

Understanding Air-Conditioning and Chilled-Water Systems

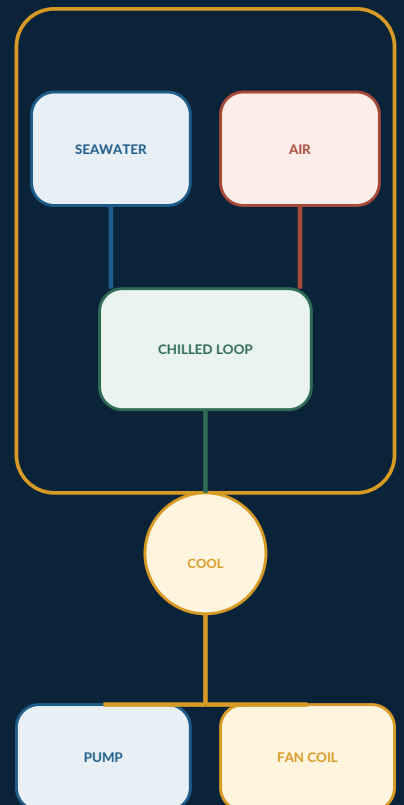
An owner's guide to seawater cooling,
refrigeration, air handling and humidity

Air conditioning is a comfort system until
heat and humidity affect people or equipment.

Offshore reliability depends on seawater flow,
refrigeration, circulation and condensate control.

Absolute Marine

Commercial thinking for private cruising.



REMOVE HEAT | CONTROL HUMIDITY

GUIDE OVERVIEW

What air-conditioning and chilled-water systems are designed to do

Marine air-conditioning removes heat and moisture from occupied spaces and may also protect navigation, communications, battery, control and electronic equipment from excessive temperature or humidity.

SCOPE	This guide covers common direct-expansion and central chilled-water systems on cruising yachts. It explains owner-level principles for seawater cooling, refrigeration, water circulation, fan coils, condensate and controls. Refrigerant work, pressure testing and electrical repair require competent specialists.
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By the end of this guide, you should be able to:

- Trace the heat-removal path from cabin air through the evaporator or fan coil, refrigerant circuit and seawater discharge.
- Identify sea suctions, strainers, pumps, chillers, water loops, air handlers, controls and condensate drains.
- Recognise restricted seawater flow, refrigerant faults, low chilled-water flow, poor airflow and drainage problems.
- Understand shared power, seawater, pump and control dependencies that can remove several zones together.
- Ask better questions during purchase, survey, refit, maintenance and offshore preparation.

CORE PRINCIPLE	Cooling performance depends on the complete heat-transfer chain. A healthy compressor cannot compensate for poor seawater flow, blocked air filters, low chilled-water circulation or an overflowing condensate drain.
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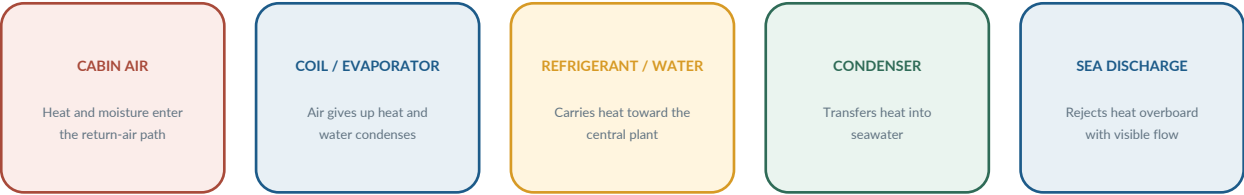
Safety

Refrigerant circuits contain pressure and may involve flammable or oxygen-displacing gases depending on the installation. Electrical equipment, rotating fans, hot compressor surfaces, seawater flooding and chemical cleaning also create hazards. Do not open refrigerant fittings or pressure vessels.

SYSTEM ARCHITECTURE

How heat moves from the cabin to the sea

A marine system removes heat from air, transfers it through refrigerant or chilled water and rejects it into seawater. Condensate formed on cold surfaces must also be collected and discharged safely.



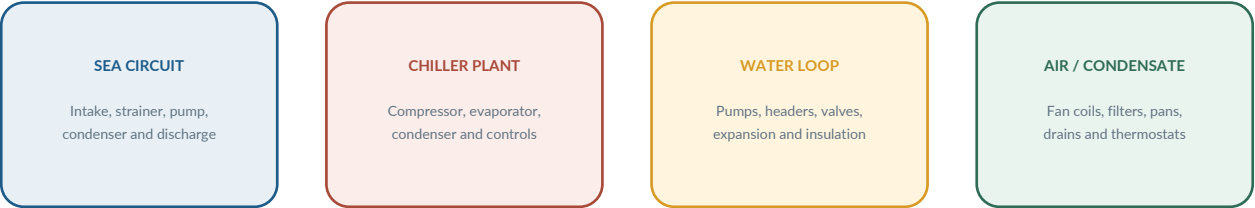
Layer	Purpose	Owner focus
Air side	Filters, fans and coils move cabin air and remove heat and moisture.	Return-air access, clean filters, unobstructed grilles, fan speed and coil condition.
Chilled-water side	Pumps circulate treated water between chillers and fan coils.	Flow, loop pressure, expansion tank, air removal, insulation and valve positions.
Refrigerant side	Compressor, condenser, expansion device and evaporator move heat through a sealed circuit.	Operating pressures and temperatures are specialist evidence; watch alarms and abnormal sound.
Seawater side	Sea suction, strainer, pump and condenser remove heat from the refrigerant.	Intake access, flow, fouling, pump condition, discharge and shared sea-chest dependencies.
Condensate side	Pans, drains or pumps remove water produced by dehumidification.	Slope, traps, pump operation, hose condition and discharge location.
Controls and power	Thermostats, sensors, staging and electrical supplies regulate demand.	Set points, load shedding, communication faults and normal start or stop sequence.

HEAT MUST LEAVE THE YACHT	Cooling can fail even while fans blow cold briefly. The complete system must continuously transfer heat into moving seawater without overloading the electrical supply.
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MAIN COMPONENTS

What owners should be able to identify

A useful HVAC drawing should show sea suction, strainers, pumps, chillers or condensing units, chilled-water headers, expansion vessel, air handlers, condensate drains, controllers and electrical feeders.



Owners should know what is common to every cabin and what can be isolated by zone.

Component or area	Why it matters	Owner focus
Sea suction and strainer	Admit cooling water while protecting the pump and condenser.	Valve position, strainer condition, leaks, fouling and access underway.
Seawater pump and discharge	Maintain condenser flow and reject heat overboard.	Prime, motor current, impeller, seal, vibration and visible discharge.
Chiller or condensing unit	Provides refrigeration and transfers heat to seawater.	Compressor stages, alarms, vibration, oil or refrigerant evidence and service history.
Chilled-water pumps and headers	Distribute cooling to multiple fan coils.	Duty or standby arrangement, differential pressure, isolation and balancing valves.
Air handlers or fan coils	Move cabin air across the cold coil and collect condensate.	Filters, fans, coils, grilles, noise, airflow and drain-pan cleanliness.
Controls and condensate systems	Regulate zones and remove water without flooding interiors.	Thermostats, sensors, drain pumps, traps, alarms and discharge route.

ACCESS IS PART OF RELIABILITY

A hidden fan coil with no service access or a strainer trapped behind stored equipment will be difficult to maintain when heat and humidity are already affecting the crew.

SYSTEM ARRANGEMENTS

Direct expansion, chilled water and staged plant

Smaller yachts often use self-contained or split direct-expansion units. Larger yachts commonly use central chillers circulating cold water to many fan coils. Each arrangement has different failure consequences.

DIRECT EXPANSION

Refrigerant serves each local evaporator

CHILLED WATER

Central plant cools a closed water loop

MULTIPLE CHILLERS

Stages capacity and may provide partial redundancy

ZONED DISTRIBUTION

Valves and pumps separate areas or priority spaces

Multiple chillers or pumps improve resilience only when one can be isolated and the remainder can carry a useful priority load.

Area	What matters	Owner focus
Self-contained direct expansion	Each unit contains compressor, evaporator and seawater-cooled condenser.	Simple zoning but many seawater branches, pumps or electrical starting loads may be involved.
Split direct expansion	Compressor or condenser is remote from the cabin evaporator.	Long refrigerant lines, leak access and control compatibility.
Central chilled-water plant	One or more chillers serve multiple fan coils through a water loop.	Common pump, header or control fault can affect the complete yacht.
Lead or lag chillers	Stages compressors or machines to match demand and share running hours.	Rotation logic, minimum flow, start sequence and whether one unit can support critical zones.
Duty or standby water pumps	Allows circulation after one pump failure.	Separate breakers, valves, non-return arrangements and actual changeover testing.
Reverse-cycle or heat-recovery operation	Uses the refrigeration circuit for heating or reclaims condenser heat.	Temperature limits, seawater conditions and control modes may differ from cooling.

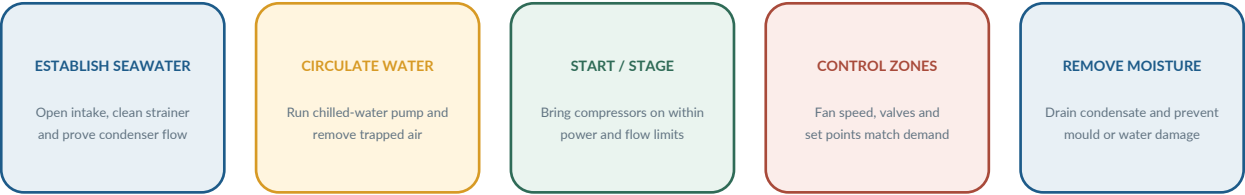
INSTALLED REDUNDANCY MAY BE CAPACITY-LIMITED

One remaining chiller may keep the bridge and selected cabins usable but cannot necessarily maintain every space at full design temperature.

OPERATION AND CONTROL

Starting, staging and controlling humidity

Reliable operation normally establishes seawater and chilled-water flow before compressor loading, then stages chillers and fan coils according to demand.



Area	What matters	Owner focus
Seawater start	The condenser needs continuous flow before significant refrigeration load.	Confirm valves, strainer, pump and overboard discharge.
Chilled-water circulation	The evaporator requires adequate water flow to avoid freezing or low-flow trips.	Confirm pump, pressure, air vents, bypass and zone-valve position.
Compressor staging	Machines start progressively to match heat load and electrical capacity.	Observe generator reserve, start current, delays and short-cycling.
Thermostat and valve control	Zones regulate air temperature by fan speed or water flow.	Extreme set points do not create extra plant capacity and may increase cycling.
Humidity control	Cold coils remove moisture when airflow, coil temperature and runtime are suitable.	Monitor cabin humidity, condensate production and ventilation contribution.
Shutdown and run-on	Pumps or fans may continue briefly to remove residual heat or prevent freeze.	Allow the designed sequence rather than isolating power abruptly.

LOWER SET POINT IS NOT FASTER COOLING

Demanding an unrealistically low cabin temperature can keep every compressor and fan at full load without improving comfort, while reducing electrical reserve and increasing condensation risk.

DEPENDENCIES AND RESILIENCE

What can remove cooling across several spaces

Comfort systems often contain hidden common points. One seawater pump, generator, chilled-water header, controller or network may support every cabin and equipment space.

SHARED SEA CHEST

One intake or strainer feeds multiple chillers

SHARED POWER

One generator, board or transformer supports plant

SHARED WATER LOOP

One leak or pump failure affects all fan coils

SHARED CONTROLS

One PLC, gateway or sensor can stop the complete plant

The useful resilience question is which priority spaces remain habitable after one common-point failure.

Area	What matters	Owner focus
Seawater intake or pump	Blocked strainer, fouled condenser or failed pump removes heat rejection.	Know alternate pump, parallel strainers or independent branches.
Electrical generation	Chillers and pumps can be among the yacht's largest continuous loads.	Generator combination, load shedding, start sequence and reduced-capacity mode.
Chilled-water loop	One major leak, airlock or header valve error can stop circulation everywhere.	Isolation by branch, makeup policy and pressure or flow monitoring.
Control network	A failed gateway, temperature sensor or software state can inhibit otherwise healthy machinery.	Local/manual control, backups, alarm meaning and supportability.
Closed accommodation	A yacht designed around air conditioning may have limited natural ventilation.	Plan alternative ventilation, shading and crew-rest arrangements.
Equipment cooling	Electronics, batteries or technical spaces may rely on conditioned air.	Prioritise cooling for operational equipment as well as comfort.

COMFORT CAN BECOME OPERATIONAL

Loss of cooling in hot, humid conditions can impair sleep, decision-making and electronics even when propulsion remains available.

MONITORING AND NORMAL VALUES

Knowing whether the heat-transfer chain is healthy

Useful evidence includes seawater flow, compressor current, refrigerant alarms, chilled-water supply and return temperatures, loop pressure, fan-coil airflow and condensate behaviour.

SEAWATER

Discharge, pressure, temperature and strainer

REFRIGERANT

Compressor current, alarms and heat-exchanger state

CHILLED WATER

Supply/return temperature, pressure and flow

AIR / DRAINS

Airflow, cabin humidity, coil and condensate

Record ambient and seawater temperatures with readings; plant performance naturally changes with conditions.

Observation	What it may indicate	Owner response
Weak or intermittent seawater discharge	Blocked intake or strainer, air ingress, worn impeller, closed valve or discharge restriction.	Reduce load and restore flow before repeated high-pressure trips.
High refrigerant-pressure alarm	Poor condenser cooling, fouling, airflow or seawater problem, overcharge or high ambient load.	Check the seawater route and avoid repeated resets.
Low-pressure or freeze alarm	Low refrigerant, low water flow, iced coil, closed valve or sensor fault.	Protect the evaporator and confirm flow before restart.
Large chilled-water temperature difference	Low flow, high load or restricted branch.	Compare pump status, valves, strainers and pressure.
Small temperature difference with poor cooling	Low refrigeration output, bypass flow, dirty coils or excessive fan/zone demand.	Review compressor stages, water balance and air-side condition.
Condensate pan wet or cabin leakage	Blocked drain, failed pump, poor slope, damaged insulation or excessive moisture.	Stop the local unit if necessary and prevent water reaching electrical or joinery areas.

TREND UNDER COMPARABLE CONDITIONS

A pressure, current or temperature is most useful when compared with the same plant stage, seawater temperature and cabin load.

FAILURE AWARENESS

Common weaknesses and warning signs

HVAC failures often begin with repeated trips, declining seawater flow, rising cabin humidity, noisy pumps, short cycling, local water stains or one zone that never reaches temperature.

LOST SEAWATER
Strainer, pump, intake or condenser restriction

REFRIGERANT FAULT
Leak, compressor, control or heat-exchanger problem

LOST WATER FLOW
Pump, airlock, leak or closed branch valve

AIR / DRAIN FAULT
Blocked filter, failed fan or condensate overflow

Repeated manual resets can hide a developing flow, refrigeration or electrical defect until damage becomes more expensive.

Failure or evidence	Possible cause	Why it matters
High-pressure trip	Seawater restriction, fouled condenser, pump fault, high load or sensor/control problem.	Compressor stops and may be damaged by repeated restart.
Low-pressure or freeze trip	Refrigerant loss, low water flow, icing or expansion-control fault.	Evaporator can freeze and rupture or cooling capacity can collapse.
Chilled-water loop loses pressure	Leak, failed expansion vessel, air release or makeup problem.	Pumps cavitate, upper fan coils lose flow and hidden water damage develops.
Seawater pump loses prime	Air leak, low inlet head, heel/trim, blocked intake or worn impeller.	Condenser overheats while the motor appears to run.
Condensate overflow	Blocked drain, failed pump, dirty pan, poor slope or high humidity.	Water damages joinery, insulation, wiring and creates mould.
One zone remains hot	Dirty filter or coil, failed fan or valve, airlock, sensor or control fault.	Local discomfort may mask a wider balancing or circulation problem.

DO NOT NORMALISE CHANGE

A chiller that trips whenever seawater warms or a cabin that always smells damp is signalling a capacity, flow, drainage or control problem.

FAILURE RESPONSE

Protecting the plant, the yacht and the crew

The first response should reduce compressor load, confirm seawater and chilled-water flow, isolate water leakage and preserve cooling for priority spaces rather than repeatedly resetting alarms.

RECOGNISE

Trip, heat, humidity, leak or abnormal noise

REDUCE LOAD

Raise set points, stop zones and preserve power reserve

CHECK FLOW

Seawater, chilled water, air and condensate

ISOLATE DAMAGE

Stop leaking or overheating unit and protect electrics

PRIORITISE / ESCALATE

Cool critical spaces and seek HVAC support

Situation or stage	Immediate thinking	Avoid
High-pressure trip	Check seawater discharge, valves, strainer and pump condition; reduce chiller stages.	Repeated reset without restoring heat rejection.
Low-flow or freeze alarm	Confirm circulation pump, loop pressure, valves and fan-coil flow.	Running a frozen or starved evaporator.
Suspected refrigerant leak	Stop affected plant, ventilate as appropriate and obtain specialist assistance.	Opening fittings, applying flame or adding unapproved refrigerant.
Chilled-water leak	Isolate the branch or plant, protect electrical equipment and control makeup.	Allowing automatic fill to hide a major leak or flood accommodation.
Condensate overflow	Stop local cooling if needed, contain water and clear or repair the approved drain path.	Directing untreated water onto bilges or wiring without checking consequences.
Loss of cooling in hot climate	Prioritise bridge, technical and sleeping spaces; improve ventilation, shading and hydration.	Continuing a demanding passage without considering crew fatigue or equipment temperature.

PROTECT THE COMPRESSOR

Most protective trips exist to prevent damage. Repeatedly resetting without correcting flow, temperature or pressure can turn a recoverable fault into compressor failure.

TESTING AND DEMONSTRATION

Testing under realistic heat, humidity and electrical load

A meaningful test should operate the plant long enough to stabilise, serve several zones and show seawater flow, chilled-water temperatures, condensate removal and generator loading.



Test	What it demonstrates	Limitations / owner focus
Seawater-flow test	Confirms intake, strainer, pump, condenser and discharge route.	A visible trickle may be insufficient; compare with baseline and plant stage.
Loaded chiller run	Shows compressor staging, stability, current and heat rejection.	Run long enough for supply and return temperatures to stabilise.
Duty or standby pump changeover	Demonstrates alternate circulation and valve or non-return operation.	Confirm flow and pressure after changeover, not merely motor start.
Zone or fan-coil test	Shows fan, valve, coil, thermostat and condensate operation.	Check representative remote and upper-deck spaces.
Condensate test	Confirms pans, pumps, traps and drains remove water.	Use approved method and inspect for hidden leakage.
Electrical/load-management test	Shows generator reserve and chiller restart or shedding behaviour.	Avoid simultaneous uncontrolled compressor starts.

CONTEXT MAKES THE RESULT USEFUL	Record ambient temperature, humidity, seawater temperature, active chiller stages, generator combination and number of zones when comparing performance.
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MAINTENANCE STRATEGY

Keeping heat transfer, airflow and drainage dependable

Maintenance should preserve clean seawater passages, refrigeration integrity, reliable circulation, dry insulation, clean air coils and unobstructed condensate drains.

Area	Good maintenance evidence	Why it matters
Sea suction, strainer and pump	Clean intake, operable valve, sound impeller or seals, stable current and discharge.	Prevents high-pressure trips and loss of heat rejection.
Condenser and chiller	Cleaning history, refrigerant records, compressor current, vibration and alarm trend.	Maintains capacity and avoids repeated protective trips.
Chilled-water loop	Fluid condition, concentration where applicable, pressure, expansion vessel, vents, pumps and insulation.	Prevents corrosion, freezing, airlocks and water damage.
Air handlers and filters	Clean filters or coils, fan condition, balanced airflow and dry insulation.	Maintains comfort, humidity control and electrical efficiency.
Condensate system	Clean pans, clear drains, functional pumps or alarms and secure hose routes.	Avoids mould, hidden leaks and interior damage.
Controls and sensors	Accurate thermostats, temperature or pressure sensors, staging logic and configuration backups.	Supports stable operation and correct fault diagnosis.

Owner-level routine

- Clean strainers and filters before visible performance decline.
- Inspect pipe and duct insulation for wet sections or broken vapour barriers.
- Rotate duty and standby pumps and lead chillers where the system is designed for it.
- Record temperatures, current and seawater conditions during representative operation.
- Review plant capacity after glazing, accommodation or equipment changes.

WORK TO REFER	Refrigerant recovery or charging, compressor work, pressure testing, brazing, electrical motor control and chemical condenser cleaning should be completed by qualified marine HVAC technicians.
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RECORDS, SPARES AND SUPPORTABILITY

Being able to understand and recover the system away from support

Useful documentation should identify exact refrigerant, compressor, pump, controller and fan-coil models, plus valve positions, normal readings and the isolation needed to keep part of the yacht cooled.

Area	Useful evidence or provision	Why it matters
Piping and wiring diagrams	Seawater, refrigerant, chilled-water, condensate and control routes.	Speeds fault isolation and identifies common points.
Operating baseline	Ambient and seawater conditions, currents, temperatures, pressures and active stages.	Allows early recognition of declining performance.
Pump and fan spares	Impellers, seals, capacitors, relays, contactors or approved motors as practical.	Supports owner or technician recovery of common failures.
Filters and drain parts	Correct filter media, drain-pump parts, float switches, hose and traps.	Prevents simple air or condensate faults stopping zones.
Refrigerant and service data	Exact gas, charge, oil, leak history, cylinder or transport restrictions and supplier.	Avoids incompatible or unavailable service materials.
Control configuration	Set points, staging logic, passwords, software and controller backups.	Protects against obsolete or failed electronic control.

Practical onboard provision

- Current HVAC piping, valve and electrical diagrams.
- Pump impellers or seals, filters, drain-pump parts and selected sensors or relays.
- Baseline records for seawater discharge, water temperatures and compressor current.
- Exact refrigerant and compressor identification without carrying unapproved substitutes.
- Marine HVAC contacts and access plans for hidden fan coils or pipework.

SUPPORTABILITY INCLUDES REFRIGERANT	A technically healthy system can become difficult to own if its refrigerant, compressor, controller or proprietary board is obsolete or unavailable in the cruising region.
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BUYER AND SURVEY PERSPECTIVE

Assessing plant condition, capacity and hidden water risk

A buyer should see the plant run under meaningful load and inspect seawater, refrigeration, chilled-water, air and condensate systems rather than judging only cabin temperature during a short viewing.

Area	Questions or evidence
System type and capacity	Is the yacht direct expansion or chilled water, and can the installed plant support present accommodation and climate?
Seawater side	Are intake, strainer, pump, condenser and discharge clean, accessible and free from recurring high-pressure faults?
Chilled-water side	Are pumps, headers, expansion, insulation, fluid and branch isolation in good condition?
Refrigeration plant	Are compressor hours, refrigerant type, leak or repair history and replacement support documented?
Air handlers and drains	Are filters, coils, fans, pans, drains and hidden joinery free from mould or water damage?
Electrical and controls	Can the generators support starts and continuous load, and are controls, sensors and software supportable?
Offshore consequence	Which bridge, equipment and sleeping spaces become difficult if one chiller or common pump fails?

Evidence worth requesting

- Loaded operating test with ambient and seawater conditions recorded.
- Chiller, pump, fan-coil and controller service history.
- Exact refrigerant type, charge and leak or compressor-repair records.
- Chilled-water fluid, pressure and condenser-cleaning records.
- History of condensate leaks, wet insulation, mould or interior remediation.

A COLD CABIN IS NOT A COMPLETE TEST	One cabin reaching set point alongside may hide restricted seawater flow, poor upper-deck capacity, high generator load or drains that fail only in humid conditions.
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OFFSHORE READINESS

Questions before relying on HVAC offshore

A ready system can reject heat through clean seawater flow, circulate chilled water or refrigerant reliably, control humidity and preserve priority spaces after one plant or pump failure.

Area	Question to resolve
Heat rejection	Which intake, strainer, pump and condenser remove heat from the yacht?
Reduced capacity	Can one chiller or pump fail while retaining bridge, technical and sleeping-space cooling?
Electrical load	Which generator combination and start sequence are needed for realistic operation?
Water management	Are condensate, insulation and chilled-water leakage controlled?
Priority spaces	Which rooms require cooling for equipment, batteries, watchkeeping or crew rest?
Supportability	Are refrigerant, compressors, controls, software and technicians available in the cruising area?

Quick readiness check

	Readiness statement
☐	I can trace the seawater, refrigeration, chilled-water, air and condensate paths.
☐	Duty and standby pumps or alternate plant arrangements have been demonstrated.
☐	Chillers and representative zones run stably under realistic ambient and seawater conditions.
☐	There are no unresolved trips, refrigerant or water leaks, weak discharge or condensate overflow.
☐	Filters, coils, pans, drains and insulation are clean, dry and accessible.
☐	Electrical start and continuous load are understood and included in generator planning.
☐	Alternative ventilation and priority-cooling arrangements exist for degraded operation.
☐	Current diagrams, baseline readings, selected spares and HVAC support contacts are available.

KEY TAKEAWAY

Dependable marine air conditioning combines clean seawater heat rejection, sound refrigeration, reliable water and air circulation, controlled condensate, manageable electrical load and a realistic degraded-operation plan.

Guidance to consult

Use current vessel HVAC piping and wiring drawings and the installed chiller, compressor, pump, air-handler and controller manufacturers' instructions, together with applicable refrigerant, electrical, flag-state, coding, insurer and service requirements.

Understanding Yacht Systems

Practical guides for owners, buyers
and offshore cruising crews.

AMTG-035

Understanding Air-Conditioning and Chilled-Water Systems

RELATED GUIDES

AMTG-005 Understanding Generators and Load Management

AMTG-017 Understanding Engine-Room Ventilation

AMTG-023 Understanding AC and DC Distribution

AMTG-036 Understanding Heating Systems

AMTG-037 Understanding Refrigeration Systems

AMTG-038 Understanding Ventilation and Dehumidification

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