

Understanding Refrigeration Systems

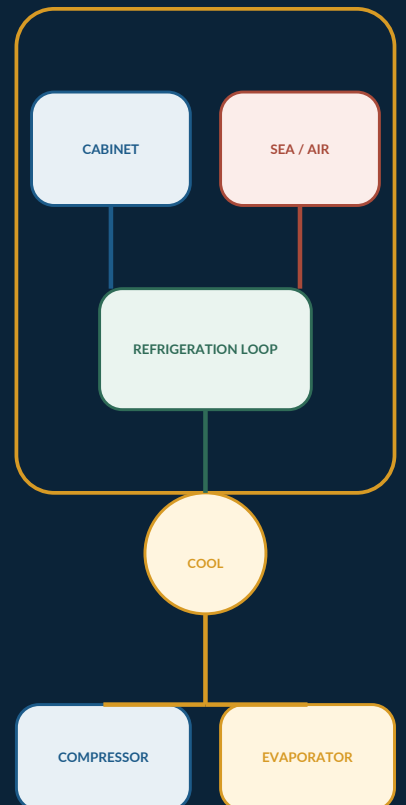
An owner's guide to compressors, heat rejection, cold storage and food security

Refrigeration preserves more than convenience. It protects food, medicines and passage endurance.

Reliability depends on insulation, heat rejection, power, controls and disciplined temperature management.

Absolute Marine

Commercial thinking for private cruising.



REMOVE HEAT | PRESERVE STORES

GUIDE OVERVIEW

What marine refrigeration systems are designed to do

Marine refrigeration removes heat from insulated cabinets, cold rooms or freezers and rejects it into cabin air or seawater while maintaining safe, stable storage temperatures.

SCOPE	This guide covers common air-cooled and seawater-cooled direct-expansion refrigeration, holding-plate systems, eutectic or cold-storage arrangements and independent domestic units. Refrigerant handling and pressure-system work require qualified technicians.
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By the end of this guide, you should be able to:

- Trace heat from the stored product through the evaporator, refrigerant circuit and condenser.
- Identify compressors, condensers, evaporators, fans, pumps, controls, drains and insulated enclosures.
- Recognise poor heat rejection, icing, refrigerant loss, bad door seals and excessive cycling.
- Understand power demand, temperature recovery and the value of independent cold-storage capacity.
- Ask better questions during purchase, survey, provisioning, maintenance and offshore preparation.

CORE PRINCIPLE	The compressor does not create cold; it moves heat. Reliable refrigeration depends equally on insulation, airflow, heat rejection, door discipline, drainage and power quality.
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Safety

Refrigerant circuits are pressurised and may contain flammable or oxygen-displacing gases depending on the installation. Electrical faults, hot compressor surfaces, moving fans, seawater leaks and food spoilage create additional hazards. Do not open refrigerant fittings.

SYSTEM ARCHITECTURE

How heat leaves a fridge, freezer or cold room

Heat enters through insulation, door openings, warm stores and internal fans or lights. The evaporator absorbs it, the compressor raises refrigerant pressure and the condenser rejects it outside the cooled space.



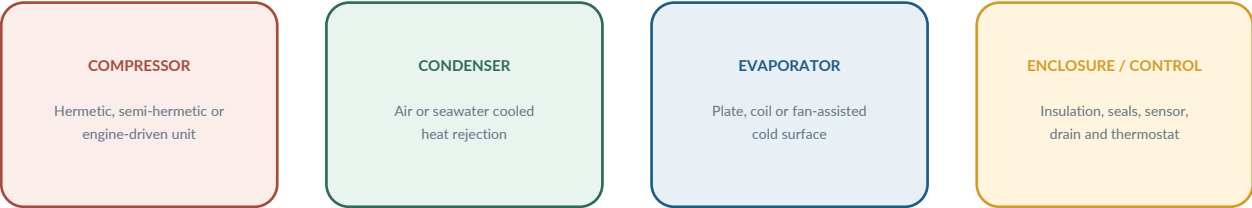
Layer	Purpose	Owner focus
Insulated enclosure	Limits heat entering the cold space.	Condition, thickness, vapour barrier, door fit and hidden moisture.
Evaporator	Absorbs heat from air or holding plate.	Frost pattern, fan airflow, drain, corrosion and sensor position.
Compressor	Circulates refrigerant and raises pressure.	Current, sound, mounting, cycling, cooling and service history.
Condenser	Rejects heat to air or seawater.	Clean fins or tubes, fan or pump, discharge airflow or water and corrosion.
Expansion device	Meters refrigerant into the evaporator.	Correct superheat or operation is specialist evidence; watch icing and unstable cycling.
Control and power	Starts and stops the system and protects it.	Thermostat, low-voltage cut-out, pressure controls, relays and breaker or fuse.

THE ENCLOSURE IS PART OF THE SYSTEM	Poor insulation, wet foam or a leaking door seal can overwhelm an otherwise healthy refrigeration plant.
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MAIN COMPONENTS

What owners should be able to identify

A useful system drawing should show the compressor, condenser, evaporator, receiver or accumulator where fitted, expansion device, controls, cabinet sensors and heat-rejection path.



Owners should know whether several boxes share one compressor, condenser, pump, controller or power source.

Component or area	Why it matters	Owner focus
Compressor and mounts	Provides refrigerant circulation and pressure rise.	Vibration, oil or refrigerant evidence, current, sound and ventilation.
Air-cooled condenser	Rejects heat into machinery or accommodation air.	Clean fins, clear airflow, fan condition and ambient temperature.
Seawater-cooled condenser	Rejects heat through intake, strainer, pump and overboard discharge.	Valve positions, flow, corrosion, fouling and leak risk.
Evaporator or holding plate	Removes heat and stores cold where designed.	Icing, corrosion, fan, drain, sensor location and full surface use.
Thermostat and controls	Regulate temperature and protect against low voltage or pressure faults.	Set point, calibration, relay or module support and alarm behaviour.
Cabinet, door and drain	Retain cold, control moisture and prevent water damage.	Gasket, hinges, latch, insulation, drain trap and cleaning access.

DOOR HARDWARE IS TECHNICAL EQUIPMENT	A weak latch or damaged gasket can add more load than a small refrigerant or control problem and may run the compressor almost continuously.
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SYSTEM ARRANGEMENTS

Air cooled, seawater cooled, holding plate and independent units

Different arrangements trade simplicity, efficiency, power demand and resilience. A yacht may combine small independent fridges with central freezers or cold rooms.

AIR COOLED
Simple heat rejection into ventilated cabin or machinery air

SEAWATER COOLED
Efficient heat rejection but adds intake and pump dependency

HOLDING PLATE
Stores cold for intermittent compressor operation

INDEPENDENT UNITS
Separate cabinets may retain partial capability

Separate cabinets improve resilience only when they do not share one compressor, pump, controller or electrical supply.

Area	What matters	Owner focus
Air-cooled domestic-style unit	Simple installation with no seawater path.	Needs adequate ventilation and may struggle in hot machinery spaces.
Seawater-cooled condensing unit	Good heat rejection in hot climates.	Adds sea chest, strainer, pump, condenser and flooding risks.
Holding-plate or eutectic system	Runs compressor periodically to freeze a thermal-storage plate.	Long pull-down, correct charge, plate condition and power scheduling.
Direct evaporator plate	Simple cold surface in cabinet.	Icing pattern, defrost method, product contact and sensor position.
Fan-forced evaporator	Provides even temperature and faster recovery.	Fan icing, blocked airflow, drain and noise.
Multiple independent systems	Allows one fridge or freezer to remain after another fails.	Confirm truly separate power, controls and heat rejection.

EFFICIENCY AND RESILIENCE ARE DIFFERENT

A central seawater-cooled plant may be efficient but can lose every cold space after one pump, sea chest or controller fault.

OPERATION AND LOADING

Pull-down, cycling, defrost and door discipline

Refrigeration demand rises sharply when warm stores are loaded, doors are opened frequently, airflow is blocked or frost insulates the evaporator.

PRE-COOL

Bring empty cabinet and stores down gradually

LOAD CORRECTLY

Allow airflow and avoid hot bulk loads

CONTROL OPENINGS

Limit warm moist air entering the space

MONITOR CYCLE

Watch temperature recovery, run time and frost

DEFROST / DRAIN

Remove ice and manage water without damaging components

Area	What matters	Owner focus
Initial pull-down	Requires sustained compressor operation and maximum heat rejection.	Allow generator or battery capacity and avoid judging faults too early.
Warm provisioning load	Introduces large heat mass and moisture.	Pre-chill stores where possible and load in stages with airflow gaps.
Door opening	Replaces cold dry air with warm humid air.	Use baskets, labels and planned access to reduce opening time.
Thermostat setting	Controls target temperature and cycling.	Lower settings do not overcome inadequate capacity and can increase icing.
Defrost	Restores evaporator heat transfer and airflow.	Use approved method; protect food and drains and avoid sharp tools.
Drainage and cleaning	Removes meltwater and contamination.	Check traps, hoses and inaccessible pans for mould or blockage.

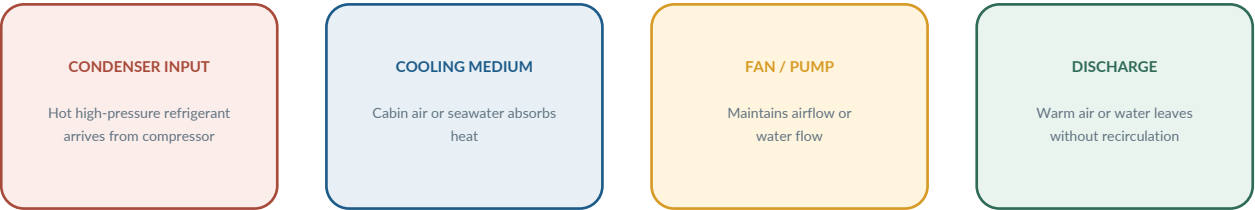
RUN TIME IS INFORMATION

A compressor that runs nearly continuously may be responding to high ambient heat, door leakage, frost, poor condenser cooling or lost refrigeration capacity.

HEAT REJECTION AND ENVIRONMENT

Airflow, seawater flow and machinery-space temperature

Every refrigeration system must reject more heat than it removes from the cabinet because compressor energy also becomes heat. Poor condenser conditions increase current and reduce capacity.



A condenser installed in a hot unventilated locker may recirculate its own heat and lose capacity.

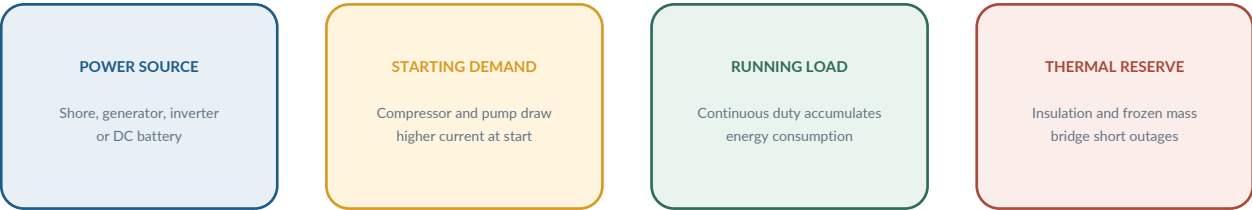
Condition	Likely effect	Owner focus
Blocked air condenser	Dust, lint or stored gear restricts airflow.	Higher pressure, current, temperature and compressor run time.
Failed condenser fan	Motor, relay, bearing or control fault.	Cooling may continue briefly but trips or overheating follow.
Restricted seawater flow	Blocked intake or strainer, worn impeller, air leak or fouled condenser.	High-pressure trip and possible pump or compressor damage.
Hot machinery space	Air-cooled condenser receives already heated air.	Improve ventilation or reduce load; assess installation suitability.
Warm seawater	Reduces temperature difference across condenser.	Expect lower capacity and higher pressure; compare with design limits.
Condenser leakage	Seawater and refrigerant sides can corrode or cross-leak.	Treat unexplained fluid, corrosion or pressure change as a specialist defect.

HEAT REJECTION SHOULD BE VISIBLE OR MEASURABLE	Air discharge temperature, fan airflow, seawater discharge and compressor current help confirm that heat is actually leaving the yacht.
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POWER AND RESILIENCE

Electrical demand, battery impact and degraded operation

Refrigeration often runs continuously across days and nights. Starting current, conversion losses and repeated cycling can become a major generator or battery burden.



A full freezer can hold temperature better than an empty one, but only if openings are minimised and insulation is sound.

Area	What matters	Owner focus
AC compressor	May require generator or inverter capacity above average running load.	Starting surge, power factor, voltage drop and transfer behaviour.
DC compressor	Can run directly from battery but may cause significant overnight discharge.	Low-voltage cut-out, wire size, battery monitor and duty cycle.
Shared inverter or charger	One fault can remove refrigeration and other domestic loads.	Prioritisation, bypass and alternate circuit options.
Seawater pump	Adds continuous electrical and flooding dependency.	Separate breaker, spare impeller or pump and safe isolation.
Thermal storage	Holding plate or frozen mass reduces compressor cycling during source changes.	Pull-down energy and realistic holdover time.
Emergency priorities	Food, medicine and critical stores may deserve limited emergency power.	Define which unit remains energised and which can be sacrificed.

COLD STORAGE NEEDS AN ENERGY PLAN	Offshore refrigeration should be included in generator, battery and fuel planning rather than treated as an incidental domestic load.
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MONITORING AND NORMAL VALUES

Using temperature, run time and current as early warning

The most useful owner evidence is stable cabinet temperature, predictable pull-down, normal compressor run time, clean heat rejection and no unexplained frost or water.

CABINET TEMP
Product and air temperature at representative locations

RUN TIME
Duty cycle and recovery after door openings

COMPRESSOR
Current, sound, temperature and cycling

HEAT REJECTION
Fan or seawater flow and condenser condition

Use an independent thermometer when a built-in display seems inconsistent with food condition or compressor behaviour.

Observation	What it may indicate	Owner response
Temperature slowly rising	High load, door leakage, frost, poor condenser cooling or lost capacity.	Reduce openings and inspect the complete heat path.
Compressor runs continuously	Warm environment, bad seal, poor insulation, low refrigerant or heat-rejection fault.	Check cabinet and condenser conditions before changing controls.
Short rapid cycles	Thermostat, sensor location, pressure control, overheating or electrical fault.	Avoid repeated starts and arrange diagnosis.
Uneven frost pattern	Airflow, refrigerant charge, restriction or evaporator issue.	Document pattern and seek specialist interpretation.
High current or hot compressor	High pressure, poor cooling, low voltage, mechanical wear or overload.	Protect the compressor and investigate before continued use.
Water or ice outside cabinet	Drain, seal, vapour barrier or insulation problem.	Prevent water damage and inspect hidden spaces.

RECORD RECOVERY TIME

How quickly temperature returns after provisioning or a power interruption is often more informative than a single cold reading.

FAILURE AWARENESS

Common weaknesses and warning signs

Refrigeration problems often begin with longer run time, slightly warmer product, unusual fan noise, repeated defrosting, intermittent low-voltage trips or a cabinet that sweats externally.

COMPRESSOR FAULT

Start relay, winding, wear or low voltage

REFRIGERANT FAULT

Leak, restriction or charge problem

HEAT REJECTION

Fan, pump, strainer or condenser restriction

ENCLOSURE FAULT

Seal, insulation, airflow or drain problem

Repeatedly adding refrigerant without locating a leak is not a durable repair.

Failure or evidence	Possible cause	Why it matters
Compressor will not start	Low voltage, relay or capacitor, control, winding or seized mechanism.	Temperature rises quickly and repeated attempts may overheat components.
High-pressure trip	Poor air or seawater cooling, fouled condenser or high ambient load.	Protect compressor and restore heat rejection.
Low-pressure or poor cooling	Refrigerant leak, restriction, icing or evaporator airflow fault.	Capacity declines and food or medicine may become unsafe.
Excessive icing	Door leakage, high humidity, blocked airflow, sensor or control problem.	Heat transfer falls and drains may overflow.
Water leakage	Blocked defrost drain, failed pan, wet insulation or seawater condenser leak.	Interior, electrical or structural damage can follow.
Temperature alarm ignored	Sensor fault, poor alarm location or normalised recurring problem.	Stores may be lost without obvious machinery failure.

DO NOT NORMALISE WARMER STORES

A fridge that is “usually a bit warm in hot weather” may have a heat-rejection, insulation or capacity problem that becomes serious offshore.

FAILURE RESPONSE

Protecting stores while avoiding further machinery damage

When refrigeration fails, preserve cold by limiting openings, moving priority stores, reducing heat load and protecting the compressor from repeated unsafe restarts.

CONFIRM
Use independent temperature and identify affected spaces

PRESERVE COLD
Keep doors shut and add safe thermal mass

CHECK SIMPLE PATHS
Power, fan, seawater flow, seal and thermostat

ISOLATE DAMAGE
Stop leaking or overheating plant

PRIORITISE STORES
Move medicine and food and seek support

Situation or stage	Immediate thinking	Avoid
Power loss	Keep doors closed, confirm alternate circuit and calculate battery or generator reserve.	Repeatedly opening boxes to check temperature.
High-pressure or overheat trip	Restore air or seawater cooling before reset.	Repeated restarts with a blocked condenser path.
Suspected refrigerant leak	Stop affected system, ventilate if required and obtain qualified service.	Opening fittings or adding unapproved refrigerant.
Cabinet temperature rising	Move critical stores to the coldest healthy unit and reduce loading.	Assuming all shelves are the same temperature.
Seawater leak	Shut the intake, isolate electrical supply and control flooding.	Continuing operation because cooling appears normal.
Extended outage	Use safe ice, alternate storage or disposal decisions based on food or medicine guidance.	Refreezing questionable food solely because the cabinet later becomes cold.

PROTECT PEOPLE BEFORE PROVISIONS	Do not accept flooding, electrical or refrigerant risk merely to save food. Isolate the unsafe system first.
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TESTING AND DEMONSTRATION

Testing pull-down, cycling, heat rejection and storage stability

A meaningful test should begin with known cabinet temperature, operate under realistic ambient conditions and show pull-down, stable cycling, heat rejection, alarm function and power demand.



Test	What it demonstrates	Limitations / owner focus
Cold-start or pull-down test	Shows available refrigeration capacity and compressor stability.	A pre-chilled empty box can hide weak performance.
Condenser-flow test	Confirms fan airflow or seawater route under load.	Observe heat discharge and compare with current or pressure history.
Door-seal test	Reveals leakage or poor latch compression.	Check full perimeter and hinge alignment.
Temperature-distribution test	Shows warm or cold spots and airflow limitations.	Use multiple suitable thermometers or data loggers.
Power-interruption recovery	Shows restart behaviour and thermal holdover.	Control the test so stores and batteries remain safe.
Alarm test	Confirms high-temperature, door or controller warnings reach the crew.	Check sensor location and delay as well as sounder or message.

USE A REALISTIC LOAD

The system should be assessed with representative stores, ambient temperature and door use, not only as an empty cabinet alongside.

MAINTENANCE STRATEGY

Keeping heat transfer, enclosure and controls dependable

Maintenance should preserve clean condensers, reliable fans or pumps, dry insulation, sound door seals, clear drains, accurate sensors and stable electrical supply.

Area	Good maintenance evidence	Why it matters
Condenser and cooling path	Clean fins or tubes, working fan or pump, open valves and clear discharge.	Maintains capacity and limits high pressure.
Compressor and electrics	Mounts, current, relay or capacitor, terminals, vibration and ventilation.	Supports reliable starts and avoids overheating.
Evaporator and airflow	Controlled frost, clean fan, clear passages and sound sensor.	Maintains even temperature and efficient heat transfer.
Cabinet and seals	Clean gasket, aligned hinges, secure latch, dry insulation and intact lining.	Limits heat and moisture ingress.
Drainage and hygiene	Clear drains, clean pans, suitable cleaning and no standing water.	Protects food, structure and electrical equipment.
Controls and alarms	Thermostat calibration, low-voltage protection, alarms and configuration backed up.	Supports stable operation and early warning.

Owner-level routine

- Clean air-cooled condensers and seawater strainers before performance declines.
- Inspect door seals, latches and cabinet sweating routinely.
- Defrost using the approved method and keep drains clear.
- Record representative cabinet temperatures and compressor run time.
- Review battery or generator load after adding another fridge or freezer.

WORK TO REFER	Refrigerant recovery or charging, leak repair, compressor work, pressure testing, brazing and mains electrical repair should be completed by qualified refrigeration technicians.
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BUYER AND SURVEY PERSPECTIVE

Assessing real cooling performance and hidden liabilities

A buyer should see the system pull down, stabilise and recover under representative conditions while inspecting cabinet insulation, doors, heat rejection, electrical demand and service history.

Area	Questions or evidence
System arrangement	Which cabinets share compressors, condensers, pumps, controllers and power supplies?
Cooling performance	How long does pull-down take and are temperatures even under realistic ambient load?
Heat rejection	Are air or seawater condensers clean, accessible and free from recurring high-pressure faults?
Enclosure condition	Are door seals, insulation, vapour barriers, drains and liners dry and sound?
Electrical load	What are starting and running demands on generators, inverter and batteries?
Failure history	Are refrigerant leaks, compressor changes, repeated recharging or cabinet water damage documented?
Supportability	Are refrigerant, compressors, controls and service technicians available for the cruising plan?

Evidence worth requesting

- Pull-down and temperature-recovery test.
- Refrigerant, compressor and leak-repair history.
- Electrical current and battery or generator load information.
- Condenser, seawater-pump and cabinet maintenance records.
- Temperature-alarm and power-loss response procedures.

A COLD EMPTY BOX IS NOT A COMPLETE TEST	Assess temperature stability, recovery, door seals, cabinet moisture and electrical demand as well as the lowest reading achieved.
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OFFSHORE READINESS

Questions before relying on refrigeration offshore

A ready system maintains safe temperatures under realistic heat load, rejects heat reliably, protects stored food or medicine and has a practical plan for degraded power or equipment failure.

Area	Question to resolve
Architecture	Which cold spaces share one compressor, condenser, pump or controller?
Heat rejection	How is condenser air or seawater flow confirmed?
Power	What is the continuous and starting demand on batteries, inverter or generators?
Storage priority	Which fridge or freezer remains powered if energy must be reduced?
Temperature evidence	How are product temperatures monitored and alarmed?
Supportability	Can the refrigerant, compressor and controls be serviced in the cruising region?

Quick readiness check

	Readiness statement
☐	I can trace the compressor, condenser, evaporator, controls, power and heat-rejection path.
☐	Representative cabinets maintain and recover temperature under realistic ambient load.
☐	Door seals, insulation, airflow and drains are sound and dry.
☐	There are no unresolved leaks, repeated trips, excessive cycling or recurring temperature alarms.
☐	Battery and generator demand is measured and included in energy planning.
☐	Independent cold-storage or transfer options exist for critical food or medicine.
☐	Temperature alarms and independent thermometers are functional.
☐	Current diagrams, baseline data, selected spares and technician contacts are available.

KEY TAKEAWAY

Dependable marine refrigeration combines sound insulated spaces, reliable heat transfer, adequate power, accurate temperature monitoring, clean heat rejection and a practical plan for protecting critical stores after failure.

Guidance to consult

Use current vessel refrigeration and electrical drawings and the installed compressor, condenser, evaporator, controller and cabinet manufacturers' instructions, together with applicable refrigerant, electrical, food-storage, flag-state, coding and service requirements.

Understanding Yacht Systems

Practical guides for owners, buyers
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AMTG-037

Understanding Refrigeration Systems

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