potential) acts as the anode, readily losing electrons and dissolving into the seawater. The less active metal (higher potential) becomes the cathode, attracting these electrons and remaining protected. This "sacrificial" process rapidly corrodes the anode metal.

2. Increased Corrosion Rate: Seawater acts as an excellent electrolyte, facilitating the flow of electrons between the metals. This significantly accelerates the corrosion process compared to each metal exposed to seawater alone.

3. Localized Corrosion: The corrosion often concentrates at the point of contact between the metals, creating deep pits and grooves. This localized attack can weaken the structure and compromise the integrity of the components.

4. Stress Corrosion Cracking: In some cases, the combined effect of stress and the corrosive environment can lead to stress corrosion cracking. This can cause sudden and catastrophic failures, especially in critical components like propellers or shafts.

(b) Reducing the Problems of Dissimilar Metal Contact:

Fortunately, several methods can be employed to reduce or eliminate the problems associated with dissimilar metals in seawater:

1. Material Selection: Choosing metals with similar electrochemical potentials minimizes the potential difference and significantly reduces the driving force for galvanic corrosion. This can be achieved by using stainless steel alloys, copper-nickel alloys, or even plastic components in strategic locations.

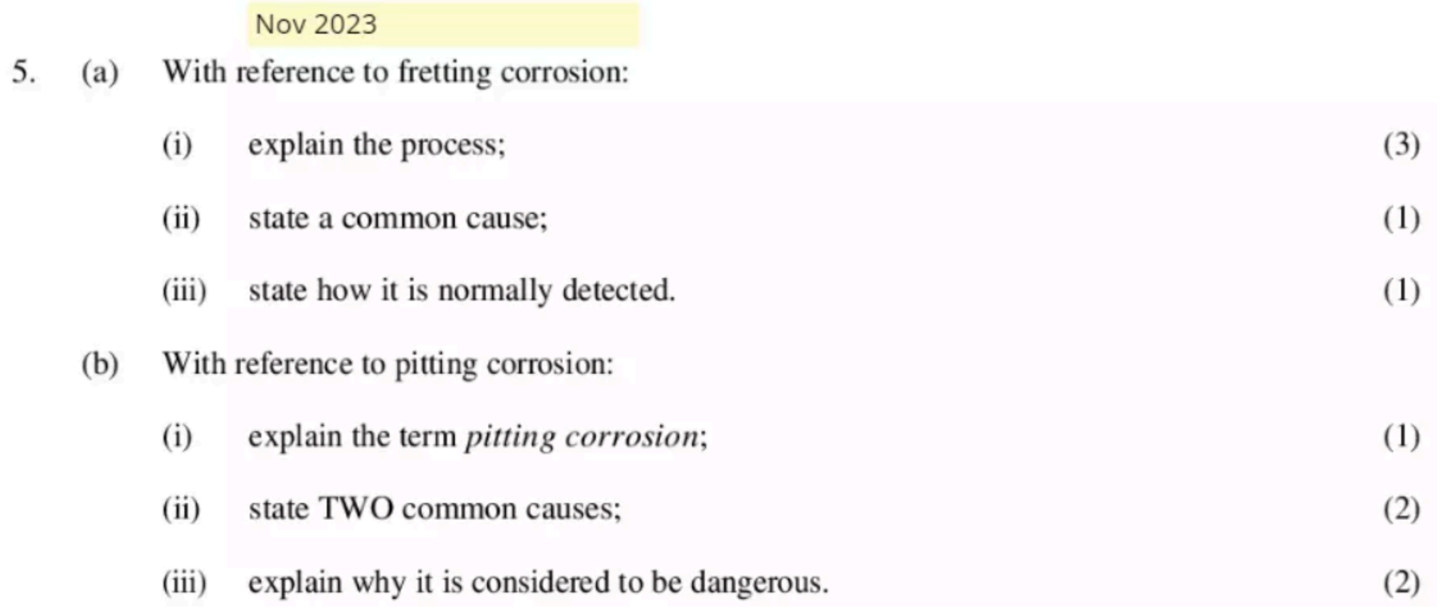
2. Cathodic Protection: This method actively protects the more active metal by applying an external current that shifts its potential to become cathodic. Sacrificial anodes (made of even more active metals) or impressed current systems can be used to achieve this.

3. Electrical Isolation: In some cases, it's possible to physically isolate the dissimilar metals from each other through non-conductive coatings, gaskets, or washers. This prevents direct electrical contact and eliminates the pathway for galvanic currents to flow.

4. Protective Coatings: Applying specialized coatings like epoxy resins, polyurethanes, or zinc primers can create a barrier between the metal and the seawater, further mitigating corrosion. However, regular inspection and reapplication may be necessary.

By carefully considering these methods and choosing the appropriate approach for your specific application, you can effectively minimize the problems associated with dissimilar metals in seawater and ensure the longevity and integrity of your marine structures and equipment.

Remember, corrosion is a constant threat in marine environments, and proactive measures are crucial for keeping your vessels and components safe and operational. Don't hesitate to consult with experienced professionals and choose the solution that best suits your needs and budget.



Nov 2023

5. (a) With reference to fretting corrosion:

(i) explain the process; (3)

(ii) state a common cause; (1)

(iii) state how it is normally detected. (1)

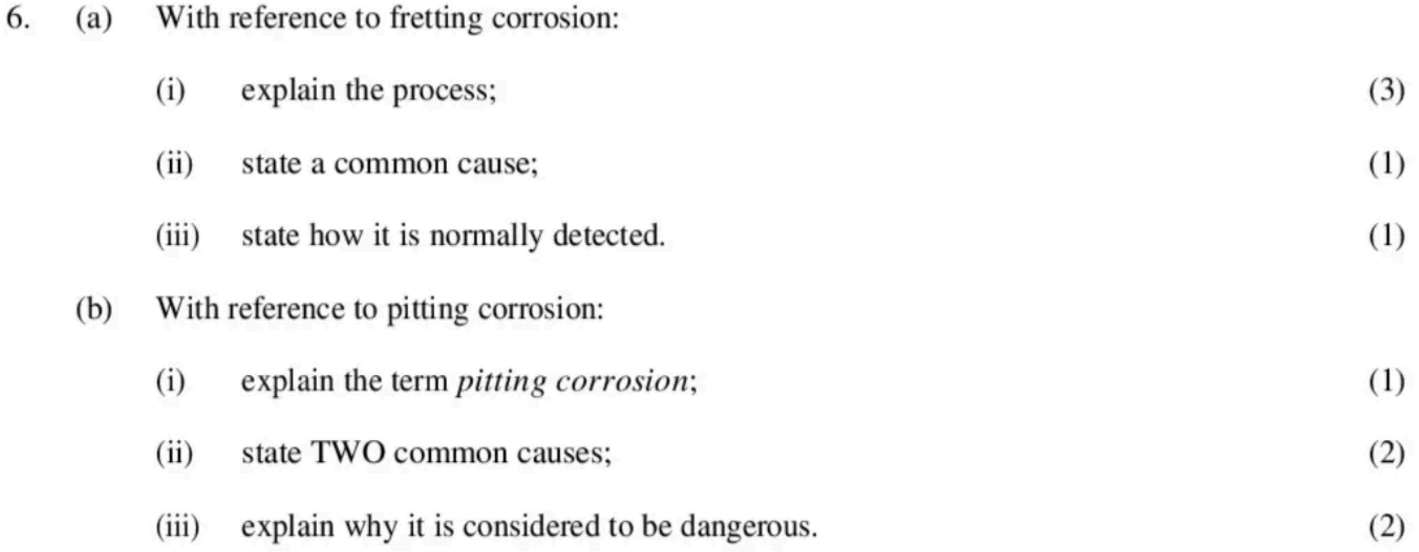
(b) With reference to pitting corrosion:

(i) explain the term *pitting corrosion*; (1)

(ii) state TWO common causes; (2)

(iii) explain why it is considered to be dangerous. (2)

Nov 2018



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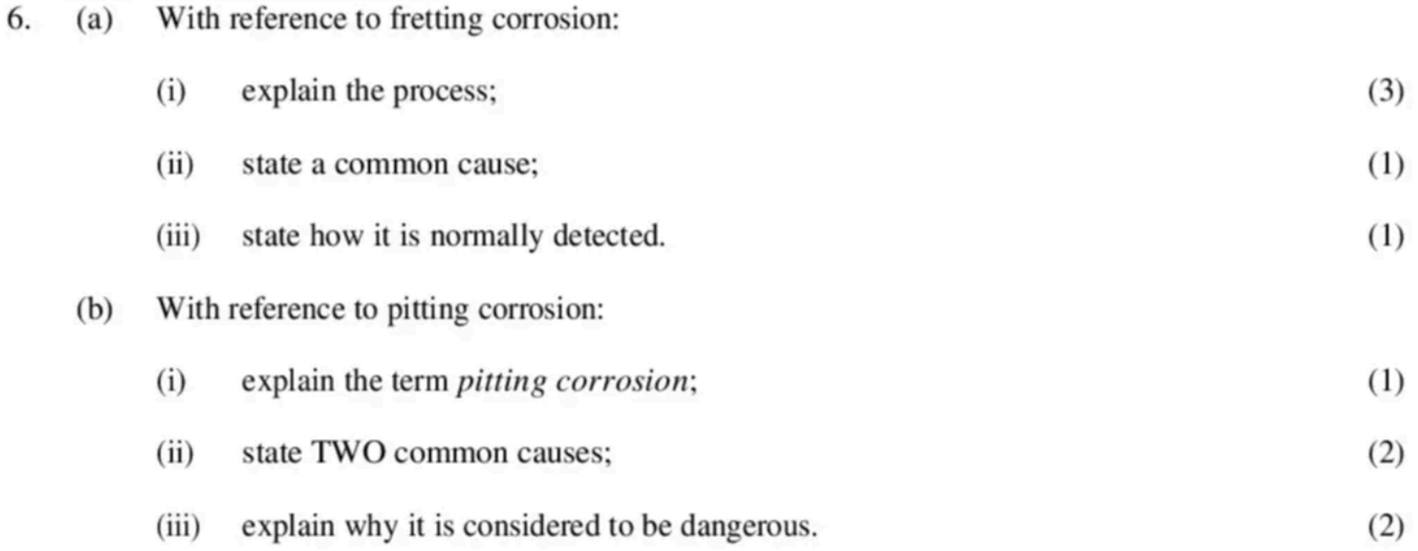
July 2021



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   (b) With reference to pitting corrosion:

   (i) explain the term *pitting corrosion*; (1)

   (ii) state TWO common causes; (2)

   (iii) explain why it is considered to be dangerous. (2)

(a) Fretting Corrosion:

(i) The Process: Imagine two surfaces in tight contact, experiencing slight, relative movement due to vibration or thermal expansion. The microscopic rubbing and slipping create wear particles, which further abrade the surfaces. This combined mechanical wear and oxidation generates a reddish-brown powder and localized pitting, known as fretting corrosion.

(ii) Common Cause: Vibration is a common culprit, particularly in components like bearings, gears, and bolted connections. Even seemingly insignificant vibrations can trigger fretting over time, especially when compounded by high pressure or poor lubrication.

(iii) Detection: Visual inspection can reveal reddish-brown powder or discoloration at contact points. However, early detection often requires non-destructive testing methods like ultrasonic testing or eddy current testing, which can detect subsurface damage before it becomes visible.

(b) Pitting Corrosion:

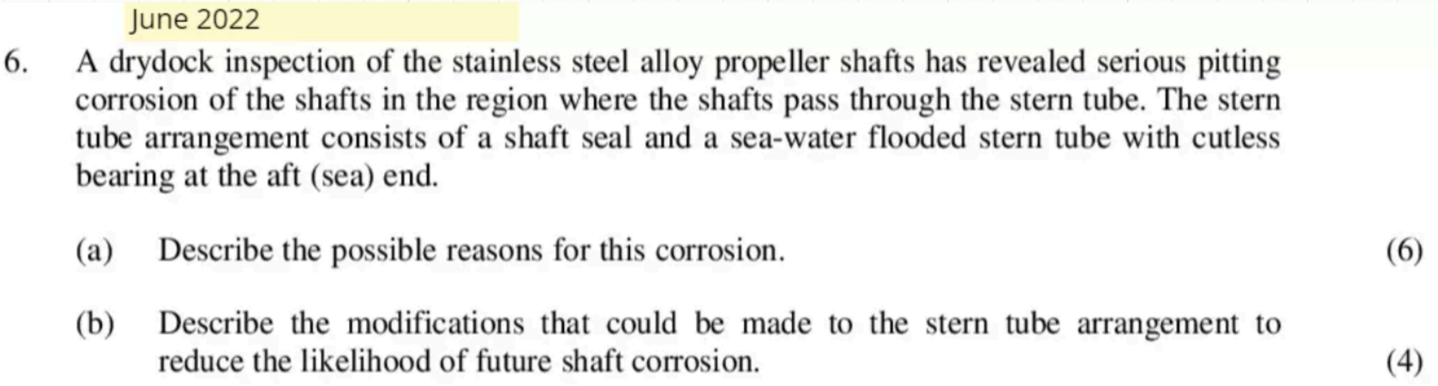
(i) Explanation: Pitting corrosion isn't a uniform attack on the metal surface, but rather the formation of isolated, deep cavities called pits. These pits can penetrate deep into the material, often invisible to the naked eye until significant damage has occurred.

(ii) Common Causes: Pitting can be caused by several factors, including:

- Chloride Ions: These are particularly aggressive towards many metals, particularly stainless steel, and can initiate pitting by breaking down the protective passive layer. Seawater and environments with high salt content are prime culprits.
- Acidic or Alkaline Environments: Extreme pH levels can disrupt the passive layer and make metals more susceptible to pitting corrosion. This can occur in industrial environments with chemical spills or even in rainwater with acidic pollutants.

(iii) Danger of Pitting Corrosion: Pitting's insidious nature lies in its localized attack. The deep, narrow pits can significantly weaken the material, even if the overall surface area affected is small. This can lead to sudden and catastrophic failures, especially in components under high stress, like pressure vessels or aircraft structures.

Understanding the mechanisms and detection methods for both fretting and pitting corrosion is crucial for ensuring the structural integrity and safety of components in various applications. Implementing strategies like vibration dampening, lubrication, protective coatings, and regular inspection can significantly mitigate these forms of corrosion and extend the lifespan of your materials.



June 2022

6. A drydock inspection of the stainless steel alloy propeller shafts has revealed serious pitting corrosion of the shafts in the region where the shafts pass through the stern tube. The stern tube arrangement consists of a shaft seal and a sea-water flooded stern tube with cutless bearing at the aft (sea) end.

   (a) Describe the possible reasons for this corrosion. (6)

   (b) Describe the modifications that could be made to the stern tube arrangement to reduce the likelihood of future shaft corrosion. (4)

The pitting corrosion discovered on your stainless steel propeller shafts within the stern tube is a concerning finding. Let's explore the possible reasons and potential modifications to prevent future recurrence:

(a) Possible Reasons for Corrosion:

Several factors could be contributing to the localized pitting corrosion in this specific area:

- Crevice Corrosion: The tight space between the shaft and the stern tube can create a stagnant seawater environment, encouraging crevice corrosion. This occurs when oxygen levels get depleted in these confined areas, hindering the passive layer formation on stainless steel, making it vulnerable to pitting attacks.

- Galvanic Corrosion: If dissimilar metals are present in the vicinity, like a bronze cutless bearing in contact with the stainless steel shaft, galvanic corrosion can occur. The more active metal (in this case, the shaft) corrodes preferentially, accelerating pitting in the tight crevice formed by the bearing contact.
- Chlorides and Other Aggressive Ions: Seawater naturally contains chlorides and other aggressive ions that can break down the passive layer on stainless steel, leading to localized pitting corrosion. The stagnant seawater within the stern tube can concentrate these ions, further intensifying the attack.
- Mechanical stress: Vibrations and minor movements experienced by the shaft during operation can create localized stress points on the surface, acting as initiation sites for pitting corrosion. These stresses can be amplified in the confined space of the stern tube.

(b) Modifications to Reduce Corrosion:

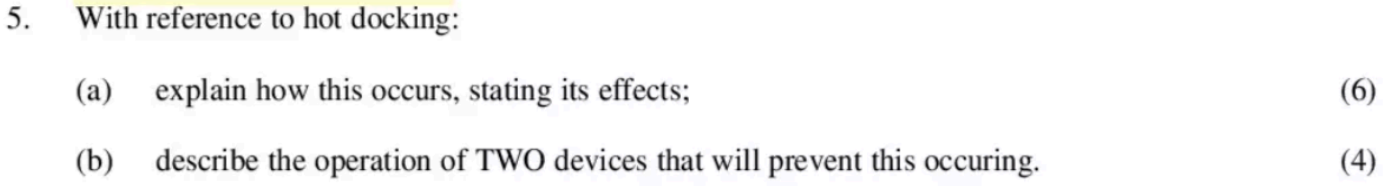
To combat these factors and prevent future corrosion, consider these modifications:

- Improve Ventilation & Reduce Stagnancy: Implementing a flushing system within the stern tube can introduce fresh seawater, replenishing oxygen levels and reducing crevice corrosion risks. Additionally, optimizing shaft seals to minimize trapped seawater within the crevice can be beneficial.
- Material Selection: Consider replacing the cutless bearing with a material compatible with the stainless steel shaft, minimizing galvanic interactions. Materials like composite bearings or elastomeric bearings offer alternatives.
- Protective Coatings: Applying specialized coatings like epoxy resins or silane-based coatings on the shaft within the stern tube can create a physical barrier against aggressive ions and enhance corrosion resistance.
- Cathodic Protection: In severe cases, employing a cathodic protection system with sacrificial anodes or impressed current can be implemented to actively protect the shaft from corrosion within the stern tube.
- Stress Reduction: Analyzing the shaft design and operational conditions to identify and address potential sources of stress on the shaft in the stern tube area can further minimize pitting initiation sites.

Remember, the most effective approach will depend on a thorough investigation of the specific factors contributing to the current corrosion issue. Consulting with experienced marine engineers and corrosion specialists is crucial to determine the optimal set of modifications for your vessel's stern tube arrangement.

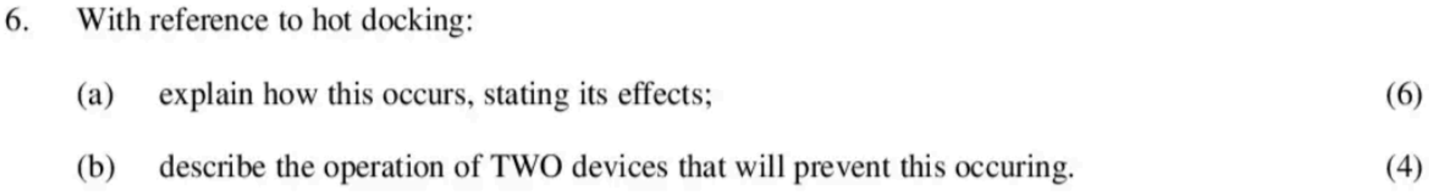
By addressing the root causes and implementing preventative measures, you can effectively protect your propeller shafts from further corrosion and ensure their longevity and safe operation.

Nov 2019


5. With reference to hot docking:

(a) explain how this occurs, stating its effects; (6)

(b) describe the operation of TWO devices that will prevent this occuring. (4)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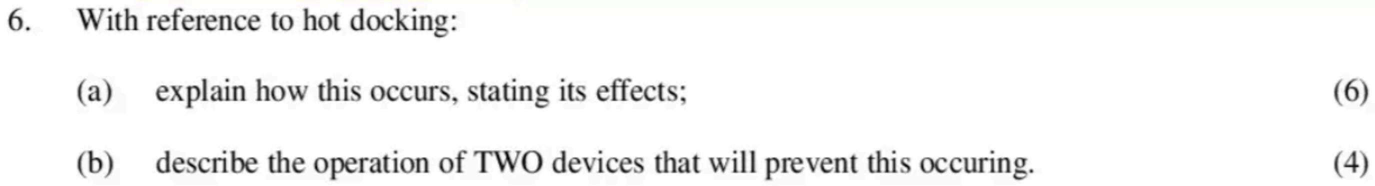

6. With reference to hot docking:

(a) explain how this occurs, stating its effects; (6)

(b) describe the operation of TWO devices that will prevent this occuring. (4)

(a) Marine Hot Docking Explained and its Effects:

Marine hot docking occurs when a boat approaches and connects to a dock while its engine is still running. While seemingly convenient, this practice can have several detrimental effects:

- Safety Risks: The running engine and propellers pose significant safety hazards for passengers, crew, and anyone near the dock. Uncontrolled prop wash can cause injuries, lines can snap, and sudden movements can lead to collisions.
- Dock and Boat Damage: The boat might strike the dock due to lack of precise control, causing damage to both structures. Running props can suck in debris or lines, damaging propellers and shafts.
- Environmental Impact: Exhaust fumes and fuel spills increase pollution in the vicinity of the dock, harming the marine environment.
- Increased Wear and Tear: Engaging gears and clutches while hot puts unnecessary stress on engine components, accelerating wear and tear.

In short, marine hot docking is generally discouraged due to safety risks, potential damage, and environmental concerns.

(b) Two Devices to Prevent Hot Docking:

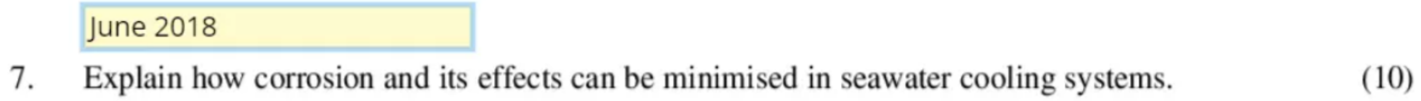
Thankfully, several devices can assist in preventing marine hot docking, promoting safe and controlled docking maneuvers:

1. Auto-Shift Interruptor: This device is connected to the boat's engine and transmission. When the boat gets close to the dock and senses a predetermined proximity through sensors, it automatically disengages the gears, forcing the engine into neutral. This eliminates the risk of accidental engagement of gears while approaching the dock, preventing uncontrolled acceleration or prop wash.

2. Automatic Docking System: This advanced system utilizes GPS, cameras, and sensors to guide the boat autonomously towards and into the docking position. Pre-programmed docking plans account for wind, current, and other factors, ensuring a smooth and precise approach. The system disengages the gears automatically at the appropriate moment, further preventing inadvertent engine engagement.

Both devices offer different levels of automation and can be tailored to specific needs and budgets. While auto-shift interruptors provide a simple and cost-effective solution, automatic docking systems offer superior precision and convenience.

Remember, regardless of the device used, responsible boatmanship and awareness are crucial during docking procedures. Always be mindful of safety, adjust your speed accordingly, and communicate clearly with anyone assisting you on the dock.



June 2018

7. Explain how corrosion and its effects can be minimised in seawater cooling systems. (10)

Minimizing Corrosion in Seawater Cooling Systems: A Balancing Act

Seawater cooling systems are the workhorses of many marine and coastal industries, but the corrosive nature of seawater poses a constant threat. Fortunately, various methods can be employed to minimize corrosion and extend the lifespan of these crucial systems. Here's a breakdown of the key strategies:

1. Material Selection:

- Corrosion-resistant metals: Choosing alloys like copper-nickel, aluminum bronze, or even titanium for critical components can significantly reduce corrosion rates compared to standard steel.
- Protective coatings: Applying special epoxy resins, polyurethanes, or even zinc primers creates a physical barrier between the metal and seawater, further mitigating corrosion.
- Plastic components: In certain areas, replacing metal with appropriate plastic materials can eliminate galvanic interactions and provide additional corrosion resistance.

2. System Design and Optimization:

- Flow velocity control: Moderating water flow velocities within the system minimizes turbulence and erosion-corrosion, especially on areas like pipe bends or constrictions.
- Proper aeration: Maintaining adequate oxygen levels in the water encourages the formation of a protective oxide layer on certain metals, reducing overall corrosion rates.

- Minimizing stagnant areas: Designing the system to avoid stagnant pockets of water prevents localized corrosion initiation and promotes uniform flow.

3. Chemical Treatment:

- Corrosion inhibitors: Introducing specific chemicals into the water can form a protective film on metal surfaces, hindering direct contact with corrosive ions. However, careful selection and monitoring are crucial to avoid unintended consequences.
- Biocides: Controlling biological growth within the system reduces the activity of microorganisms that can contribute to biofouling and localized corrosion.
- pH control: Adjusting the pH of the water slightly to the alkaline side can offer some protection for certain metals, but requires careful control to avoid exceeding environmental regulations.

4. Cathodic Protection:

- Sacrificial anodes: Attaching readily corroding metals like zinc or aluminum to the system creates a galvanic cell, sacrificing themselves to protect the more valuable components.
- Impressed current systems: This method utilizes an external power source to provide a controlled current, actively protecting the entire system surface.

5. Monitoring and Maintenance:

- Regular inspections: Visually checking for signs of corrosion, scaling, and biofouling is essential for early detection and prevention of major damage.
- Non-destructive testing: Employing methods like ultrasonic testing or eddy current testing can reveal subsurface corrosion before it becomes visible, allowing for timely corrective action.
- Proper maintenance: Adhering to recommended maintenance schedules for cleaning, coating reapplication, and component replacement ensures optimal system performance and longevity.

Remember, minimizing corrosion in seawater cooling systems is not a one-size-fits-all approach. The optimal strategy depends on various factors like the specific environment, materials used, operating conditions, and cost considerations. Consulting with experienced marine engineers and corrosion specialists is crucial to determine the most effective combination of methods for your unique system.

By implementing a comprehensive approach that combines preventive measures, monitoring, and effective maintenance, you can effectively minimize corrosion and maximize the lifespan and efficiency of your seawater cooling system.