Thermaltake

" Ideas originate from humanity, realizing ideas is our belief. "

iTherm Liquid Cooling Symposium
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Thermaltake's history of Liquid Cooling

Six years of progressive design and manufacturing improvements

- Pump designs
- Manufacturing methods
- Fluids
- Design assumptions

2000

2002

2004

2006

Lessons learned

- Pump designs inadequate
- Tolerance variances created leaking
- Supplier component issues
- Fluid contamination issues

2006

2004

2002

2000

- Pump pressures increased
- Metal joining methods used
- In House manufacturing controls
- Custom fluids developed

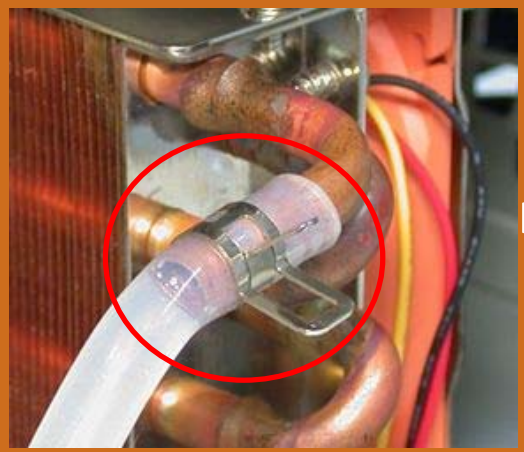
Lessons learned

As we progressed from early designs and manufacturing methods, we learned about the need to return to basics, solving each component DFM issue individually first, using proven methods and practices.

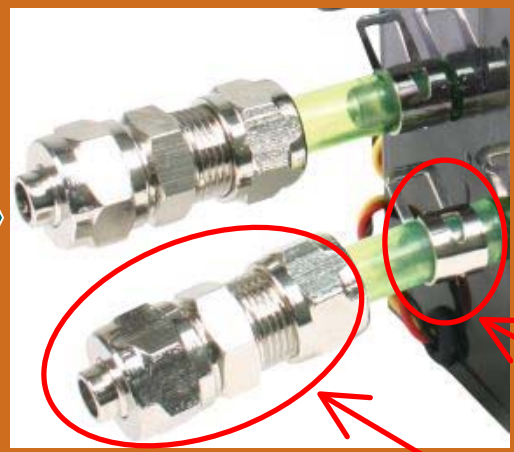
Auto Industry: Radiator Designs and brazing methods

Fan / Blower Industries: Low cost pump designs

Refrigeration Industry: Hosing and connector systems



2000 ~ 2003: Clamp Only



2004 ~ 2006: Quick Connector (Screw); Clamp + Epoxy

Manufacturing challenges

- Leak Proof Design and Assembly
  - ✓ Minimize interconnection points
  - ✓ Flexibility
  - ✓ Shipping
- High conductivity materials
  - ✓ Copper for major parts
- Robust fluids with wide environmental limits
  - ✓ Freeze and boil protection
- Fill, Seal, and leak testing
  - ✓ Factory and user installation
- Overall system reliability
  - ✓ Testing and in process controls

Source Exchangers (Acrylic Cover vs. Copper Cover)

Cover Material	Acrylic 	Copper 
Cover Assembly Method	O-ring + Screw	Brazed by Copper and Silver Alloy
Resisted Temperature	70℃	> 200℃
RMA Rate for Leak	5 %	< 3 ppm

Pumps

Dimension: 100 x 50 x 86 mm
Rated Voltage: 12 V
Rated Current: 0.16 A
Power Consumption: 2 W
Water Head: 120 cm-H2O
Max. Flow Rate: 90 Liter/hour

Old Design

Dimension: 45 x 40 x 20 mm
Rated Voltage: 12 V
Rated Current: 0.3 A
Power Consumption: 3.6 W
Water Head: 168 cm-H2O
Max. Flow Rate: 75 Liter/hour

New Design for Compact Application

Dimension: 80 x 80 x 65 mm
Rated Voltage: 12 V
Rated Current: 0.6 A
Power Consumption: 7.2 W
Water Head: 166 cm-H2O
Max. Flow Rate: 500 Liter/hour

New Design for High Performance Application

Ambient Exchangers

Manufacture Process	AX for Refrigeration Industry 	AX for Auto Industry 	Traditional Stacked Fins for PC Industry 
Flow Channel Type	Single Loop	Multi-Channel	Single Loop
Flow Impedance	Medium	Low	Medium
Design Flexibility (Tube Size, Fin Size, Fin Pitch, Shape, …)	Low	Medium	High
Tooling Cost	Low (Standard Tooling)	High	Medium
Unit Price	Low	High	Medium

Flexible Tube Material Selection

Flexible Tube Selection Guidelines:

- Air tight and gas impermeable
- Flexibility
- Good weathering resistance
- Resistant to ozone

Evaporation Rate Test for Tube

Tube Dimension: Length = 2m, ID = ¼", OD = 3/8"

Chamber: Ta = 50°C, Humidity = 30%RH

Liquid: Distilled Water

Duration: 2400 Hours

Results: (1 day = 24 hours)

Flexible Tube Material	Butyl Rubber	PU	Silicone
Avg. Evaporation Rate (gram/day)	0.004	0.32	0.43

Note: Butyl rubber has all the advantages listed above, it is the recommended economy material for flexible tube.

Fluid Selection and Process

Fluid Selection Guidelines:

- Low freezing point
- High atmospheric boiling point
- High flash point
- Non-corrosive
- Good chemical and thermal stability
- Good thermo-physical properties
- Environmentally friendly
- Cost effective

Liquid Type	Freezing Point (℃)	Thermal properties	Toxic	Corrosive	Cost
Distilled Water	0	Excellent	None	None	Low
EG/Water (32:68 v/v)	-40	Medium	Low	Low	Low
PG/Water (50:50 v/v)	-35	Medium	None	Low	Low
Potassium Formate/Water (40:60 wt./wt.)	-35	Good	None	Low	High
Calcium Chloride Solution (29:71 wt./wt.)	-40	Medium	None	High	Medium
Methanol/Water (40:60 wt./wt.)	-40	Medium	Medium	Low	Low
Ethanol/Water (44:56 wt./wt.)	-32	Medium	None	Low	Low

Final Product Testing

Reliability tests:

1. Storage Temperature / Humidity Test

Temperature (°C)	Humidity (%RH)	Dwell time at Temperature (Hours)	Temperature Gradient (°C/hr)
-40	Uncontrolled	72	60
70	90	72	60
25	50	24	60

2. Accelerated Life Test

$$AF = \left[\frac{RH_{op}}{RH_{test}}\right]^{-n}\left[e^{-(Ea/k)}\left[\frac{1}{T_{test}+273}-\frac{1}{T_{op}+273}\right]\right]$$

Where:

AF = acceleration factor

RH_{test} = relative humidity during accelerated test

RH_{op} = nominal operational relative humidity

n = constant factor determined during testing (assumed to be 2.0)

k = Boltzmann's constant

T_{test} = test temperature

T_{op} = nominal operational temperature

E_a = activation energy determined during testing (assumed to be 1.0)

Note: Like traditional air cooler, the life of liquid cooling system depends on the life of fan (Life of pump is longer than life of fan), the life of liquid cooling system is about 50,000 hours with two ball bearings fan.

Final Product Testing (Cont.)

Reliability tests:

3. On-Off Cycling Test

Temperature (℃)	On-time (min.)	Off-time (min.)	Number of Cycles
25 ± 5	1	1	5000

Note: This test is same as the component level test for fan and pump, it is to verify the ability of the system to cycle power during expected product life.

4. Liquid Evaporation Rate Test

(1). Measure the weight of whole cooling system

(2). Apply 100W to SX, set chamber Ta = 35℃, humility = 30 %RH, duration = 240 hours.

(3). Measure the weight of whole cooling system after test

(4). (Liquid Storage Amount)/(Liquid Evaporated per Hour) = Usage Time before Refill

Example: Thermaltake Tide Water VGA liquid cooling module, usage time before refill = 20,000 hours

All-in-One Design for Dual Graphics Card

All-in-One Design for CPU

Performance of 0.21°C/W on CPU

Fanless Liquid Cooling System

The Result

Better Systems!

Higher Reliability!

Lower costs!

Open Discussion / Questions