

COLD CHAIN TECHNOLOGY BRIEF

FISHING VESSEL APPLICATION

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Key figures

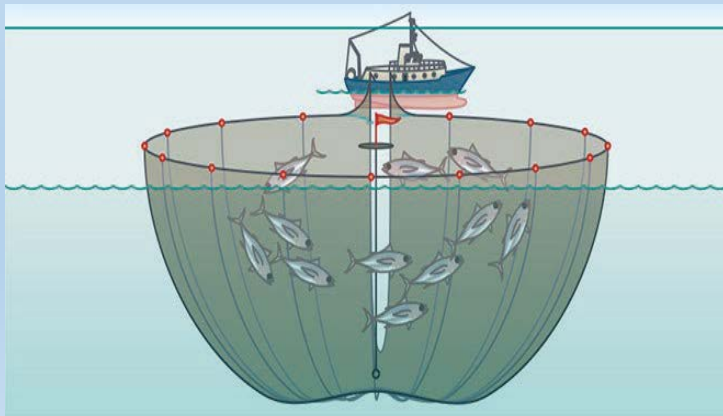


Total number of fishing vessels in the world: about 4.4 million.

Over 80% are less than 12 m long.

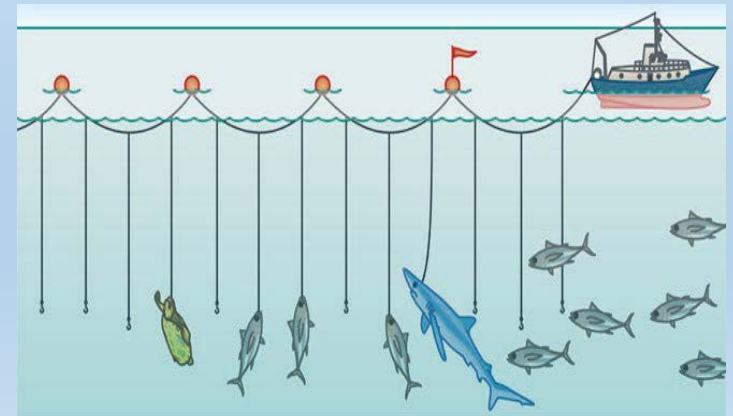
Asia and the Pacific have 73% of the world total.

2% of motorized fishing vessels are industrialized vessels, 24 m or more.



Fishing Gear

For large scale fishing, the most widely used are purse seine and long lines.



If not consumed fresh, fish is processed for conservation: Canned, frozen meals or fillets, freeze dried etc.



Industrial processing of fish can be done on board factory ships, or in land based plants. In all cases, the process is relatively similar to other kinds of food processing.



Refrigeration Needs are highly diversified

Catches	Conservation	Processing		
Local	Ice	None (fresh)		
Mid-distance	Brine freezing	Industrial	Land based or "Factory Ships"	Canned
Long distance	Deep Freeze			Frozen whole, Fillets & Meals



About 70% of refrigeration for fishing still relies on R-22.

Typical Process Needs

- Brine or Sea Water cooling
 - For various process needs
 - For direct freeze of some catches on board
- Plate and blast freezers
- Air cooling
 - In clean cold rooms for processing.
 - In cold rooms to store frozen goods.
 - To cool the holds of ships in warm climate.
- Ice machines
 - Centralized production in harbors
 - Production on board large ships



Refrigeration needs are typically at 2 temperature levels:

- “MT” (Medium temperature), about -5°C evaporation.
- “LT” (Low temperature), about -40°C evaporation.

Specific features *on board ships*

Marine does not require radical technology changes from land based applications, but adapted design:

- Extra reliability is expected (no big repairs on board).
- Pitch and roll conditions.
- Safety is especially important (no escape !).
- Corrosion in marine environment.
- Material compatibility for sea water cooled condensers:
- Warm climates ? Not a big issue:
 - Machinery is indoor in machine rooms.
 - Condensers are mostly water cooled: temperature remains moderate.

System architectures / Independent systems

- **Independent systems used for:**

- Chillers for sea water or brine cooling.
- Condensing units plus D-X for air cooling.
- Ice machines

- **Fluids used**

- Mostly R-22
- R-404A in more recent systems.

- **Possible alternatives**

- For sea water chillers: medium pressure synthetic fluids like R-134a or lower GWP alternatives (New systems only).
- For condensing units with D-X, alternative blends can be considered, for new systems and retrofits.

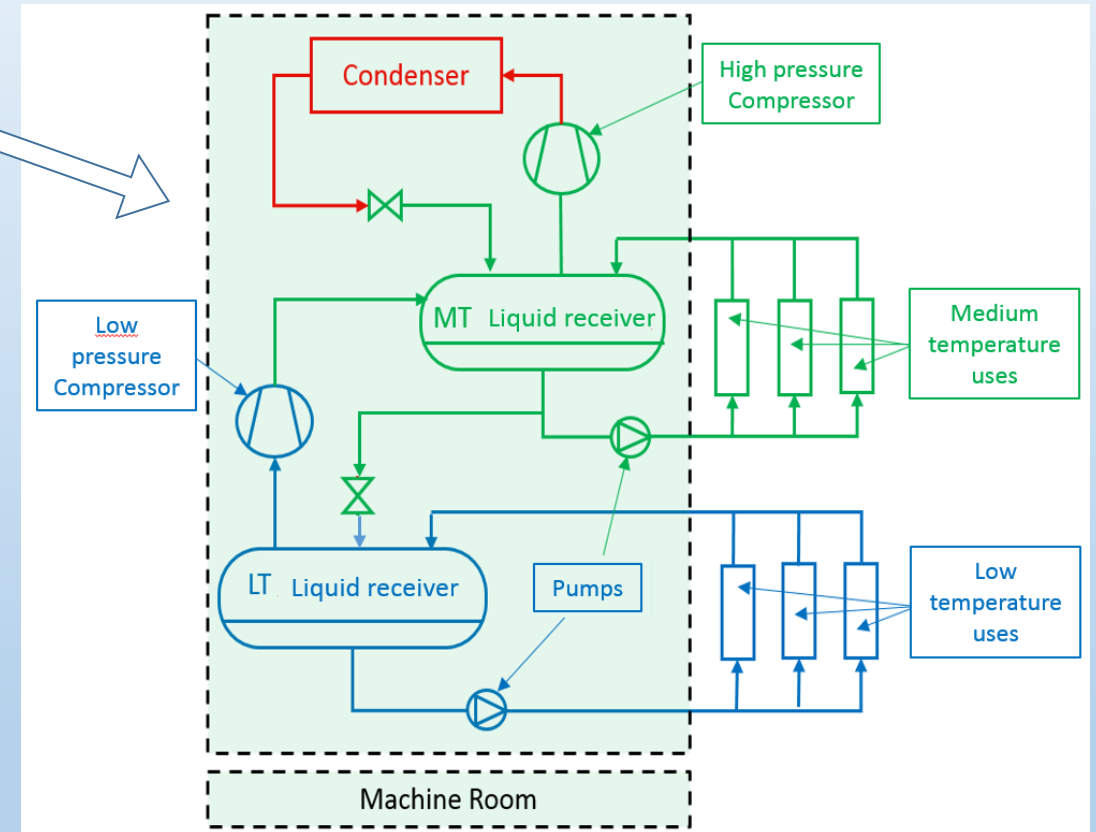
Large Centralized Systems

Large Flooded systems used in large factory vessels:

- Liquid is refrigerant pumped to cold rooms, freezers etc, often at 2 temperature levels (cascade system). **Typical sketch:**
- Use one single refrigerant at both temperature levels. Usually **R-22 or Ammonia**).
- Large refrigerant charge, long piping, many connections: → often relatively large leaks of fluid.

Alternatives to R-22

- **For retrofits**, no proven satisfactory solution has been found.
- For ships with still long expected life time, **complete replacement** of refrigeration systems.
- For **new systems** (new ships or system replacement), various options are possible.



Alternative to R-22 for Large Centralized Systems

Various alternatives exist, with different fluids and (or) architectures.

- **With same architecture, ammonia** is feasible, but existing R-22 systems must be replaced for safety & material compatibility.
- **With different architectures, other options** are possible with different fluids in cascades, like:
 - At **Low Temperature** stage, CO₂ is very attractive.:
 - Excellent energy efficiency.
 - Compressors and piping are small compared to other fluids: cost effective.
 - Lower evaporation temperatures are feasible with good cost and efficiency. This improves the capacity of freezing systems, allowing reduced capital cost for freezers, or improved productivity.
 - CO₂ has less risks than NH₃ for flammability and toxicity.
 - But CO₂ not suitable at ultra-low temperature (below -50°C).
 - At **Medium Temperature stage**, various fluids are possible. Ammonia is an option, but it can also be HFCs like 134a or 134a / HFO blends.
 - Indirect Systems can also be considered for Medium Temperature stage, with chillers using various suitable fluids.

Safety Issues

- Like for land based systems, flammable or (and) toxic fluids are feasible.
- It is preferred, but not mandatory, to keep such fluids out of working areas, and restrict them to machine room.
- Acceptability depends on ship owner. Some vessels are using ammonia, with satisfactory return on experience.
- Adequate safety measures required, like:
 - Restricted access to some areas.
 - Special ventilation triggered by leak detectors.
 - Special training.
- Retrofit from non-flammable to flammable fluids generally not feasible.
- Hydrocarbons are not considered acceptable in fishing vessels.

Retrofits and conversions from R-22 or 404A

- **Blends with glide** (R-407 family or similar) require close analysis of systems:
 - OK for small systems (condensing units with a few D-X cooling coils).
 - In large systems (multiple coils or freezers from a receiver, pump or gravity fed), glide can cause severe performance deterioration (capacity and COP).
- Changing to **NH₃** always requires a **major overhaul, when at all possible**:
 - Stringent limitations on condensing temperature: air cooled or warm climates difficult.
 - Material compatibility (no copper with ammonia !)
 - Yet, major overhaul can be quite interesting if combined with conversion to NH₃ / CO₂ cascades, because of substantial improvements in efficiency, and productivity of freezers. This is done increasingly in factory ships.

Conclusions

New systems

- Technically, there are satisfactory solutions to avoid R-22 and R-404A for most applications in new systems.
- For centralized systems, these rely mostly on wider use of CO₂ and NH₃.
- Related safety issues are generally well controlled on board ships where implemented, and for land based in most developed countries.
- Some developing countries are not ready to use NH₃ and CO₂ safely. Technical solutions exist, but **training is critical for implementation.**

Conversions from R-22 / 404A

- There are suitable blends with glide for small D-X systems in most cases.
- There is no clear solution for large systems. Retrofits may lead to drastic performance deterioration. Major overhaul or replacement of system may be needed.