The Hot Water Tank Problem

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Newpark Shipyards manufactures and repairs large barges. Many of the barges brought in for repair are tankers with substantial amounts of fuel vapor in the tanks. In the past this explosive gas was vented to the atmosphere but clean air standards now require that it be burned cleanly. The shipyard had to choose between a $250,000 flare system or a $500,000 hot water system which would use the fuel vapor to produce hot water which would then be used to clean the barge. The decision on which alternative boilded down to whether the hot water produced would on one day would be hot enough to use the next. This was because the vapor had to be removed but the tanks would not be safe for workers to enter for up to eight hours more.

Here is a simplified version of the problem:

> At six a.m. a tank contains 20,000 gallons of water at 90 degrees Fahrenheit. One hour earlier the water in the tank had been at At six a.m. fuel vapor from a barge is burned and the heat transferred to the water in the tank via a heat exchanger at a rate of 80,000 BTU per minute for four hours. Assuming that the ambient air temperature remains at a constant 80 degrees and that only Newton's Law of Cooling applies (ignore radiant heat loss) what will be the temperature at the end of the four hours and how long (if at all) will the water in the tank remain above 170 degrees Fahrenheit.

Investigate the problem above, answering the question posed. Then investigate the sensitivity of the answer to the "constant ambient temperature" assumption by assuming that the temperature is a constant during each clock hour, starting with 40 degrees from 6:00 to 7:00 and that it increases two degrees per hour until 6:00 p.m and then decreases two degrees per hour until it gets back to 40 degrees at 6:00 a.m. at which time the cycle repeats.

residual amounts of hydrocarbon