

The cold chain in the fishery sector. Refrigeration Technology Review

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« Fishing Industry » is highly diversified



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



Local Fishing and distribution rely mostly on ice

- “Passive” cooling; can be used without any machinery on board ships.
- Provides cold storage.
- Very well suited for fish:
 - Provide the quick cooling after catching, needed for good quality.
 - The temperature is just as needed for short term conservation.
 - The water from melting could affect the quality of other goods, but does not alter the quality of the fish, protected by its skin and scales.



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 kind of food processing.



Typical Process Needs

- Ice machines (production, storage, distribution)
 - Centralized production in harbors
 - Production on board large ships
- Brine or Sea Water cooling
 - For various process needs
 - For direct freeze of some catches on board
- Plate freezers
- Air conditioning
 - In Clean cold rooms for processing.
 - In cold rooms to store frozen goods.
 - To cool the holds of ships in warm climate (reduce ice consumption).
 - Comfort cooling of crew in factory ships.

Specific features *on board ships*

- Extra reliability is expected.
- Pitch and roll conditions.
- Safety is especially important, but well trained & dedicated crews.
- Corrosion in marine environment.
- Material compatibility for sea water cooled condensers:
 - **With HFCs**, shell & tube condenser using **copper-nickel**.
 - **With NH₃**, only **titanium** can handle NH₃ and sea water simultaneously.
- Warm climates ? Not a big issue:
 - Machinery is indoor in machine rooms.
 - Condensers are mostly water cooled: temperature remains moderate.

Marine requires special design, but no radical technology changes from land based applications.

Refrigerants: prior state of the art

Land based

- In land based industrial systems for food processing, including fishing sector, NH₃ is already dominant in Art-2 countries. In Art-5 countries, R-22 is dominant, both for process cooling, and large ice machines.
- R-404A is also used in some applications in Art-2 countries, especially for medium / small systems, including ice machines.

Ships

- On board ships, R-22 used to be dominant for cost and safety reasons.

Future trends and issues / New systems

The problem of large systems

- Many food processing systems are large with direct expansion of fluid distributed to cold rooms, freezers etc, often at 2 temperature levels (cascade system).
- Large refrigerant charge, long piping, many connections: difficult to have leak tight systems → often relatively large leaks of fluid. This makes high GWP fluids like R-404A undesirable.

Alternatives to R-22

- In the past years, NH₃ gained wide acceptance in ships, associated with proper safety measures.
- Hydrocarbons are not considered an option in ships for safety reason.
- CO₂ cascade systems very interesting when applicable (land based and ships).

The interest of CO2 cascades

- Excellent energy efficiency at low temperature.
- At low temperature, 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 the capital cost for freezers, or improving the productivity.
- CO2 has less risks than NH3 for flammability and toxicity. And in low stage of cascades, the operating pressure remains moderate.

--> **CO2 is very attractive for low stage of cascades.** The temperature of the high stage is generally between -10 and 0°C, with various technologies and fluids for the high stage. Ammonia is the main option, but it can also be HFCs like 134a, or a brine chiller using any suitable fluid.

Ice Machines

- Typical sizes 500 kg to 40 tons of ice per unit
- Fluids: R-22 / R-404A, and NH₃ for large machines (>5 to 10 T/h)
- But NH₃ is suitable only when water cooled:
 - Air cooled NH₃ condensers are very expensive.
 - And condensing temperature is too high if air cooled in warm countries.
 - Not a problem on ships (sea water cooled)



There remains a problem for land based ice machines:

- For small sizes (NH₃ not available).
- ..or when there is no condensing water at adequate temperature. This can happen:
 - when water is too scarce
 - ...or when evaporative cooling towers are not practical because, of sand, saline environment etc.

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 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, if 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 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, even in warm climates.
- These rely mostly on wider use of NH₃ and CO₂.
- Related safety issues are well controlled on board ships, and for land based in most developed countries.
- Some developing countries are not ready to use NH₃ and CO₂ safely. **Training is critical for implementation**, more than technical solutions.
- There are still some niches where R-22 / R-404A are difficult to replace; for instance small to medium ice machines in warm climates.

Conversions from R-22 / 404A

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



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