

$$NTU = \frac{UA_{ice}}{C_w} \Rightarrow \frac{572}{349} = 1.64$$

$$T_{supply} = -7.27^{\circ}\text{C}$$

$$T_{return} = -5.14^{\circ}\text{C}$$

$$T_{oo,avg} = \frac{T_{supply} + T_{return}}{2} \Rightarrow \frac{-7.27 + (-5.14)}{2} = -6.20^{\circ}\text{C}$$

$$t = -\frac{mcp}{UA} \ln \left[\frac{T_f - T_{oo,avg}}{T_i - T_{oo,avg}} \right] \Rightarrow -\frac{(0.355)(4184)}{(182)(0.03414)} \ln \left[\frac{4.44 - (-6.20)}{29.44 - (-6.20)} \right]$$

$$= 289 \text{ s} = \boxed{4.81 \text{ min}} < 5.00 \text{ min} \text{ Meets requirement}$$

Summary:

The calculations predict the cooler can cool six 12-oz cans from about 85°F to 40°F in less than 5 min. The original preliminary calculation predicted about 4.43 min when salted ice water bath was assumed to remain at 18°F. The final analysis also considered the temp rise of the circulating water and finite convection between the returning water and the ice. With this effect included, the final predicted cooling time is about 4.81 min, which is below the 5 min requirement. The design requires about 223 kJ of heat removal, a local coolant velocity near 0.30 m/s, at least 300 L/hr of operating circulation, and about 1.34 kg of ice.

Materials:

- Insulated 10-qt cooler
- 6 12-oz aluminum cans
- Removable 6 can carrier
- 2 240 L/hr submersible pumps
- Acrylic flow divider/baffle
- Clear tubing and fittings
- Rechargeable 12V battery
- Water
- Salt
- Approx. 1.34 kg of ice