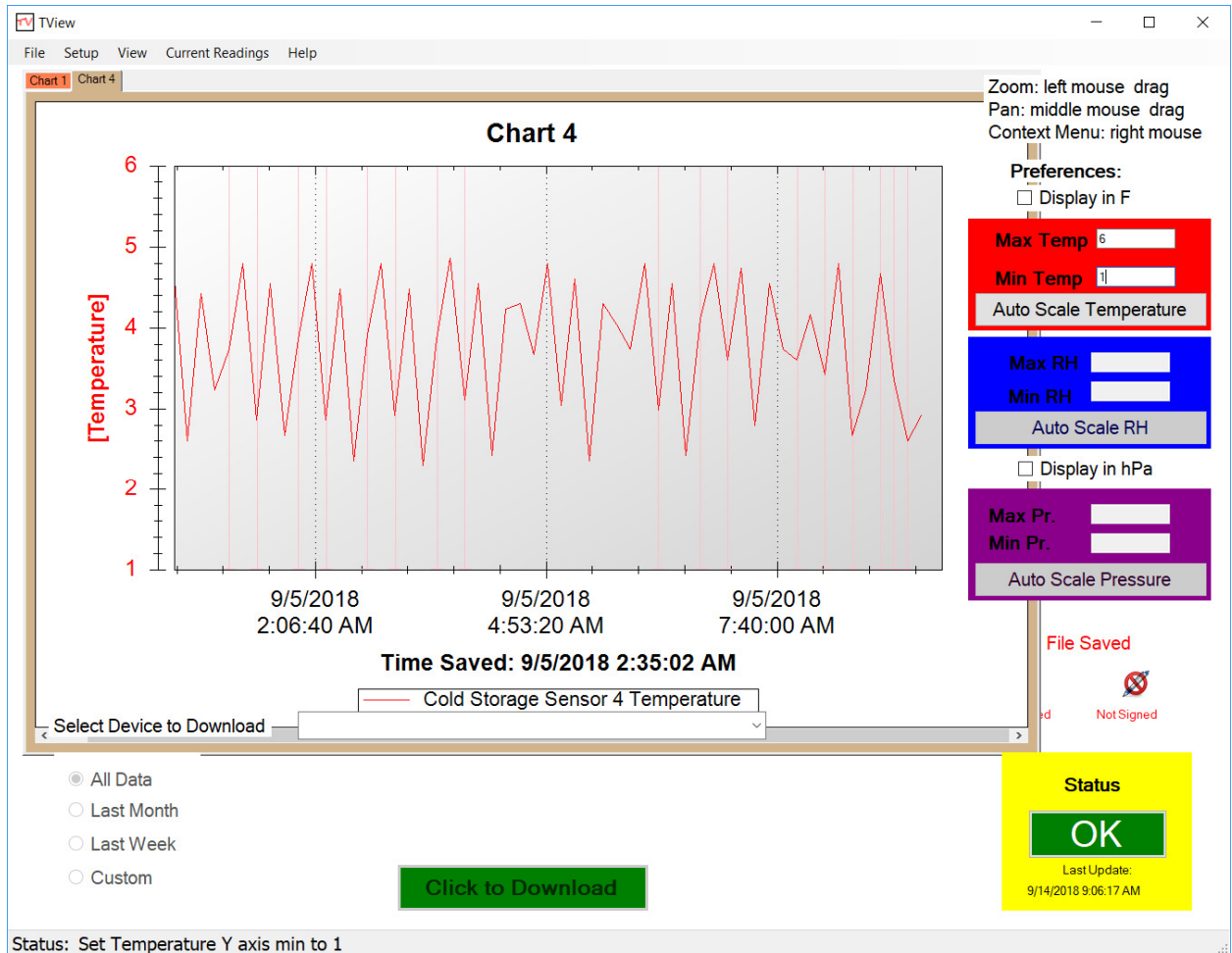


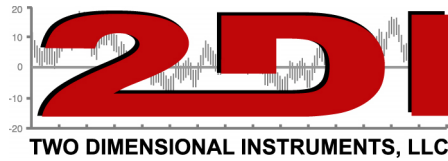
Recently we received a call from a panicked TV2 user. He sent a copy of his temperature history showing a number of alarms.



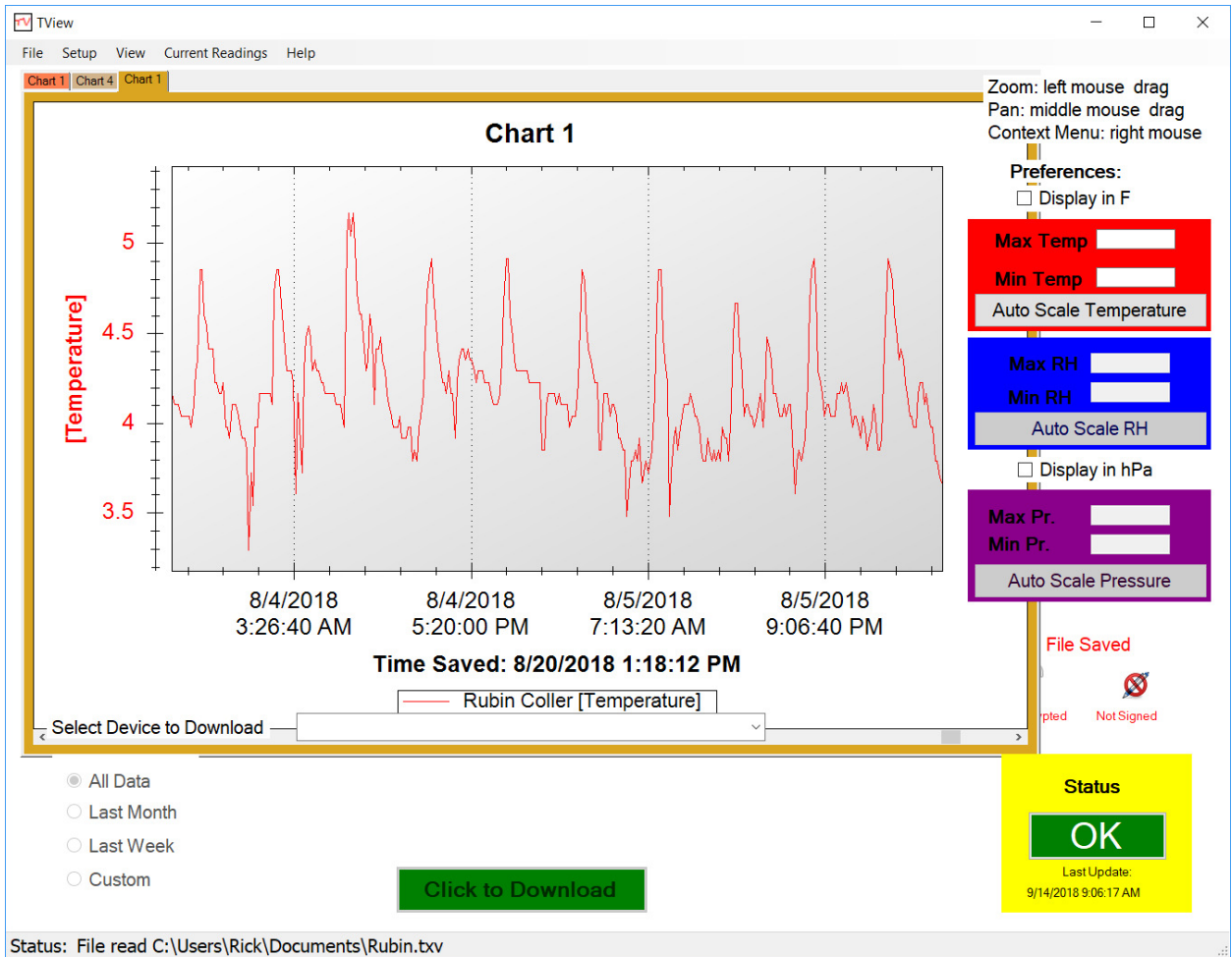
He was convinced that the TV2 was giving false alarms. He also sent, at my request, a copy of his alarm settings. The alarm settings were set so that any time the temperature fell below 2.5° for more than two minutes an alarm was triggered. However he was logging temperature once every 10 minutes. Therefore, the alarms were not always in concert with the logged temperatures.

Although these alarm settings seem reasonable as he wanted to provide the maximum protection for vaccines stored in his refrigerator, it demonstrates a lack of understanding in how a refrigerator actually works.

Most people assume that a refrigerator quickly cools down to its set temperature stays there, steady and constant. **That is not the way a refrigerator works.** It is *always* warming up and



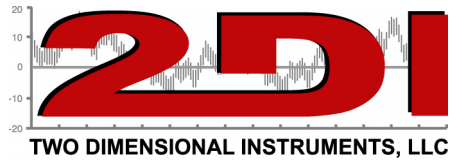
cooling down. It never just sits there at the correct temperature. The chart below illustrates this point very clearly.



When the refrigerator cools down to its set temperature the compressor turns off and waits to come on again until the temperature warms up to some set point. The refrigerator in the chart above appears to have its compressor-of point set to somewhere around 3.5 or 4°C. The few points below that temperature are probably due to lag. And it looks like the compressor is set to come on around 4.8°C. This is exactly like your air condition at home or in the office. The temperature is never just stable. It is always moving up and down.

How quickly a refrigerator, or you home for that matter, it warms up is due to several factors.

1. How much insulation there is in the walls, roof, floor and door.
2. How often the door is opened.
3. Type of door:
 - a. Glass

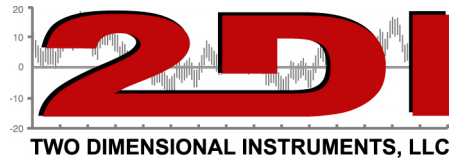


- b. Metal
 - c. Wood
4. If something warmer than the refrigerator temperature is placed inside. (This can have a major effect if the object has a large mass).
 5. Where the refrigerator is located:
 - a. An office environment
 - b. An un-air-conditioned warehouse
 - c. Outside
 6. An in-efficient or failing compressor.
 7. Compressor settings.
 8. A poor, bad or failing thermostat.
 9. Poor contacts on a switch.
 10. Poor gaskets allowing air leakage around the door.
 11. Steady power supply.

Once a refrigerator warms up it must cool down again to the thermostat setting. How quickly it cools down is determined by several factors:

1. The type, size and age of the compressor.
2. The amount of insulation in the walls, roof, floor and door.
3. The type of refrigerator door:
 - a. Glass
 - b. Metal
 - c. Wood
4. How well the refrigerator has been maintained
 - a. How clean the refrigerator coils are.
 - b. Proper air flow around the compressor and the coils.
5. How full the refrigerator is.
6. Where product is located inside the refrigerator.
7. Whether the fan outlet inside the refrigerator is restricted or not.
8. The temperature difference between the setting and the outside air temperature.
9. Where the thermostat sensor is located inside the refrigerator.

In this case the TV2 user was confused because the temperature was moving up and down and a lot of alarms were occurring. In this particular case there was no correspondence between the alarms and the logged data points. This was because he was logging an average of all temperatures over a ten-minute period, but the alarms were set for a two-minute delay. So it was possible for the temperature to drop down below his alarm point for two minutes and then quickly warm up



again within the ten-minutes period. However, he would never see the dip in temperature since all temperatures within that ten-minute period were averaged together.

We suggested that he set his log rate for once a minute. That way any momentary dips in temperature will be very visible on his temperature history chart. We also suggested that he put his temperature sensor in a vial of liquid to buffer the temperature swings. This dampens the response time of the TV2 sensor, but it probably gives a more accurate picture of the temperature of the liquids he is storing in his refrigerator.