Work Log of Apple Power Mac G5 Quad Liquid Cooling System Pump Repair

Introduction

While repairing the LCS unit of a G5 Quad, the original pump got damaged and stuck at the highest speed. It appeared to be doing its job just fine, but it was a little noisy and possibly shorter lived (or making the rest of the system shorter lived) than when under proper speed control. So, the pump was replaced.

Changelog

General information about the pumps

All versions of the Power Mac G5 Quad LCS units use Laing DDC pumps. The same Laing models were also generally available from stores selling PC water cooling supplies at the time of the G5's introduction and some years after. The specific models that were used included Laing DDC-2 (DDC2B-VC), DDC-3.1, and DDC-3.2. All pump models in the G5s were equipped with the Volume Compensator (the -VC suffix in the pump model specifier), which was/is only available to OEMs.

The older Power Mac G5 Dual machines with Delphi LCS units also utilized Laing DDC pumps. The older generation Delphi unit had Laing DDC-1 pumps (DDC1-VC and DDC1A-VC). The volume compensators in some of these pumps were prone to diaphragm breakage and leaking.

The DDC-1 and DDC-3.1 models were lower powered at 10 W and max 3900 rpm while the DDC-2 and DDC-3.2 models were higher powered at 18 W and max 4500 rpm. In practice, DDC-2 was the highest powered model with higher head pressure than the other models, but it also had the highest failure rates. The DDC-1 pumps had black impellers, the DDC-2's orange or brown, and the DDC-3's blue ones. In all the Apple LCS units, the rpm was limited to max 3600, so the pump's version did not actually matter.

The Laing DDC-1 and DDC-3 models had different electronics and signalling and are not interchangable. The tachometer signal in the DDC-1 models has 12 pulses per revolution whereas the in the DDC-3 models it has 2 pulses per revolution. The speed control scheme is, apparently, also different. The DDC-3.1 and DDC-3.2 are essentially the same pump: the DDC-3.2 has one connection bridged compared to the DDC-3.1, yielding a higher powered pump. The DDC-2 and DDC-3 models are interchangable, but the wiring order on the PCB is the exact opposite.

The current Laing DDC models, somewhat confusingly named DDC-1T, DDC-1+, and DDC-1RT, have new design and are no longer compatible with the Power Mac G5 signalling. The newer pumps can be driven by the G5, but the speed control scheme is yet again different, and therefore the PWM pin of the newer pumps should be left unconnected.

The Laing pumps are and were also sold as Swiftech MCP350 and MCP355. The MCP350 was/is equivalent with the Laing DDC-1, DDC-3.1, and the newer DDC-1T models and the MCP355 with the Laing DDC-3.2 and the newer DDC-1+ models.

The references section has a pointer to bmaverick who sells pristine DDC-1 pumps that are compatible with the Power Mac G5 Dual Delphi LCS units. The DDC-3.1 and DDC-3.2 pumps used in the G5 Quad machines are not easily available non-used. The compatibility of the pump can be checked from the PCB, which should read "3.3" in the correct models or from the order of the wires coming out from the pump, which should be black, yellow, blue (or the other way around, depending on how the pump is held). The references section has a link to a photo of the correct PCB version.

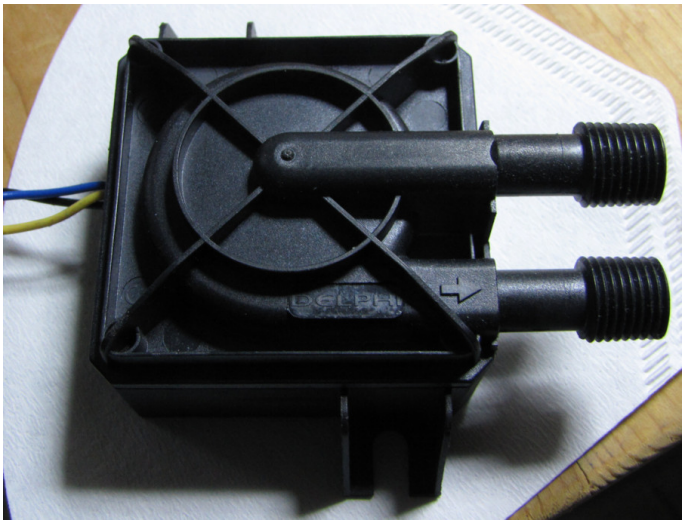
Required tools and materials

The following tools and materials were used:

- Detaching the pump
    1. Torx T15 screwdriver
- Draining and rest of take apart
    1. same stuff as in the previous round
- Pump repair
    1. Dremel tool with a 1,5 mm drill bit
    2. soldering iron and lead-free solder
    3. hot-melt glue gun and glue stick(s)
    4. a Laing DDC-3.2 (sold as Laing DDC-1plus RT) pump and a new pump top

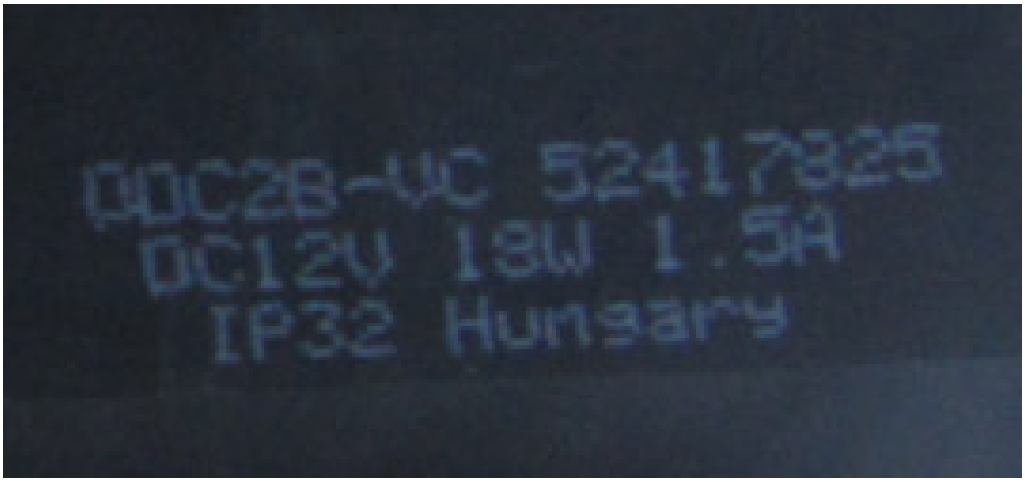
Replacement pump

A replacement pump was first needed, and luckily a used DDC-3.2 in fair condition was found. The pump was originally sold as DDC-1Plus RT and, as such, had the wrong type of top (threaded hose connectors). Therefore, a new top with the correct 3/8" barbed connectors was also acquired from a PC water cooling shop.



DDC-3.2 donor pump with threaded connectors

The original pump in the G5 was a DDC2B-VC, and the plan was to exchange only the PCB. That plan, however, proved not to fly.



The original DDC-2 pump model

Take Apart

Before taking anything apart, the unit was half drained using the syringe familiar from the previous rebuild. The syringe was again attached to the service port using the service port coupler and a syringeful of liquid was pumped out of the unit at a time.

After draining, the two hoses attached to the pump were detached by cutting the ends longitudinally with a carpet knife. This method of removal was found easier during the previous rebuild.

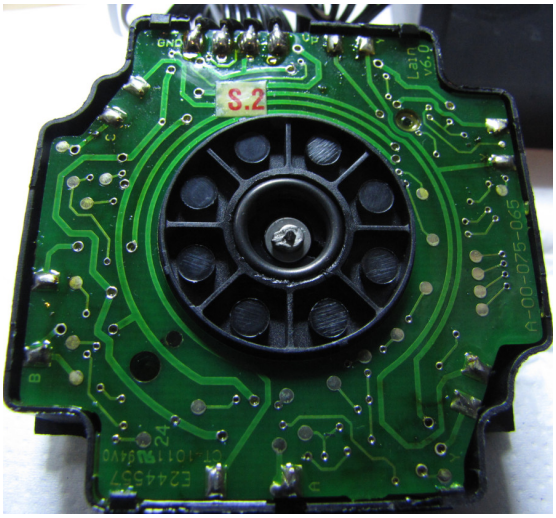
With the hose connections open, the whole unit was flushed and reverse flushed with deionised water. Flushing was, unfortunately, done after recklessly leaving the unit to dry while waiting for the new pump.

There are two Torx T15 screws that hold the pump on the LCS base plate. These screws were first removed by loosening each a few rounds in turn. Then the detached pump was taken apart by removing the four Torx T15 screws that hold it together, again, by loosening each one a few rounds in turn. The volume compensator is spring loaded and jumps in one's face like a jack-in-the-box.

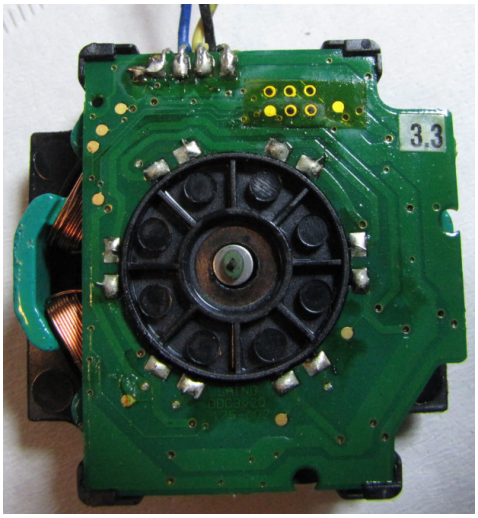
After removing the screws, as mentioned, the bottom of the pump, along with the springs, jumps right off. The pump top and the top O-ring also detach easily. Being held by strong magnets, lifting out the impeller requires slight force. The bowl part that also holds the PCB is held in the volume compensator by the smaller O-ring and possibly by some small dots of adhesive. The bowl part was carefully pryed out using a spudger or something like that.

DDC2B-VC blowout

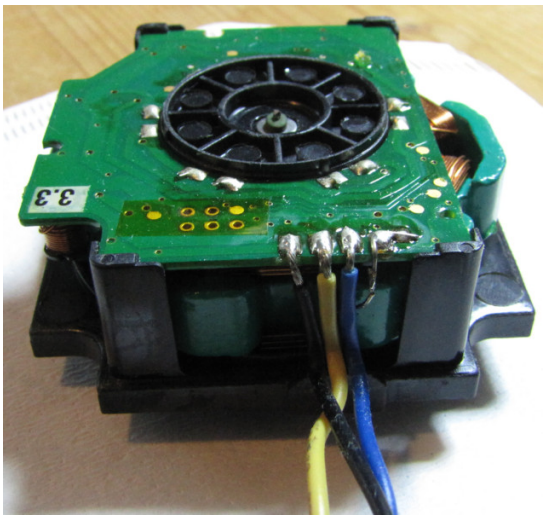
After dismantling the pump, the PCB was removed, but it turned out to be a useless effort, only motivated by the fact that the DDC-3 donor pump did not have a volume compensator. Carrying on however, the PCB is held to the bowl part by a clip mechanism and loads of yellow adhesive that cracks easily. Slight bending and knocking took out the adhesive and the PCB lifted off without much difficulties. It has been reported that bending the PCB too much will easily pop out some small components on it. The same useless effort was duplicated on the donor pump.



DDC-2 PCB



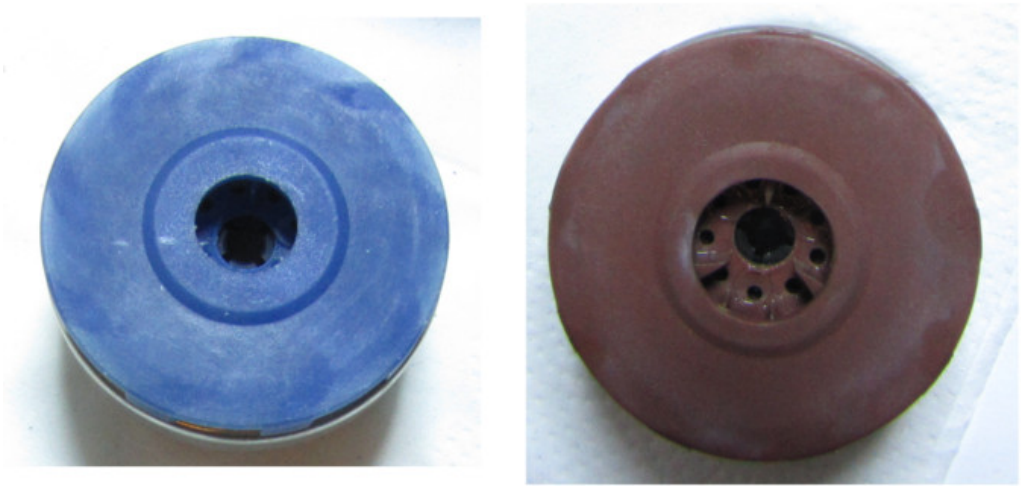
DDC-3 PCB



DDC-3 PCB, better view at original wiring

Removing the PCBs was an exercise in futility for several reasons. First and foremost, the motor housing parts are not the same mold between the DDC-2 and DDC-3 models, and the PCBs cannot be exchanged without some Dremel work. On the other hand the DDC-3 motor housing lacks the little overflow hole found in the DDC-2 housing to utilize the volume compensator. The impellers are also of slightly different size. Finally, the DDC-2 pump top cannot accommodate the DDC-3 impeller, because the DDC-3 impeller has a smaller inlet and the DDC-2 top has a protruding ring around the inlet, which would contact the DDC-3 impeller.

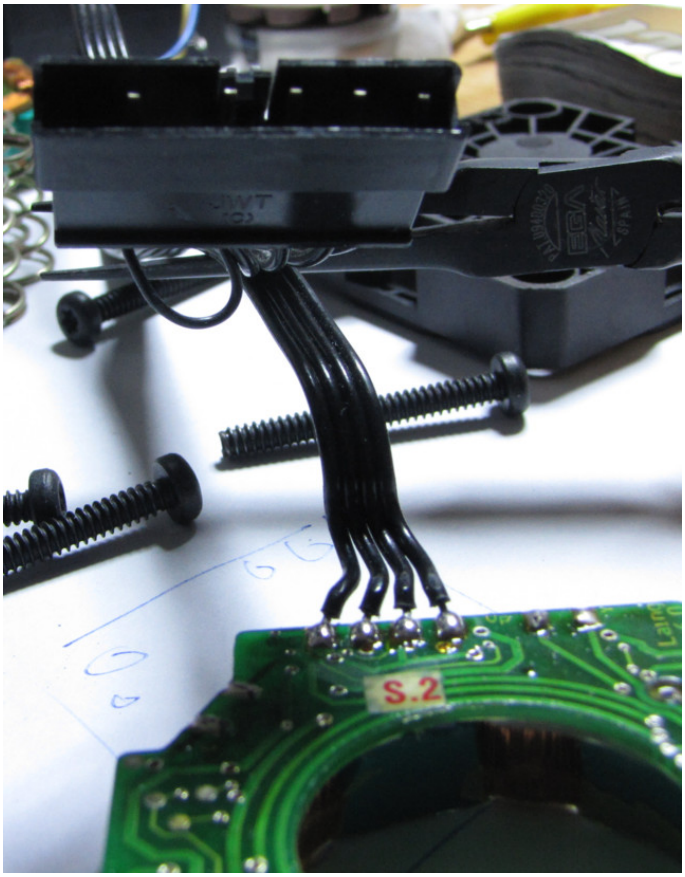
DDC-2 pump top, ring around the inlet



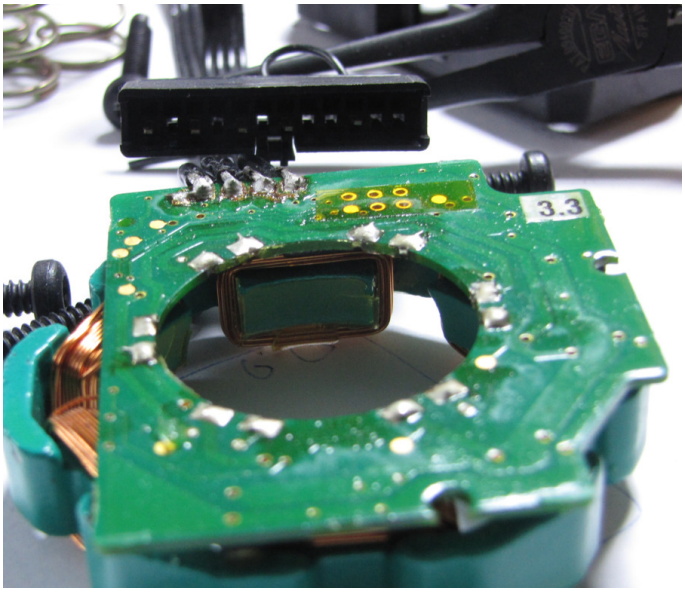
DDC-3 (blue) and DDC-2 (brown) impellers side by side

Pump exchange

After the useless PCB detachment, the G5 pump connector wire was detached from the original pump and soldered on to the DDC-3 donor pump. The wiring order was the exact opposite. A low powered electronics soldering gun was used along with some lead-free solder. Compared to regular solder, the lead-free solder produced an unbelievable smoke and less than nice-and-shiny end result (it was a first try at lead free soldering and it turned out that the solder was also bad quality, further reducing the chances of success).



Original wiring on the DDC-2 PCB



G5 connector wired to the DDC-3 PCB

Bearing in mind that the DDC-2 has a small hole for the liquid to pass to the volume compensator, the DDC-3 motor housing had to be modded to the same effect. A Dremel type tool and a 1.5 mm drill bit was used to drill a small hole through the bottom of the housing to the bottom of the bowl side. Over 10k rpm was needed for the drill to start eating into the hard plastic.

DDC-3 motor housing modded for the VC, bottom

DDC-3 motor housing modded for the VC, bowl

Next, the DDC-3 PCB was reattached to its original housing. Before seating the PCB, a couple of blops of yellow hot melt glue were applied to the housing and magnets to hold the PCB better in place.

Finally, the pump was put back together with the pump top, top O-ring, impeller, motor housing, and PCB from the new pump and the bottom O-ring, VC, springs, base, and Torx bolts from the original pump. Tightening the Torx screws needs some care to avoid ruining the top. A bar clamp was used to hold the pump firmly together while tightening the screws.

With the pump back together, it was leak tested by blocking one of the hose connectors and pumping water in through the other connector with the syringe. As no leaks to the outside were apparent after a few rounds, the pump was opened to see whether anything had leaked to the PCB compartment. Nothing had and the operation looked like a success this far.

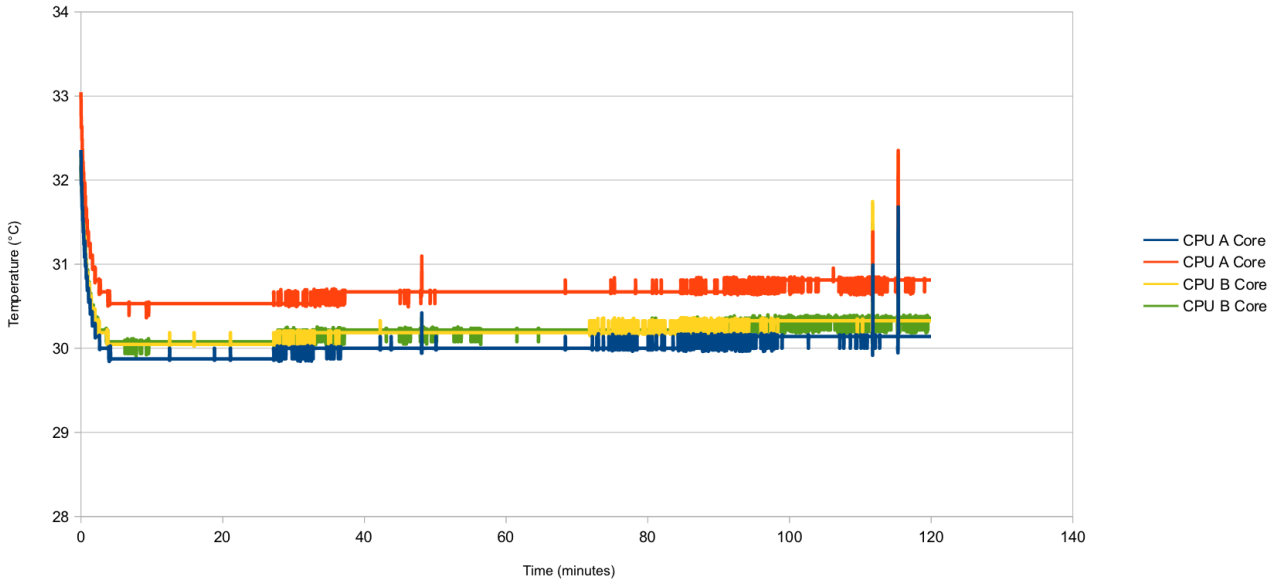
Rebuild

Rebuilding the LCS unit, new pieces of hose were cut to length and cleaned for the pump connection. Attaching the hoses was easier done with the pump still detached from the LCS base.

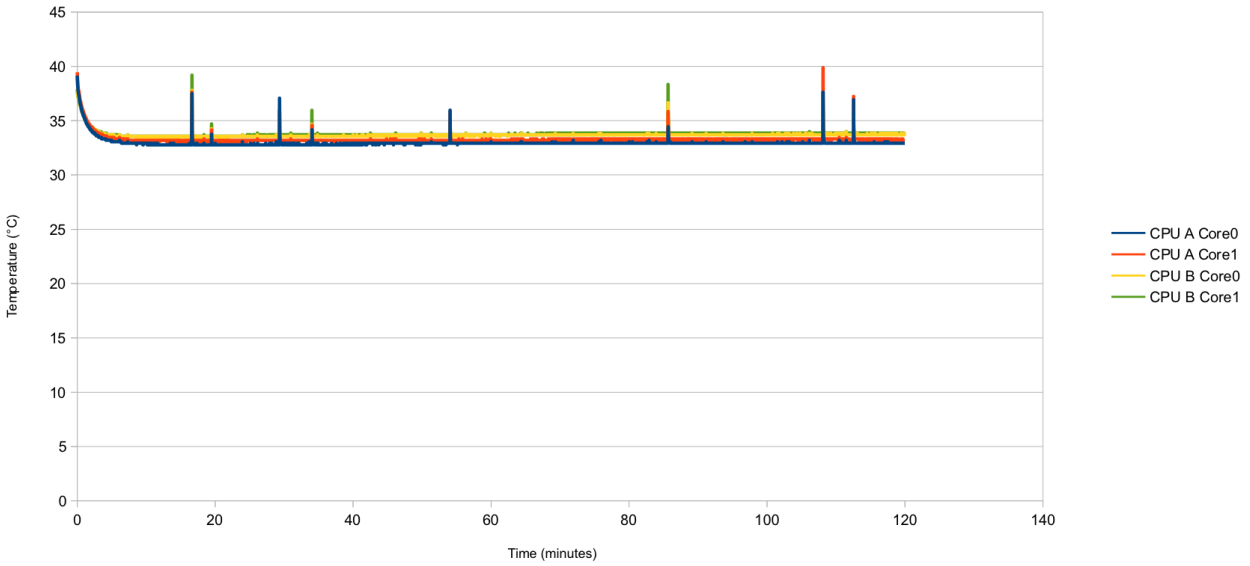
With the LCS unit in one piece, it was refilled with the same EC6 coolant as previously, using the same syringe method. However, now that the refill was done with the syringe from the start (no vacuum assisted "prefill" this time), purging all the air bubbles took much more time, maybe an hour or so. The refill took around 250 ml of coolant some of which was left over. Filling was done so that the volume compensator also started filling slightly.

Results

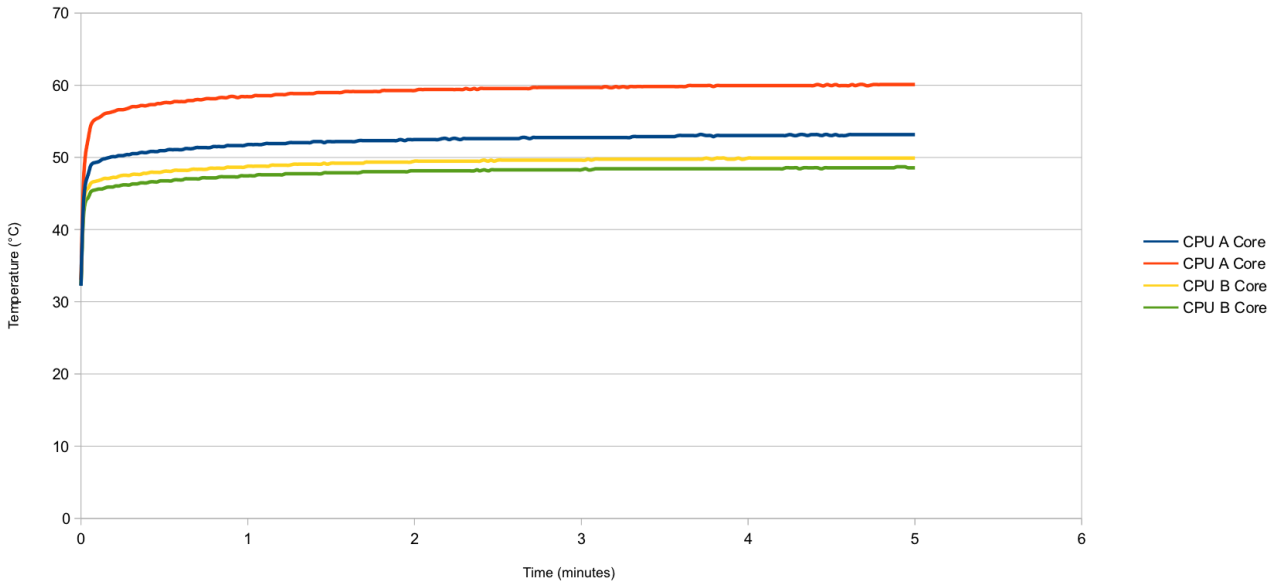
Motivation was to restore motor speed control in the pump and thus reduce noise. This goal was accomplished. The same array of testing as after the initial rebuild was run soon after the repair to see how temperatures were affected by the weaker pump and difference in pump speed. The broken DDC-2 was probably pumping at 4500 rpm under the test whereas the new DDC-3 should be going at the max 3600 as allowed by the G5's fan controller.



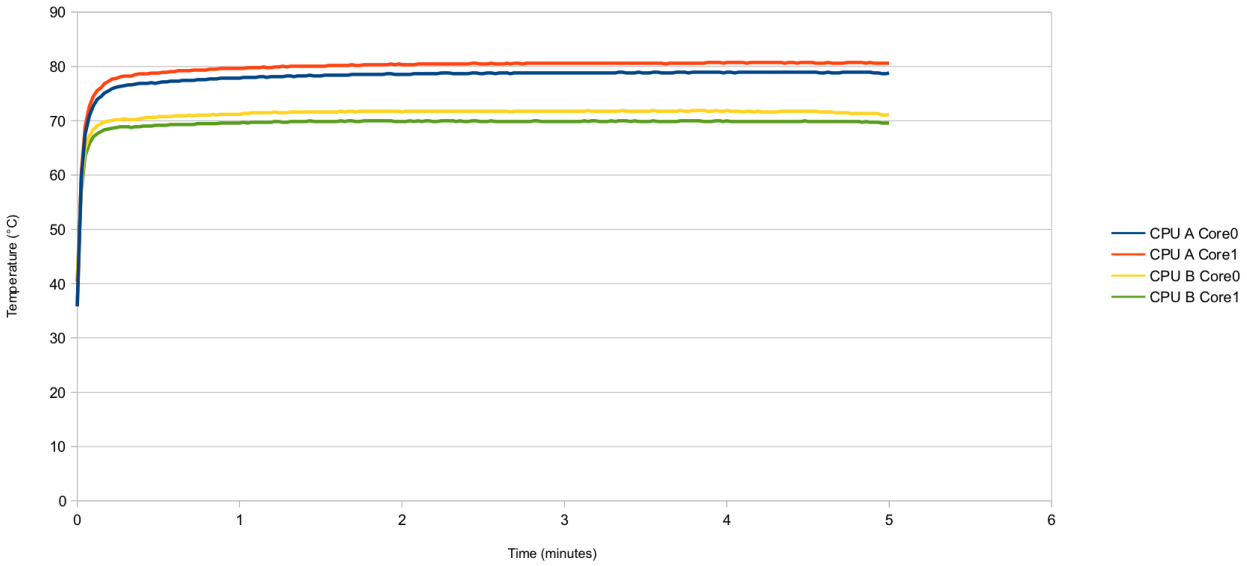
CPUs idling for two hours, after first rebuild (ambient 22,8 °C)



CPUs idling for two hours, after pump exchange (ambient 22,5 °C)



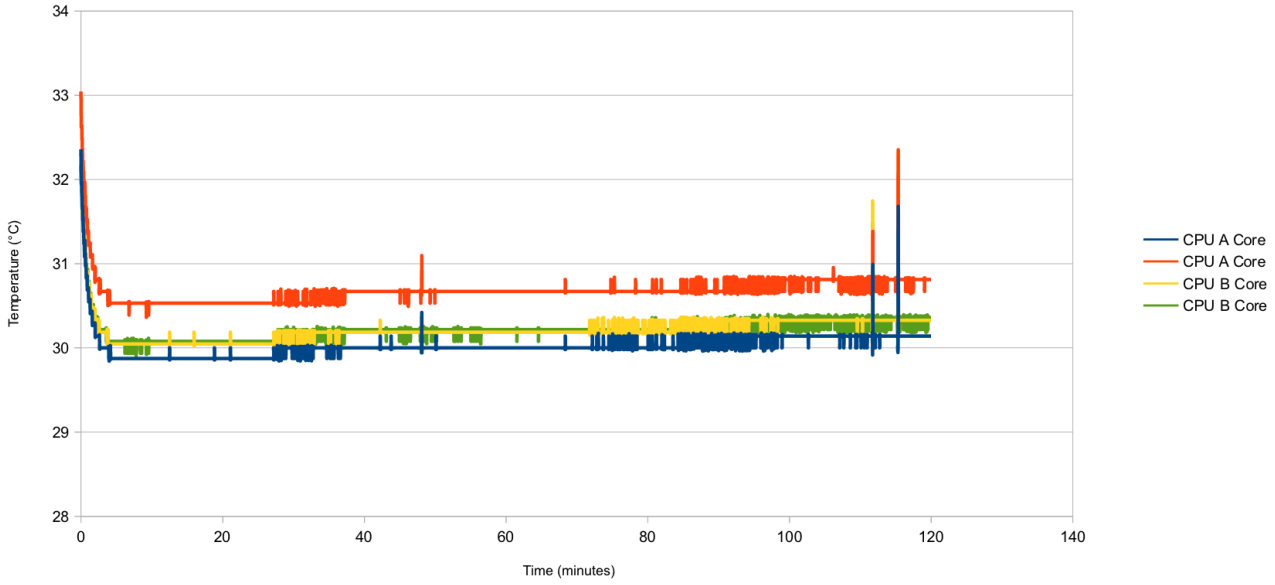
CPUs fully loaded, after first rebuild



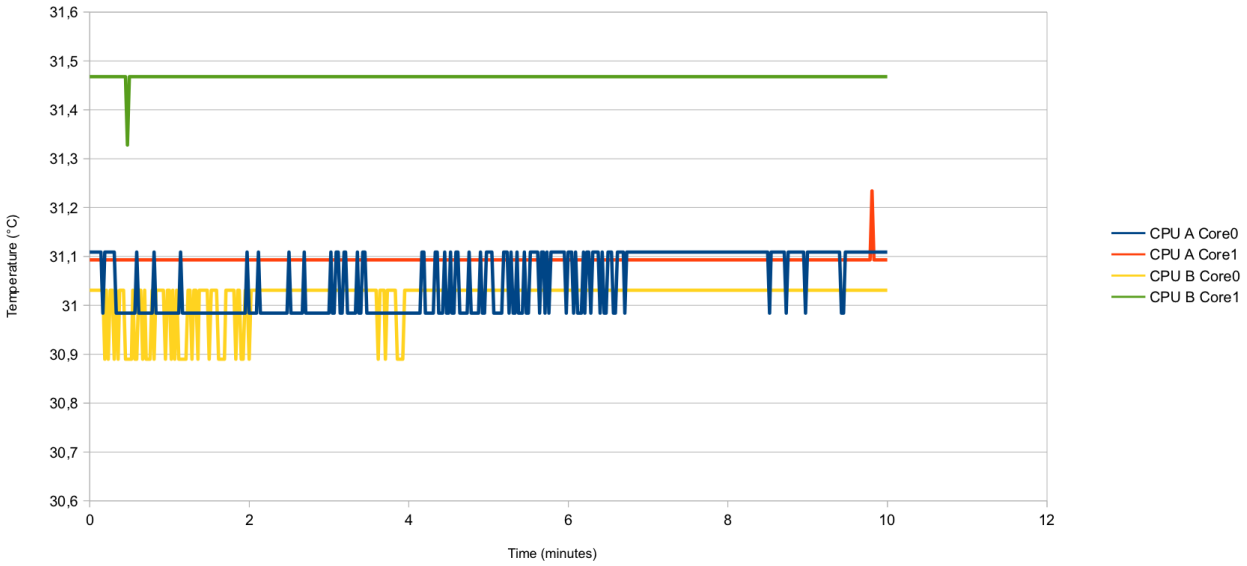
CPUs fully loaded, after pump exchange

At this point, the results looked rather grim. Idle temperatures were several degrees up and fully loaded temperatures were up by around 20 degrees. Usage in OS X was also less than pleasant as fans kicked in, with force, from almost any actions.

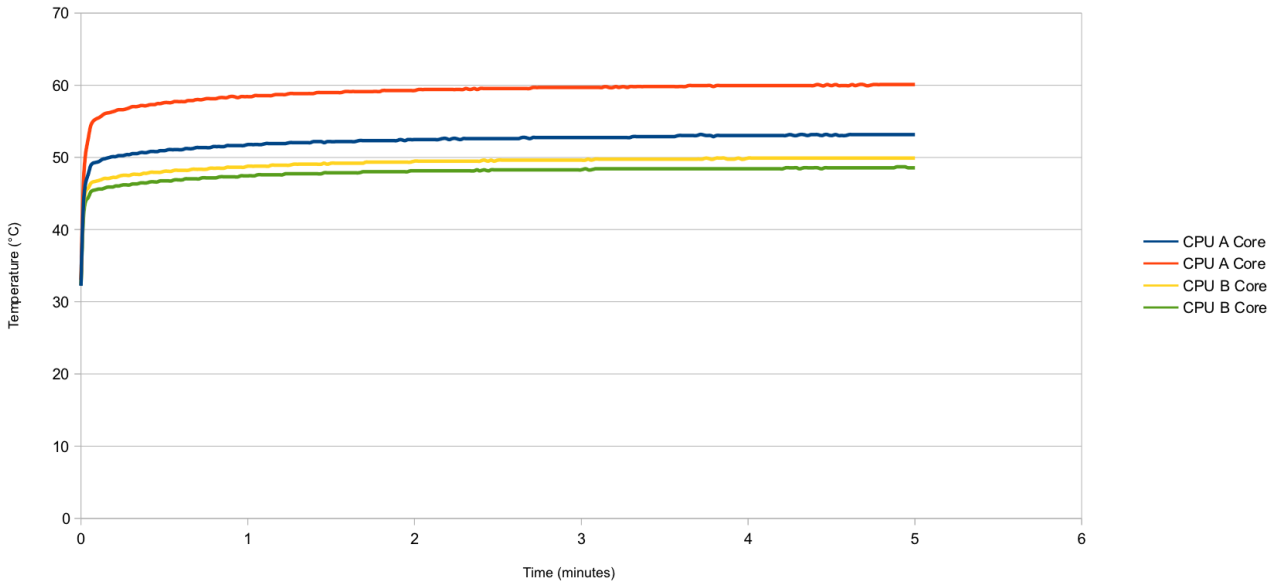
After some weeks of normal usage, however, the situation slowly improved. Apparently, leaving the unit to dry during the repair had caused some of the old coolant to solidify and then with some usage it slowly dissolved. The testing was repeated.



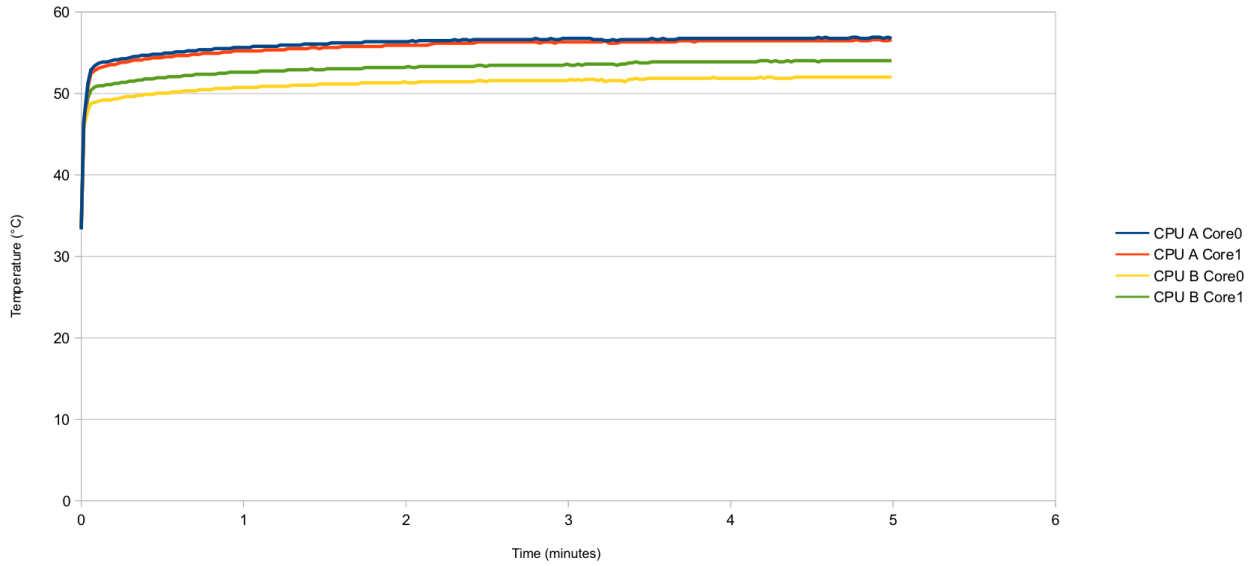
CPUs idling for two hours, after first rebuild (ambient 22,8 °C)



CPUs idling for 10 minutes, after pump exchange and over month of usage (ambient 24,2 °C)



CPUs fully loaded, after first rebuild



CPUs fully loaded, after pump exchange and over month of usage

In OS X, the fans stay at the minimum 970/1000 and pump at 1250 when idle. Fully stressed the fans stabilize at around 1600-1900 rpm depending on the ambient temperatures. Status as of 2012 end of July: the machine still works and the LCS holds up in the 30 °C summer room temperatures fine.

References

- Work Log of Apple Power Mac G5 Quad Liquid Cooling System Repair
- BMaverick's DDC-1T Site
- Swiftech mcp350 pump mod.