Fishing Vessel Energy Audit Project

To provide vessel owners with practical measures to save fuel, the Alaska Fisheries Development Foundation (AFDF) partnered with Alaska Longline Fishermen's Association (ALFA), Alaska SeaGrant, Nunatak Energetics, and Navis Energy Management Solutions to conduct energy audits and collect data from Alaskan fishing vessels from 2012 to 2017. The information below is provided to help vessel owners identify operational and equipment solutions to improve fuel efficiency, and to tailor these solutions to their specific needs.

Improving RSW System Performance

The following are some practical operational and equipment related strategies to improve refrigerated sea water (RSW) system performance and save fuel.

Operating practices

Many of the vessels surveyed can reduce refrigeration fuel consumption by up to 15% and improve refrigeration capacity by opening the condenser water flow valve. Increasing condenser flow allows the condenser to remove more heat from the refrigerant. This has the effect of lowering the discharge pressure from the compressor and increasing the system capacity. As long as the pressure differential required by the thermal expansion valve is maintained (typically around 75 psi), lowering the discharge pressure by increasing condenser flow will have a positive effect on performance. Figure 1 illustrates how discharge pressure affects the performance of a Carlyle O6D compressor according to manufacturer's specifications.

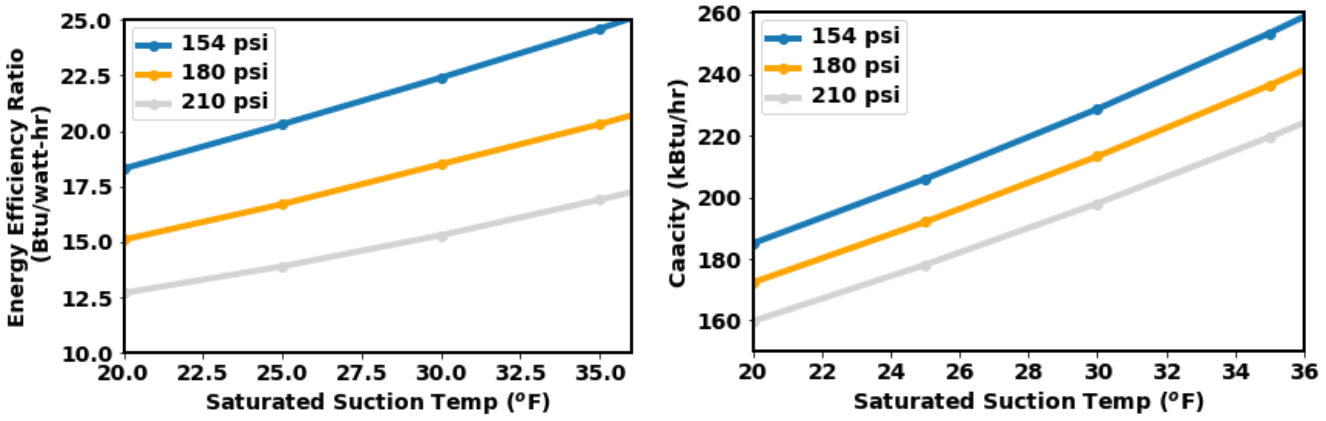

Figure 1 Compressor EER and Capacity dependence on discharge pressure

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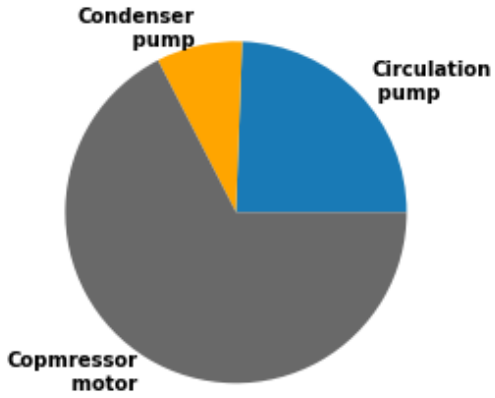
Turn off the circulation pump



Fiaure 2 RSW load break down

Figure 2 shows the typical load break down observed in RSW systems. The compressor uses approximately ⅔ of the total system power and is the dominant load on the engine. However, the circulation pump also uses approximately ¼ of the system power. The average RSW circulation pump observed used approximately ⅓ of a gallon of fuel per hour. On top of that, all of the power supplied to a water-cooled circulation pump ultimately heats the water in the hold, forcing the compressor to work harder and cycle on more frequently. Turning off the circulation pump when it is not needed can be a significant fuel savings.

Variable Frequency Drives (VFD)

VFDs adjust the frequency of AC electricity to slow down or speed up a motor. In RSW systems, a VFD can slow down the compressor speed as the hold temperature approaches the desired temperature. Alternatively, a VFD could be used to optimize the circulation pump speed based on the temperature change across the evaporator. VFDs also provide a soft-start feature that eliminates the sudden power surge normally associated with starting a large motor.

Hold Insulation

Insulating and sealing the fish hold reduces heat infiltration that must be removed by the freezer system. A well run RSW system can achieve a coefficient of performance (COP) of about 3.5 when the hold is at 33°F. That means every 1 kWh supplied to the system removes 3.5 kWh of heat from the hold. Figure 3 shows fuel consumption per day for a range of hold insulation values. The Figure assumes a COP of 3.5, a surface area of 1100 ft^2 (associated with a hold capacity of 50 tons water) and average ambient air and water conditions. The R value represents both heat conduction through the walls and air infiltration. The reported fuel consumption accounts for neither freezing fish nor engine idle fuel consumption because those loads are independent of the hold insulation.

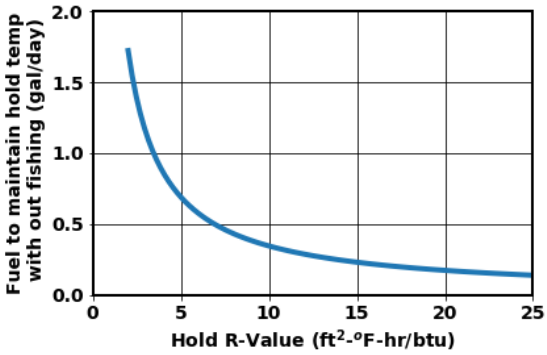


Figure 3 Value of hold insulation

Estimating the overall R-value of a fish hold can be tricky.
One method is to use the RSW system to pull the hold to 32°F, then place a known volume of ice in the hold and turn the RSW system off. Record the outdoor air and water temperature, and time how long it takes for the ice to melt. The overall R-value is then approximated by Equation 1, where A is the surface area of the hold (ft^2), *time* is the time it takes the ice to melt (hours), T_{air} and T_{water} are the ambient air and water temperature in Fahrenheit, m_{ice} is the weight of ice introduced to the hold (lbs) and R is the overall average R-value of the hold, in ft^2-hr-°F/Btu. The factor of 144 is the heat of fusion of water, in units of Btu/pound.

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$$R = A \times time \times \frac{(T_{air}+T_{water})/2-32}{144\, m_{ice}} \qquad (1)$$

Water source temperature

The temperature of the water in the hold before starting the refrigeration has an impact on how much time and fuel are required to cool the water to temperature. Figure 4 illustrates the fuel required to cool the hold to 33°F from a range of starting temperatures in a typical RSW system (including auxiliary engine overhead fuel consumption). Every five degree decrease in starting temperature corresonds to a fuel savings of 2 gallons per pull down. Purchasing ice at the dock will offset all of the pull down fuel, and can also contribute to refrigerating the fish.

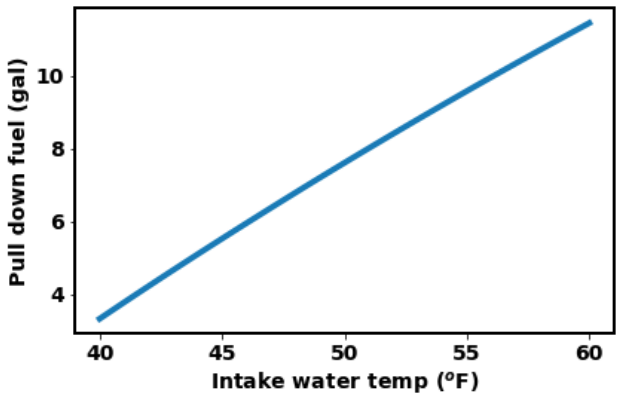

Figure 4 Fuel consumption based on starting water temperature

Simple steps to save fuel:

- **Reduce compressor discharge pressure—**Discharge pressure can be regulated by the amount of water moving through the condenser. Lowering the discharge pressure can significantly reduce energy consumption and increase system capacity. Check with your refrigeration technician to evaluate the minimum discharge pressure needed for your application.
- **Variable Frequency Drives—**VFDs speed up or slow down electric motors by regulating the frequency (Hz) of the power supply. VFDs can monitor hold temperature and automatically adjust compressor RPM to meet demand.
- **Insulate—**Check the insulation and seals on hatches to make sure heat stays out. Good insulation and functional seals increase efficiency.
- **Start with cold water—**Every five degree increase in starting temperature equates to about two additional gallons of fuel. If you can, purchase ice at the dock to eliminate pull down fuel consumption.

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