

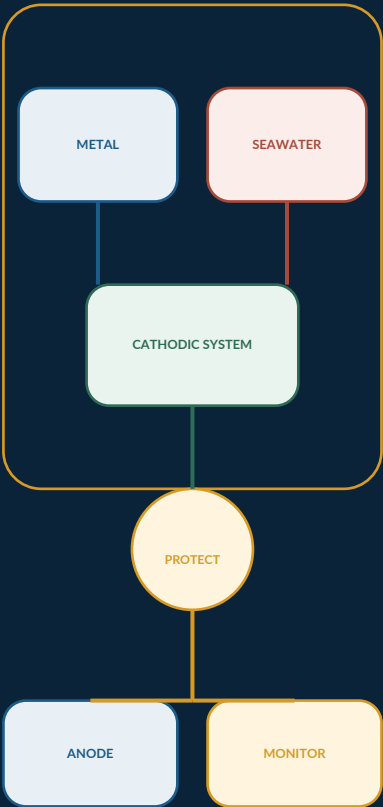
Understanding Hull Cathodic Protection

An owner's guide to anodes, bonding, reference electrodes and shore-power interaction

Cathodic protection controls corrosion current; it does not replace coatings, material compatibility or isolation. Too little protection allows attack, while too much can damage coatings or vulnerable materials. Measurement matters.

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GUIDE OVERVIEW

What hull cathodic protection is designed to do

Hull cathodic protection reduces corrosion of immersed metals by making them cathodic through sacrificial anodes or a controlled impressed-current system.

SCOPE	This guide covers sacrificial anodes, impressed-current systems, reference electrodes, bonding conductors, underwater metals, shore-power isolation and potential measurement. Correct design depends on hull material and water chemistry.
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By the end of this guide, you should be able to:

- Trace the complete path from command or supply to the physical result.
- Identify the principal components, controls, protection and monitoring.
- Recognise common failure modes and early warning signs.
- Understand hidden dependencies and safe degraded operation.
- Ask better questions during purchase, survey, sea trial, refit and offshore preparation.

CORE PRINCIPLE	Protection should be verified by suitable potential measurement and material-specific guidance rather than by anode appearance alone.
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Safety

Stray current and incorrect bonding can accelerate corrosion rapidly. Electrical testing around shore power and underwater systems should be completed by competent specialists; isolate safely before continuity work.

SYSTEM ARCHITECTURE

How the complete system produces its intended effect

Understanding Hull Cathodic Protection depend on a complete chain of command, control, power, physical equipment, feedback and safe shutdown.



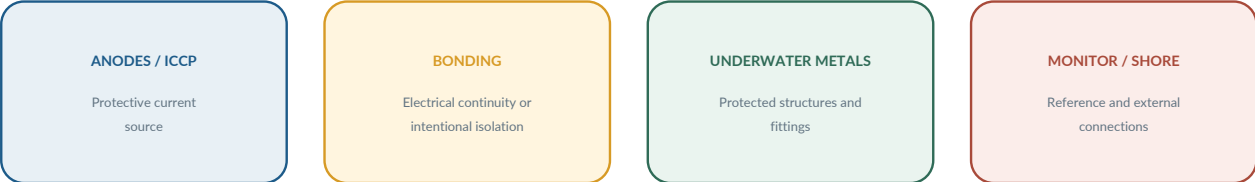
Area	Why it matters	Owner focus
Protected metal	Hull, shaft, propeller, rudder, fin or fitting participates in an electrochemical cell.	Identify material and whether it is bonded or isolated.
Seawater electrolyte	Conductivity varies with salinity, temperature and harbour conditions.	Expect different anode demand in fresh, brackish and seawater.
Sacrificial anode or ICCP	Supplies protective current to shift metal potential.	Use correct material, contact and controlled output.
Bonding path	Provides intentional electrical continuity where the design requires it.	Inspect resistance, connections and modifications.
Reference electrode and measurement	Shows actual potential relative to a known reference.	Use appropriate technique and material criteria.

CORE PRINCIPLE	Cathodic protection controls electrochemical potential; it cannot restore lost metal or substitute for sound coatings and material selection.
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MAIN COMPONENTS

What owners should be able to identify

The installation should be traceable from controls and power to working equipment, protective devices, monitoring and manual isolation.



Area	Why it matters	Owner focus
Sacrificial anodes or ICCP	Provide the protective current.	Material, mass, attachment, coating clearance and output.
Reference electrodes	Measure potential for survey or ICCP control.	Condition, position, calibration and service life.
Bonding conductors	Connect selected underwater metals.	Continuity, corrosion, terminal security and design intent.
Underwater metals	Require appropriate protection without harmful coupling.	Material compatibility, coatings and local anodes.
Monitoring and control unit	Regulates and alarms impressed-current systems.	Power, output, reference signal, limits and event history.
Shore-power isolation	Limits low-voltage galvanic current through protective earth.	Galvanic isolator, monitor or isolation transformer condition.

ACCESS AND LABELLING	Access, identification and service history are part of system reliability.
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SYSTEM ARRANGEMENTS

Sacrificial anodes, ICCP and shore-power isolation

Different arrangements trade simplicity, performance, redundancy, maintenance burden and failure consequence.



Area	Why it matters	Owner focus
Sacrificial anode system	Uses a more active alloy that is consumed instead of protected metal.	Correct alloy depends on water and protected material.
Impressed-current system	Uses powered anodes and reference feedback.	Requires control, alarms, power and careful commissioning.
Local component anodes	Protect shafts, thrusters, tabs or heat exchangers locally.	Electrical contact and hydrodynamic retention matter.
Bonded network	Connects selected fittings to shared protection.	One poor connection can leave a component isolated.
Intentionally isolated component	Avoids unwanted galvanic coupling in some designs.	Do not add bonding casually without engineering review.

PRACTICAL DISTINCTION	Anode alloy must suit the water and protected material. More active or larger is not automatically safer.
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OPERATION AND CONTROL

Inspecting, measuring and interpreting protection

Safe operation requires correct preparation, clear mode awareness, monitoring and a controlled return to standby or safe state.

INSPECT
Anodes, coatings and bonding

MEASURE
Hull potential with reference electrode

INTERPRET
Compare with material criteria

CORRECT
Repair coating, bonding or protection

Area	Why it matters	Owner focus
Visual inspection	Review anode consumption, coatings and underwater metals at haul-out.	Uneven patterns are diagnostic evidence.
Potential survey	Measure with a suitable reference electrode at defined locations.	Record water type, shore connection and operating state.
Interpretation	Compare readings with hull material and coating criteria.	Avoid generic "good voltage" conclusions.
ICCP operation	Monitor reference signal, output current and alarms.	Check automatic and manual limits.
Shore connection	Observe potential change when shore earth is connected or isolated.	Investigate excessive shift or current.

OPERATOR FOCUS

The operator should know what the system is doing physically, not only which mode is displayed.

DEPENDENCIES AND RESILIENCE

What can remove apparently independent capability

Apparently separate equipment can share power, structure, cooling, sensors, hydraulics, networks or one vulnerable compartment.

SHARED BONDING

One break isolates several metals

SHARED SHORE EARTH

Marina circuit changes current

SHARED COATING

Damage increases current demand

SHARED ICCP CONTROL

Sensor or power fault affects hull

Area	Why it matters	Owner focus
Coating condition	Damaged coating increases exposed metal and protection demand.	Repair coatings as part of the system.
Bonding continuity	Anode current cannot protect an electrically disconnected component.	Test intentional paths.
Shore protective earth	Other vessels and marina faults can alter galvanic current.	Use approved isolation and monitoring.
ICCP power and reference	One controller or electrode can affect the whole hull.	Retain alarms and manual safe state.
Water conductivity	Freshwater can make unsuitable anode alloys ineffective or overactive.	Match material and settings to operating water.

COMMON-MODE RISK

Follow the shared power, cooling, structural and control paths before describing equipment as independent.

MONITORING AND NORMAL VALUES

Recognising normal condition and early deterioration

Useful monitoring combines displayed values with sound, temperature, movement, leakage, vibration and actual performance.



Area	Why it matters	Owner focus
Anodes disappear unusually fast	Stray current, excessive exposed metal or wrong alloy may be present.	Measure potentials and electrical leakage.
Anodes show little consumption	Poor electrical contact, wrong alloy or overcoating may isolate them.	Check continuity and surface condition.
One component pits while others are sound	Local isolation, material or coating problem.	Test component potential and bonding.
ICCP output remains high	Coating damage, reference fault or excessive demand.	Inspect hull and validate reference electrode.
Potential changes on shore power	Galvanic isolator, transformer, marina or onboard fault.	Investigate before prolonged connection.

TREND, DO NOT GUESS	Trend comparable operating conditions rather than relying on a single reading.
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FAILURE AWARENESS

Common weaknesses and warning signs

Most serious faults begin with small changes, intermittent alarms, unusual noise, heat, leakage or declining performance.

UNDERPROTECTION
Insufficient current or poor continuity

OVERPROTECTION
Excess current or wrong anode

STRAY CURRENT
DC leakage causes rapid attack

REFERENCE / ICCP
Sensor or controller fault

Area	Why it matters	Owner focus
Underprotection	Insufficient anode mass, poor contact, broken bonding or low ICCP output.	Pitting and wastage progress underwater.
Overprotection	Wrong alloy, excessive ICCP output or unsuitable freshwater arrangement.	Coating damage or hydrogen-related effects can occur.
Stray-current corrosion	DC leakage leaves a submerged metal surface.	Very rapid local attack may develop.
Reference-electrode fault	ICCP controller receives wrong potential.	Output may become too high or too low.
Galvanic isolator or transformer fault	Shore-earth protection is compromised.	Safety and corrosion consequences require competent testing.

DO NOT NORMALISE CHANGE	A recurring alarm or unusual behaviour is evidence of a defect, not a normal characteristic.
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FAILURE RESPONSE

Responding to rapid corrosion, ICCP alarms and stray current

The first response should protect people and the wider yacht, stop further damage and move to a safe reduced-capability plan.

DISCONNECT SHORE
Remove external circuit when safe

ISOLATE FAULT
Stop suspected DC leakage

MEASURE
Confirm potentials and current paths

HAUL / REPAIR
Inspect damage and restore protection

Area	Why it matters	Owner focus
Rapid anode loss or new pitting	Disconnect shore power if safe and arrange potential and leakage survey.	Simply install larger anodes without finding the cause.
ICCP alarm	Follow manufacturer safe mode and verify reference and output.	Force maximum output.
Suspected stray current	Isolate non-essential DC circuits methodically and seek specialist testing.	Disconnect protective earth unsafely.
Bonding conductor damaged	Restore only to documented design with correct conductor and connection.	Bond an intentionally isolated metal without review.
Severe underwater corrosion	Haul out, assess remaining thickness and repair before further exposure.	Assume new anodes reverse existing damage.

PROTECT THE WIDER YACHT

Never remove or defeat the shore protective earth as a corrosion remedy. Electrical safety remains the priority.

TESTING AND DEMONSTRATION

Testing continuity, potential and shore-power interaction

A meaningful test should operate the system under representative load, verify protective functions and demonstrate safe manual or degraded operation.

CONTINUITY

Bonding paths and intentional isolation

POTENTIAL SURVEY

Reference electrode measurement

SHORE TEST

Galvanic isolator or transformer

ICCP TEST

Output, alarms and reference response

Area	Why it matters	Owner focus
Bonding continuity test	Shows intended electrical paths between protected metals.	Use low-resistance method and know intentional isolation.
Potential survey	Measures actual protection at several hull and component locations.	Technique and reference condition are critical.
Shore-power comparison	Shows effect of earth connection and isolation device.	Maintain electrical safety during test.
ICCP functional test	Shows reference response, output control and alarms.	Use manufacturer or corrosion specialist procedure.
Haul-out inspection	Shows anode contact, consumption, coatings and metal damage.	Photograph and compare with prior intervals.

MEANINGFUL EVIDENCE	A no-load start or green status light does not demonstrate performance under real conditions.
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MAINTENANCE STRATEGY

Maintaining anodes, bonding, coatings and ICCP

Maintenance should preserve the energy source, working machinery, structure, controls, sensors, protection and correct fluid or electrical condition.



Area	Why it matters	Owner focus
Sacrificial anodes	Use correct alloy and size; maintain clean electrical contact.	Provides predictable consumption.
Bonding network	Inspect conductors, terminals and resistance.	Maintains intended current paths.
Coatings	Repair hull, shaft, fin and fitting coatings correctly.	Reduces protection demand and local cells.
ICCP system	Service power unit, anodes, reference electrodes and alarms.	Prevents uncontrolled output.
Shore isolation	Test galvanic isolator monitor or isolation transformer.	Controls marina interaction without compromising safety.

WORK TO REFER

High-energy, structural, pressure, lifting and safety-critical work should be completed by competent specialists.

RECORDS, SPARES AND SUPPORTABILITY

Keeping documentation, spares and supportability current

Useful onboard records should show the current arrangement, normal values, service history, safe isolation, selected spares and specialist support.

UNDERWATER MAP
Metals, anodes and bonding

POTENTIAL HISTORY
Location and measurements

HAUL-OUT PHOTOS
Consumption and damage

SHORE / ELECTRICAL
Isolation and leakage tests

Area	Why it matters	Owner focus
Underwater-metal map	Materials, coatings, anodes, bonding and isolation.	Provides design context.
Potential measurements	Reference type, locations, water and shore state.	Shows trend and effectiveness.
Haul-out photographs	Anode consumption and corrosion patterns.	Makes change visible.
Electrical leakage tests	DC leakage, shore isolation and repairs.	Supports stray-current diagnosis.
Material and part records	Anode alloy, reference electrode and controller details.	Prevents wrong replacements.

SUPPORTABILITY	A spare part is useful only when its compatibility, tools, settings and installation procedure are understood.
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BUYER AND SURVEY PERSPECTIVE

Assessing design, measured protection and corrosion history

A buyer should see the system operate under representative conditions and understand structural, power, control and support implications.



Area	Why it matters	Owner focus
Hull and metal materials	Steel, aluminium or composite hulls require different approaches.	Confirm design basis.
Protection architecture	Are anode or ICCP coverage and bonding documented?	Request drawings and surveys.
Damage pattern	Is there pitting, coating blistering, dezincification or rapid anode loss?	Seek corrosion specialist interpretation.
Shore-power interaction	Is an isolator or transformer fitted and tested?	Compare potentials connected and disconnected.
Service and support	Are ICCP parts, reference electrodes and correct anodes available?	Include haul-out and specialist survey cost.

BUYER FOCUS	Anode appearance alone is not enough; potential measurements and corrosion patterns provide stronger evidence.
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OFFSHORE READINESS

Questions before relying on hull cathodic protection

A ready system has the correct anode or ICCP design, sound bonding where intended, current measurements within material-specific limits and no evidence of stray-current attack.

Area	Question to resolve
Materials	Which hull and underwater-metal alloys require protection?
Protection source	Which sacrificial anodes or ICCP zones serve each component?
Measurement	What potential readings were obtained and under what water and shore conditions?
Bonding	Which fittings are intentionally bonded or isolated?
Shore power	How are galvanic current and protective earth managed?
Damage history	Where has pitting, coating failure or rapid anode loss occurred?

Quick readiness check

	Readiness statement
☐	Hull, shafts, fittings, fins, thrusters, anodes and bonding are mapped.
☐	Correct anode alloy and ICCP settings suit the operating water and materials.
☐	Potential measurements are current and taken with a suitable reference electrode.
☐	No unresolved rapid anode loss, pitting, coating blistering or stray-current evidence remains.
☐	Bonding paths and intentional isolation are documented and tested.
☐	Shore-power isolation equipment is functional without compromising safety.
☐	Haul-out photographs and measurements are compared with previous intervals.
☐	Correct replacement materials and corrosion specialist contacts are available.

KEY TAKEAWAY

Dependable cathodic protection combines correct material design, sound coatings, intentional bonding, suitable anodes or ICCP, measured potentials and control of shore and stray-current effects.

Guidance to consult

Use current vessel hull, bonding, shore-power and cathodic-protection drawings and the installed anode, ICCP, galvanic-isolator or isolation-transformer manufacturers' instructions, together with material-specific corrosion expertise.

Understanding Yacht Systems

Practical guides for owners, buyers
and offshore cruising crews.

AMTG-055

Understanding Hull Cathodic Protection

RELATED GUIDES

AMTG-024 Understanding Bonding, Earthing and Galvanic Protection

AMTG-030 Understanding Seacocks and Through-Hull Fittings

AMTG-016 Understanding Shaft Lines, Bearings and Propellers

AMTG-048 Understanding Fin Stabilisers

AMTG-022 Understanding Inverters and Shore Power

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