伺服器水冷散熱應用

Liquid Cooling Application in Server System

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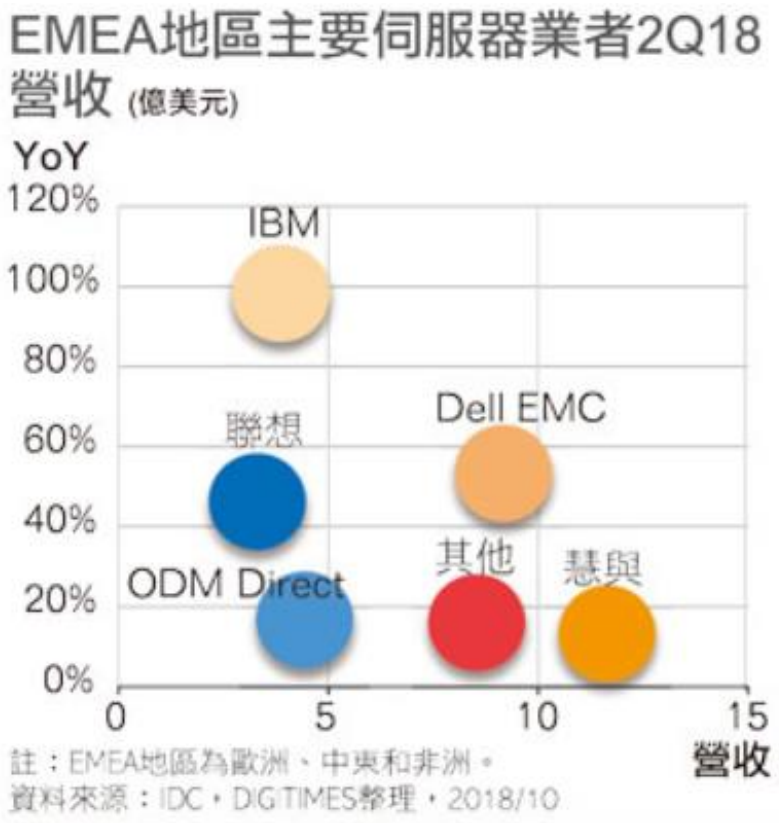
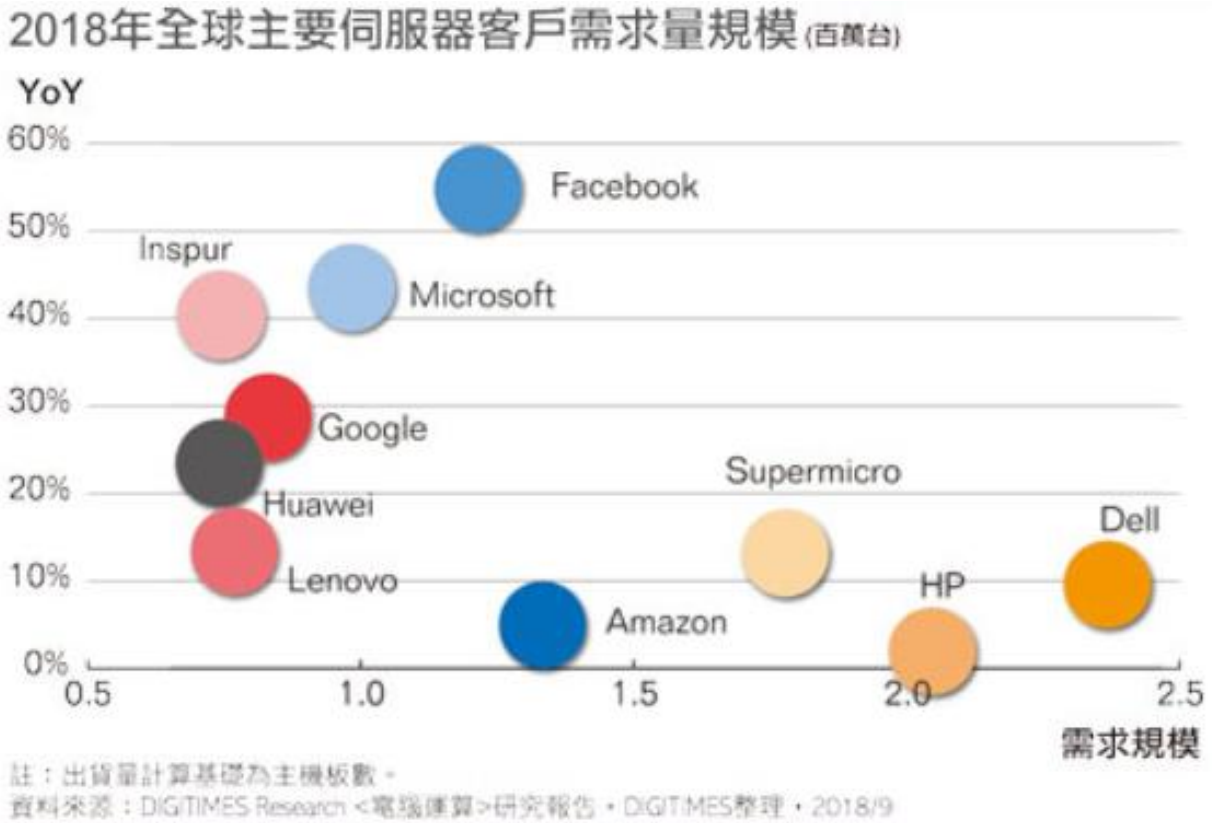
ADLINK

Building Forward Together

Marketing survey





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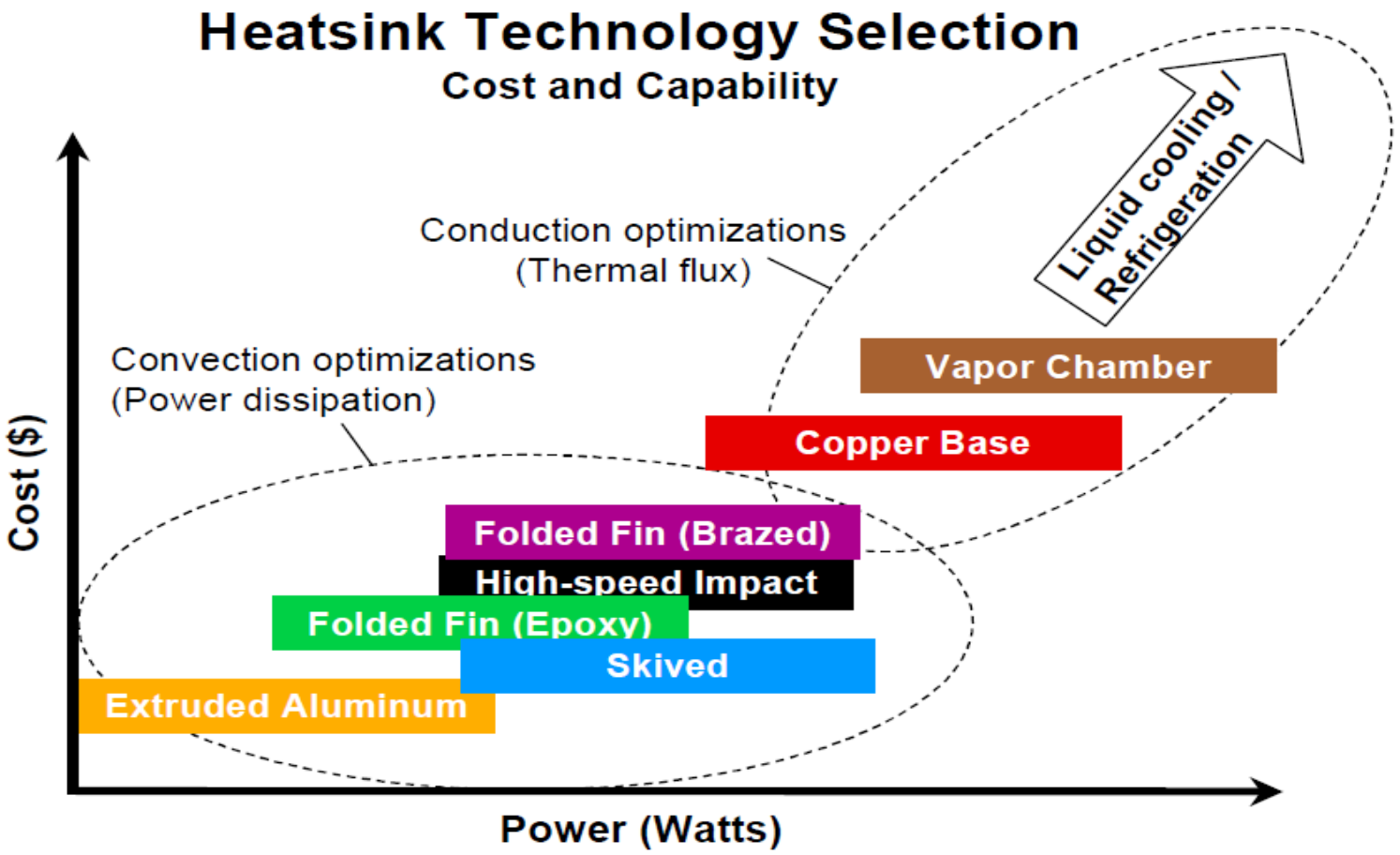
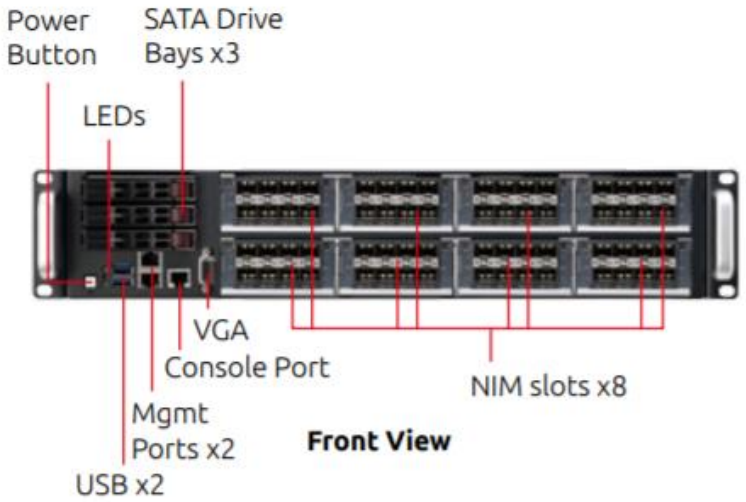
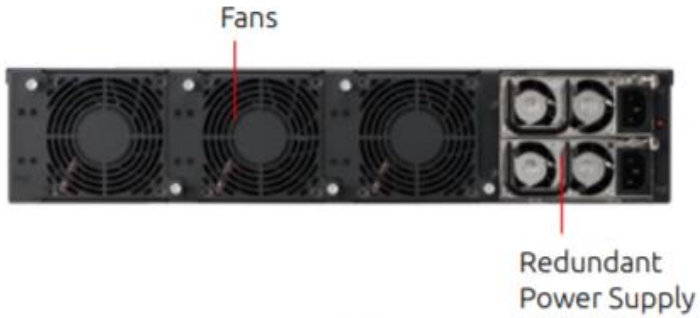


Air cooling system

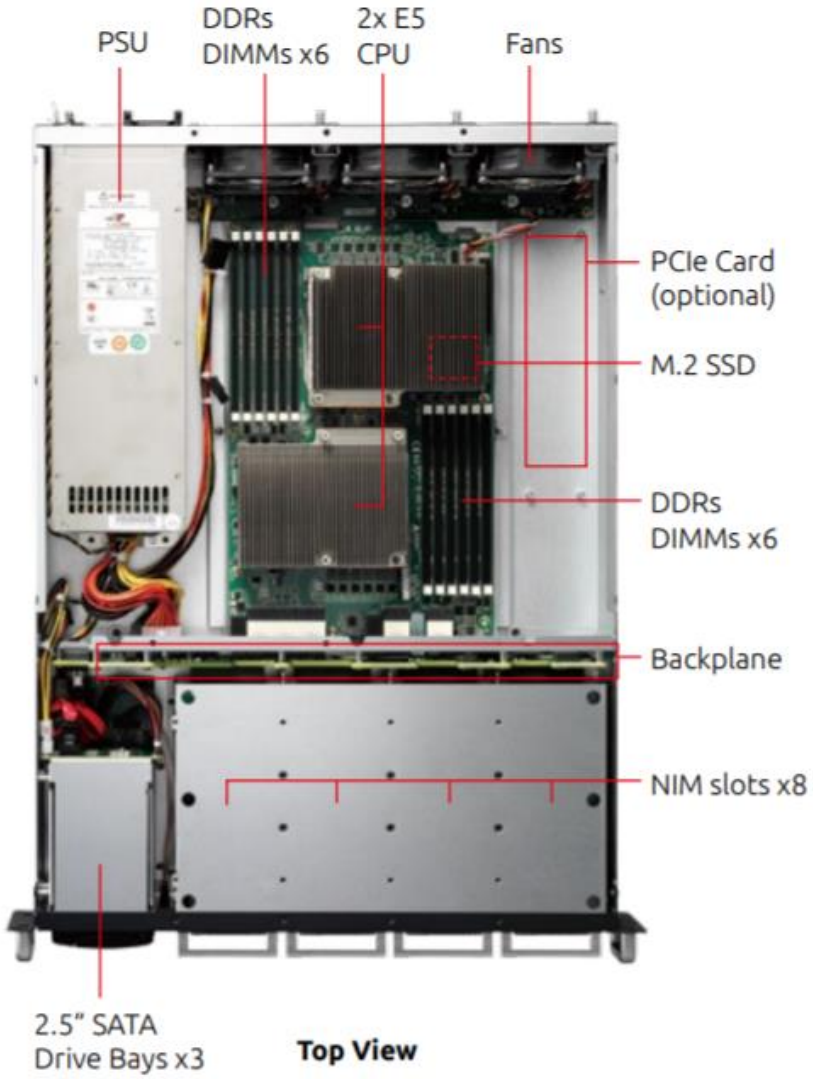
2U 19” Network server Appliance (W*H*L=440*88*600)



Front View



Rear View



Top View

Air cooling VS Liquid cooling

Power segmentation

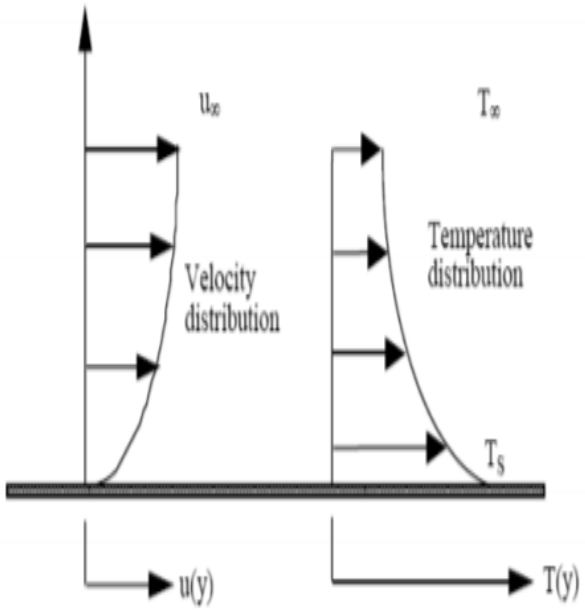
240W

	Traditional Air Cooling	Embedded Heat Pipe Sinks	Enhanced Volume Air Cooling	Loop Heat Pipe - CALYOS -	Liquid Assisted Air Cooling
Processor TDP	145W	215W	240W	350W	350W
Reliability	Very good	Very good	Good	Very good	Average
Mechanical Integration	Standard & Rigid	Standard & Rigid	Custom & Rigid	Custom & Flexible (3.2&6.4 mm tubes)	Custom & Flexible (>10 mm tubes)

Newton Cooling Law

熱對流:固體與流體之間的熱傳,熱通量(q”)與溫度(T)成正比

q”=hΔT , 一般以h表示熱傳導係數(heat transfer coefficient)



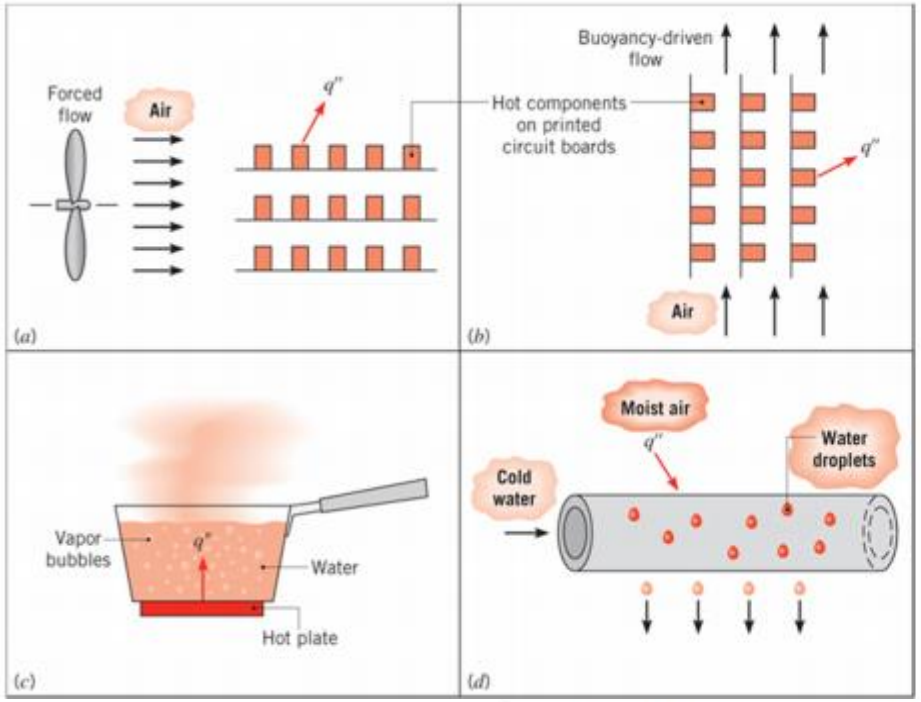


TABLE 1.1 Typical values of the convection heat transfer coefficient

Process	h (W/m^2 · K)
Free convection	
Gases	2–25
Liquids	50–1000
Forced convection	
Gases	25–250
Liquids	100–20,000
Convection with phase change	
Boiling or condensation	2500–100,000

熱傳量(W)=熱通量(q”)*面積(A)

01

Flotherm XT

EDA/MDA

System analysis

02

Cold Plate

Selection

03

Radiator

Selection

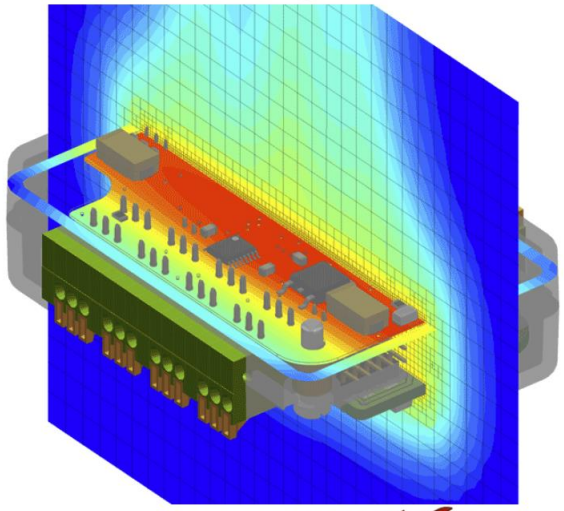
04

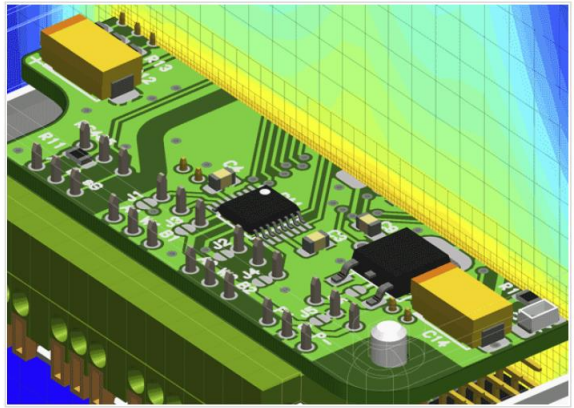
Coolant

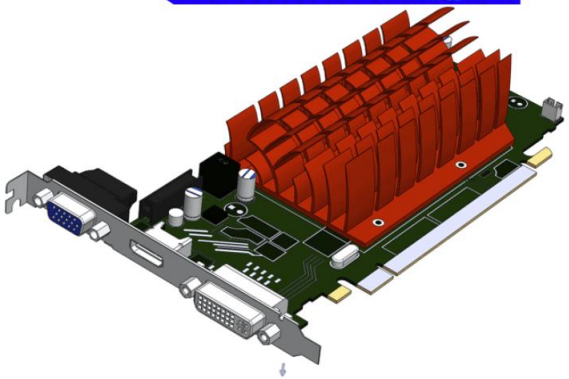
Selection

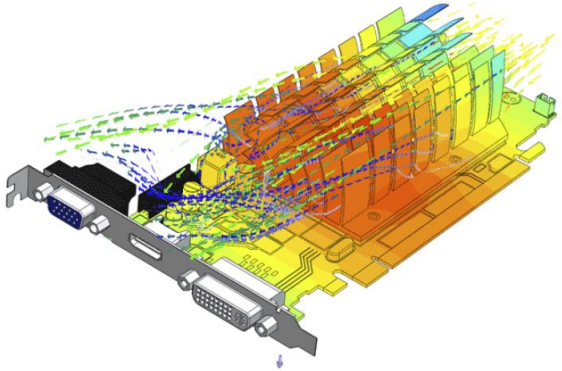
FloTHERM XT

架構於 SolidWorks 前處理介面，並搭配原本 FloTHERM Smart Parts Library，不儘可以透過 Smart Parts 進行概念設計分析，也可以透過 3D CAD 介面進行產品細部設計分析



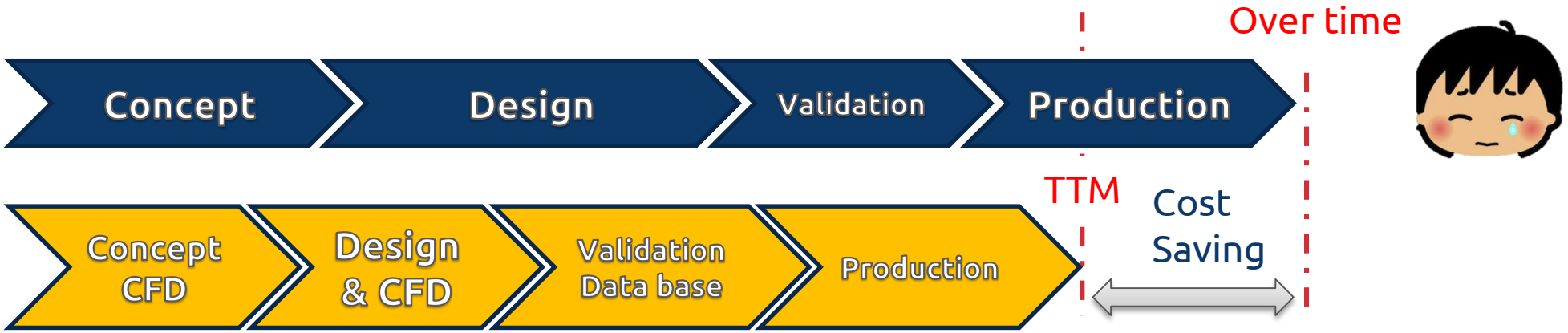




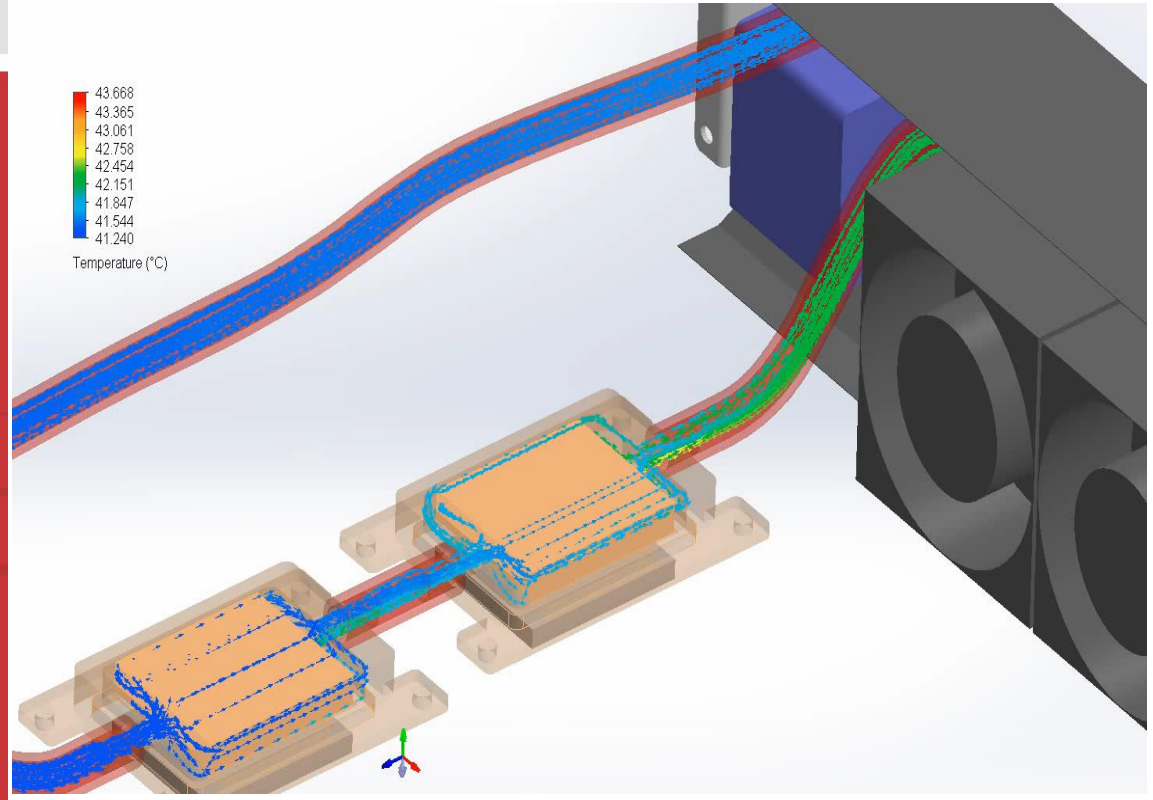


FloTHERM XT Strength

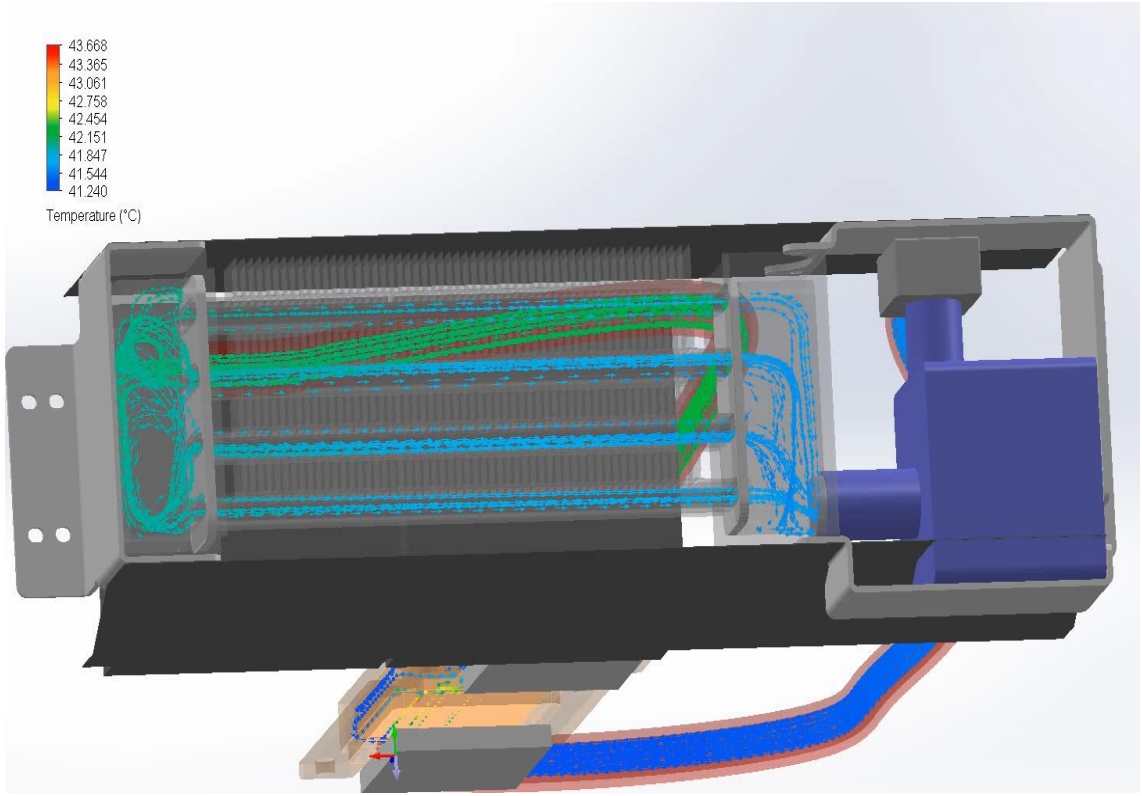
- FloTHERM XT結合電子設計自動化(EDA)和機械設計自動化(MDA)技術的電子冷卻模擬解決方案，相對於傳統仿真軟體具有獨特的技術優勢
- 在概念階段仿真設計，仿真贯穿整個設計流程。
- FloTHERM XT是一款由概念設計覆蓋至設計驗證階段的電子散熱軟體
- 縮短了EDA/MDA協同工作的間隙
- 直覺性的網格技術、收斂性好、可定制的GUI、建模功能强大
- 源自两個成功軟件的DNA: FloTHERM和FloEFD
- 機構設計工程師與熱傳工程師都可以使用



Postprocessing

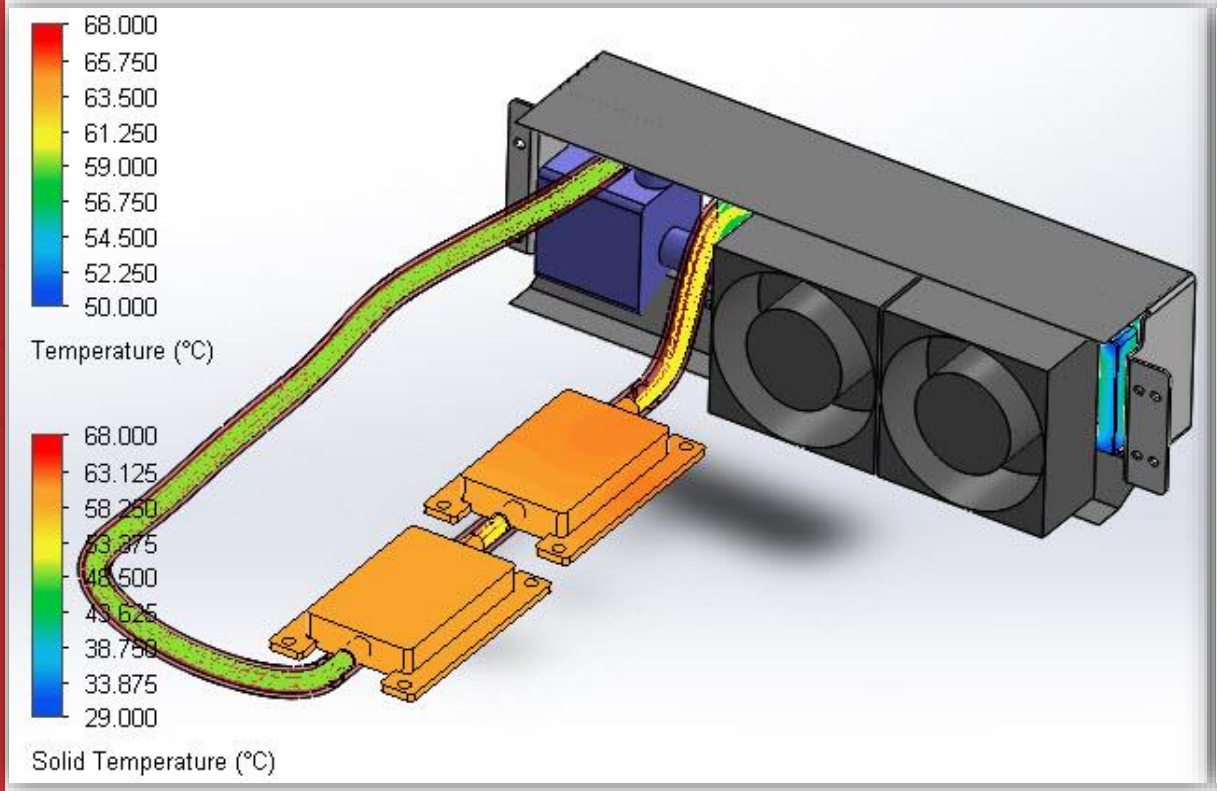


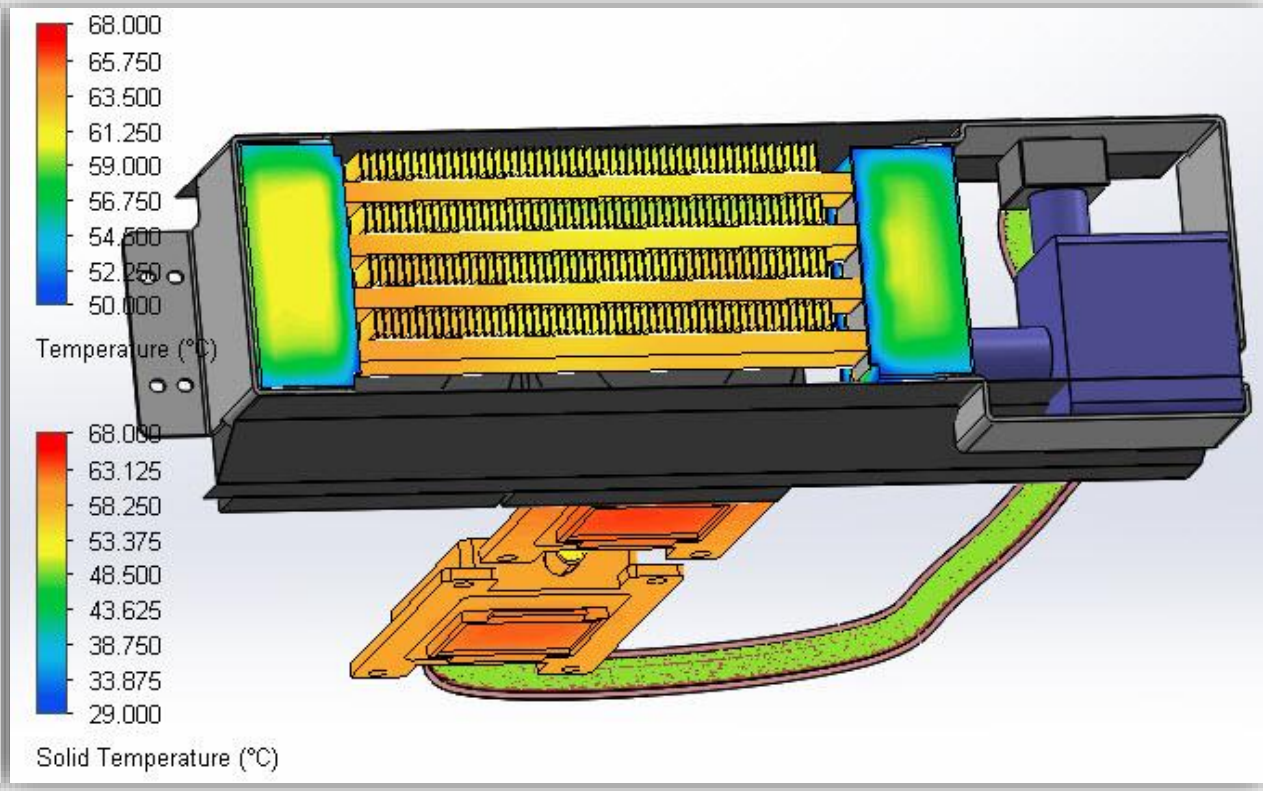
Stream line



Stream line

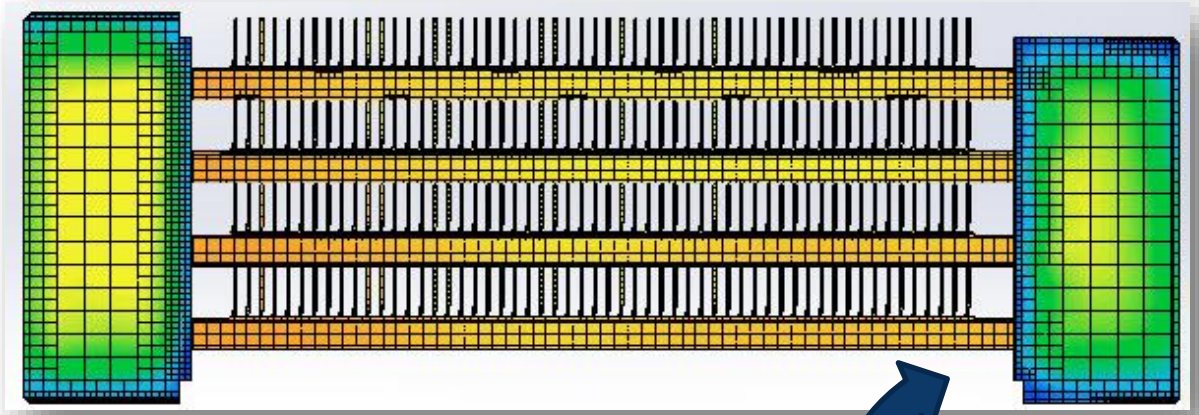
Temperature field

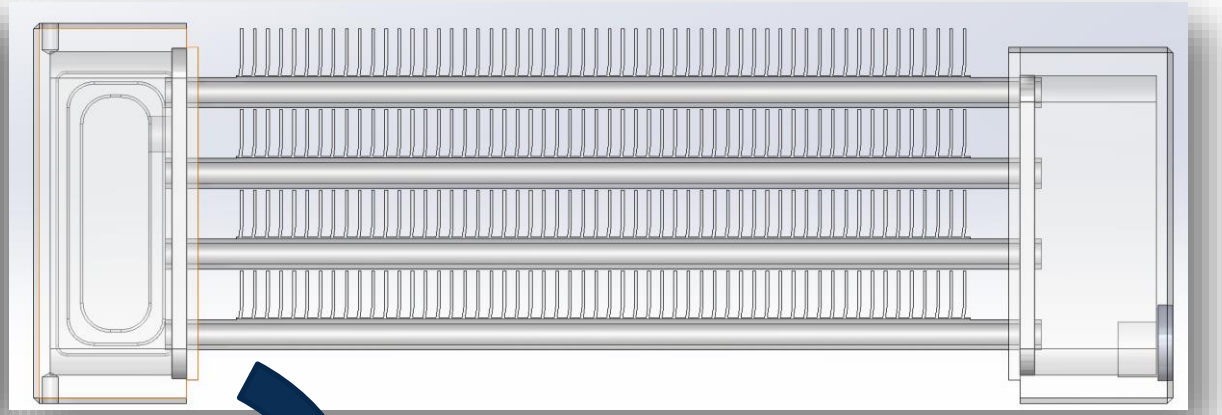


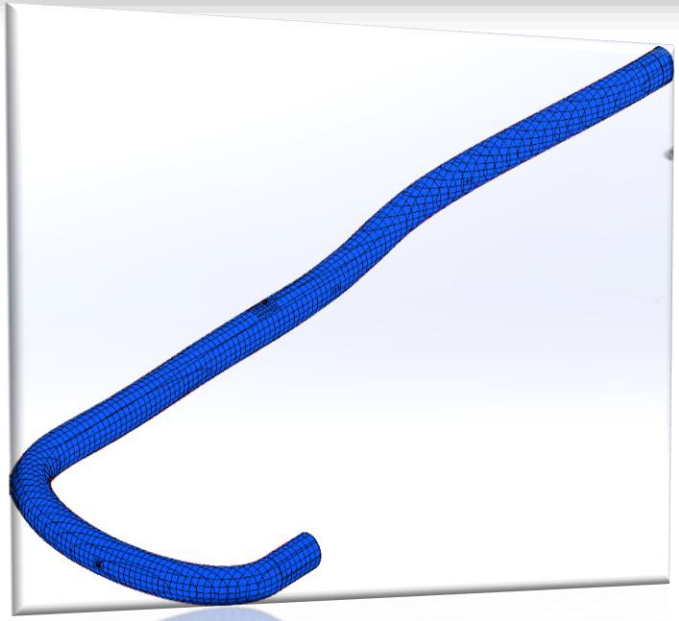


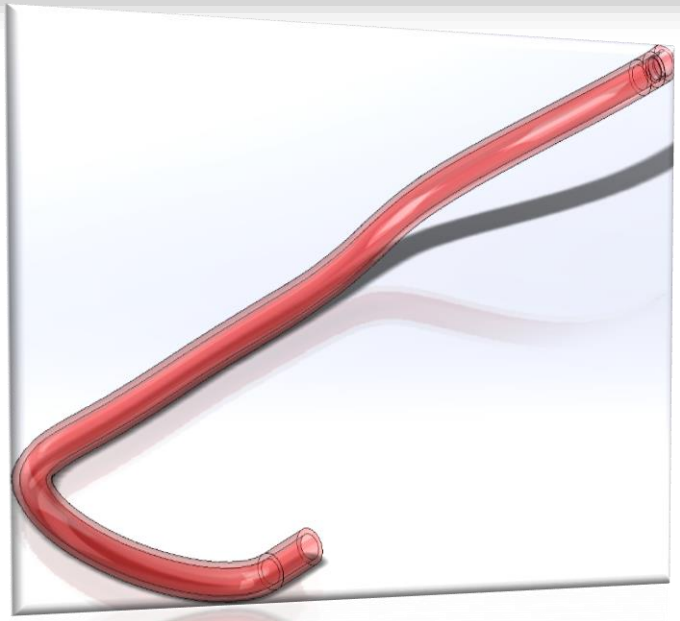
Mesh Generation

Automatization



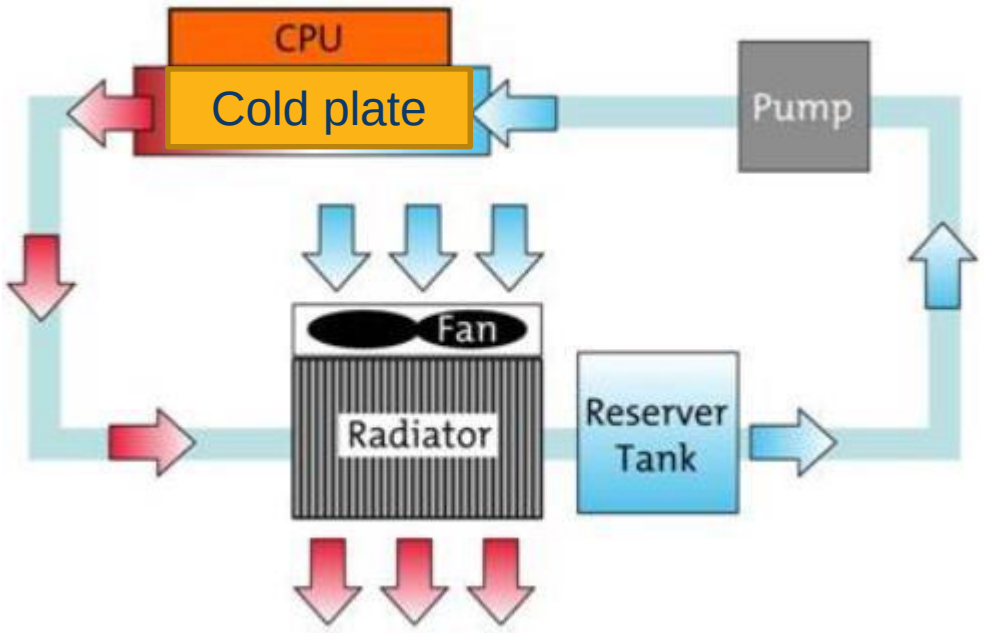






- **Structured Mesh**
- **Partial Cell**

Liquid Cooling System



Concept

1.The cold plate remove heat from the processor into the liquid.

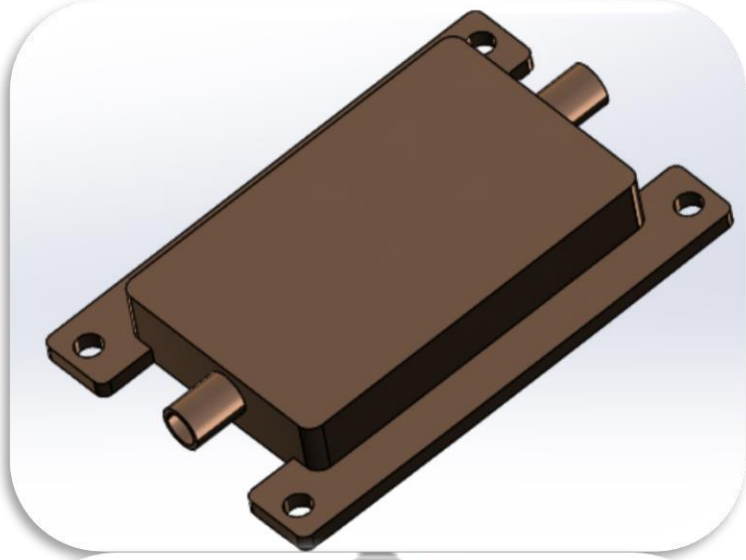
2.The Radiator moves heat from the liquid into the air by fan flow.

3.The pump moves the liquid through the cold plates an the radiator.

Working flow

1. A Heat **exchanger (cold plate)** to transfer heat into Coolant
2. A **Pump** to drive the Coolant
3. A **Tank** for storing excess coolant
4. **Coolant** to transfer the heat
5. A **Radiator** with **fans** to move heat from coolant into ambient

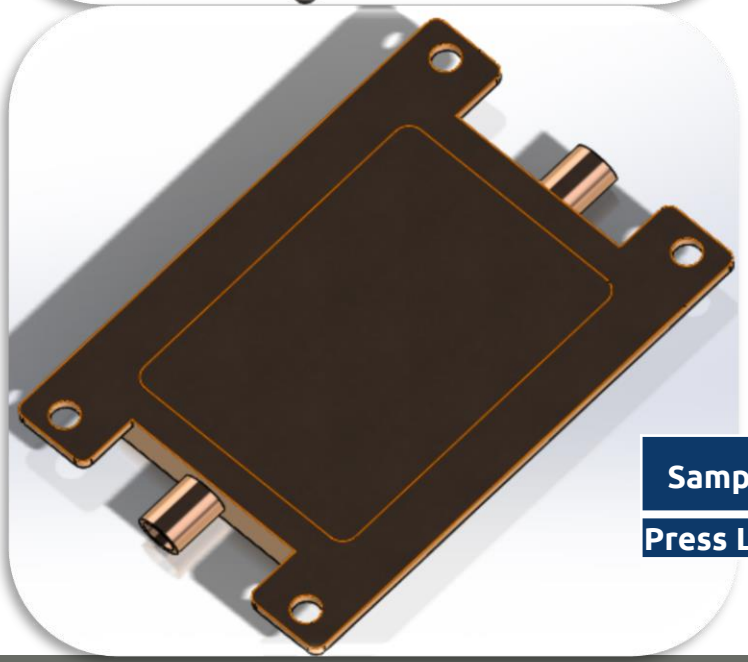
Cold plate structure



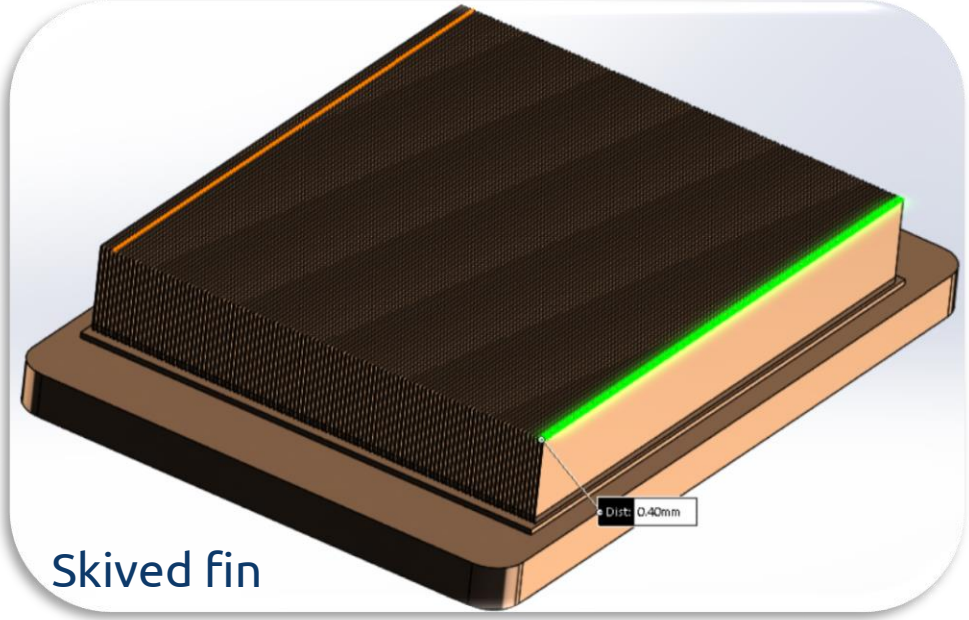
Friction Stir Welding 摩擦攪拌銲接

結合方式
由於材料受到壓力與摩擦熱的作用後將會使其產生塑化，因此可藉由銲接探針來傳送此接合部位所需的熱能，進而完成工件的接合。

優點
1. 整個銲接過程相當簡單，不需使用銲條或填料等消耗物。
2. 對鋁、鎂合金銲件而言，摩擦攪拌銲接可達到高接合強度的性能要求。
3. 摩擦攪拌銲接可使用於對銲道裂縫敏感性較高的合金材料。



Sample No.	item.01	Intel Spec (2011 Narrow)
Press Load(lb)	53.2	50~80



Skived fin

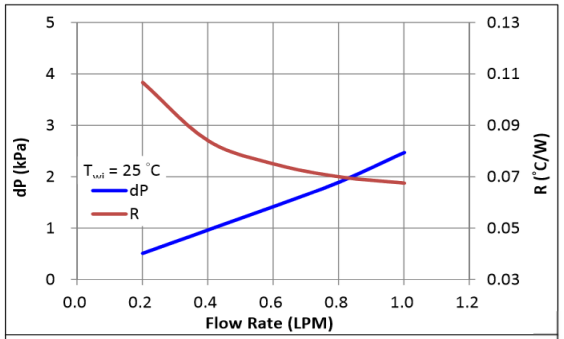
Cold plate performance

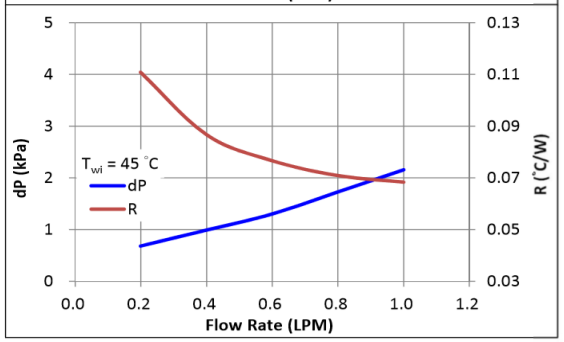
Test Results

SN: 7831 2018/7/5

Production	CoolJag AD Cold Plate	Date	2018.7.5
Applicant	Chia Cherne Industry Co., Ltd.	SN	7831
Test Apparatus	LW-9670B Cold Plate Thermal Performance Tester	Tested by	John Lee
Test Condition	Ambient Temp. 29 °C	Checked by	Larry Lee

FR	dP	Ti	To	Ta	Tcase	P	R
LPM	kPa	°C	°C	°C	°C	W	°C/W
0.201	**0.510**	25.0	33.1	29.2	37.8	120	**0.107**
0.399	**0.960**	25.0	29.1	29.1	35.1	120	**0.084**
0.601	**1.420**	25.0	27.8	29.2	34.0	120	**0.075**
0.800	**1.890**	25.0	27.1	29.1	33.4	120	**0.070**
1.001	**2.470**	25.0	26.7	29.2	33.1	120	**0.068**
0.199	**0.680**	45.0	52.8	29.3	58.3	120	**0.111**
0.400	**0.990**	45.0	49.0	29.3	55.4	120	**0.087**
0.599	**1.300**	45.0	47.7	29.3	54.2	120	**0.077**
0.801	**1.730**	45.0	47.0	29.2	53.5	120	**0.071**
1.000	**2.157**	45.0	46.6	29.2	53.2	120	**0.068**



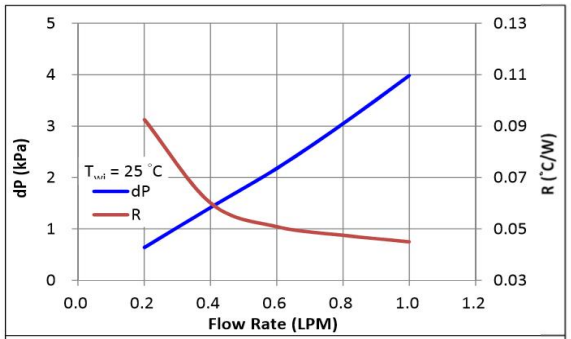


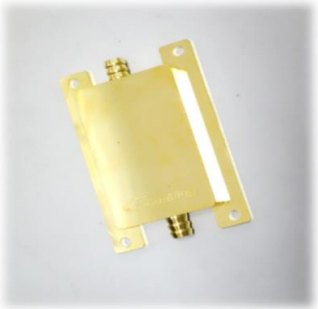
Test Results

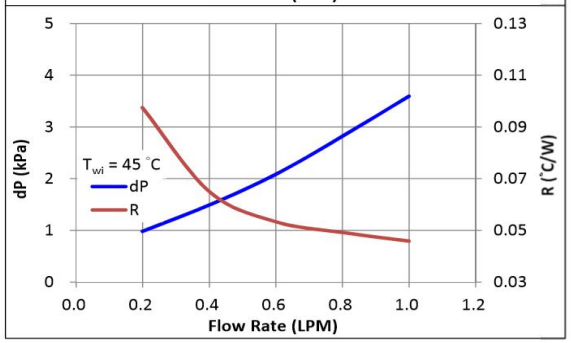
SN: 7831 2018/7/5

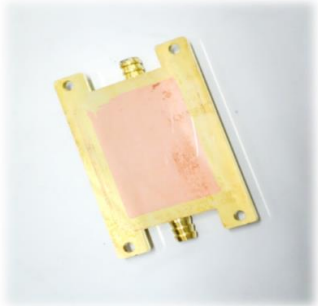
Production	CoolJag BD Cold Plate	Date	2018.7.5
Applicant	Chia Cherne Industry Co., Ltd.	SN	7831
Test Apparatus	LW-9670B Cold Plate Thermal Performance Tester	Tested by	John Lee
Test Condition	Ambient Temp. 27 °C	Checked by	Larry Lee

FR	dP	Ti	To	Ta	Tcase	P	R
LPM	kPa	°C	°C	°C	°C	W	°C/W
0.201	**0.640**	25.0	33.2	27.3	36.1	120	**0.093**
0.401	**1.420**	25.0	29.1	27.3	32.2	120	**0.060**
0.601	**2.180**	25.0	27.8	27.4	31.1	120	**0.051**
0.801	**3.050**	25.0	27.1	27.4	30.7	120	**0.048**
0.999	**3.980**	25.0	26.7	27.4	30.4	120	**0.045**
0.199	**0.980**	45.0	52.8	27.0	56.7	120	**0.098**
0.400	**1.490**	45.0	49.0	27.0	52.8	120	**0.065**
0.599	**2.080**	45.0	47.7	27.1	51.4	120	**0.053**
0.800	**2.820**	45.0	47.0	27.1	50.9	120	**0.049**
1.000	**3.597**	45.0	46.6	27.2	50.5	120	**0.046**



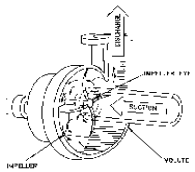






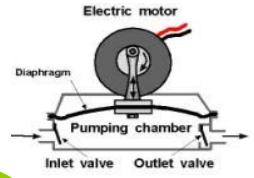
Pump_Type

Centrifugal Pump



- 電子散熱常用
- 流量穩定且連續
- 自排氣性能：無×
- 價格中等

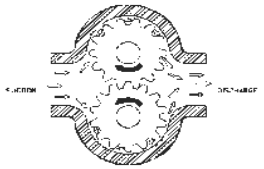
Diaphragm Pump



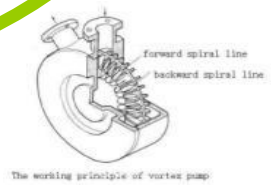
- 電子散熱少用
- 高壓低流量，脈衝流
- 自排氣性能 優◎
- 價格高

Gear Pump

- 電子散熱少用
- 高壓低流量，微波動流
- 自排氣性能：佳○
- 價格中等



Vortex Pump



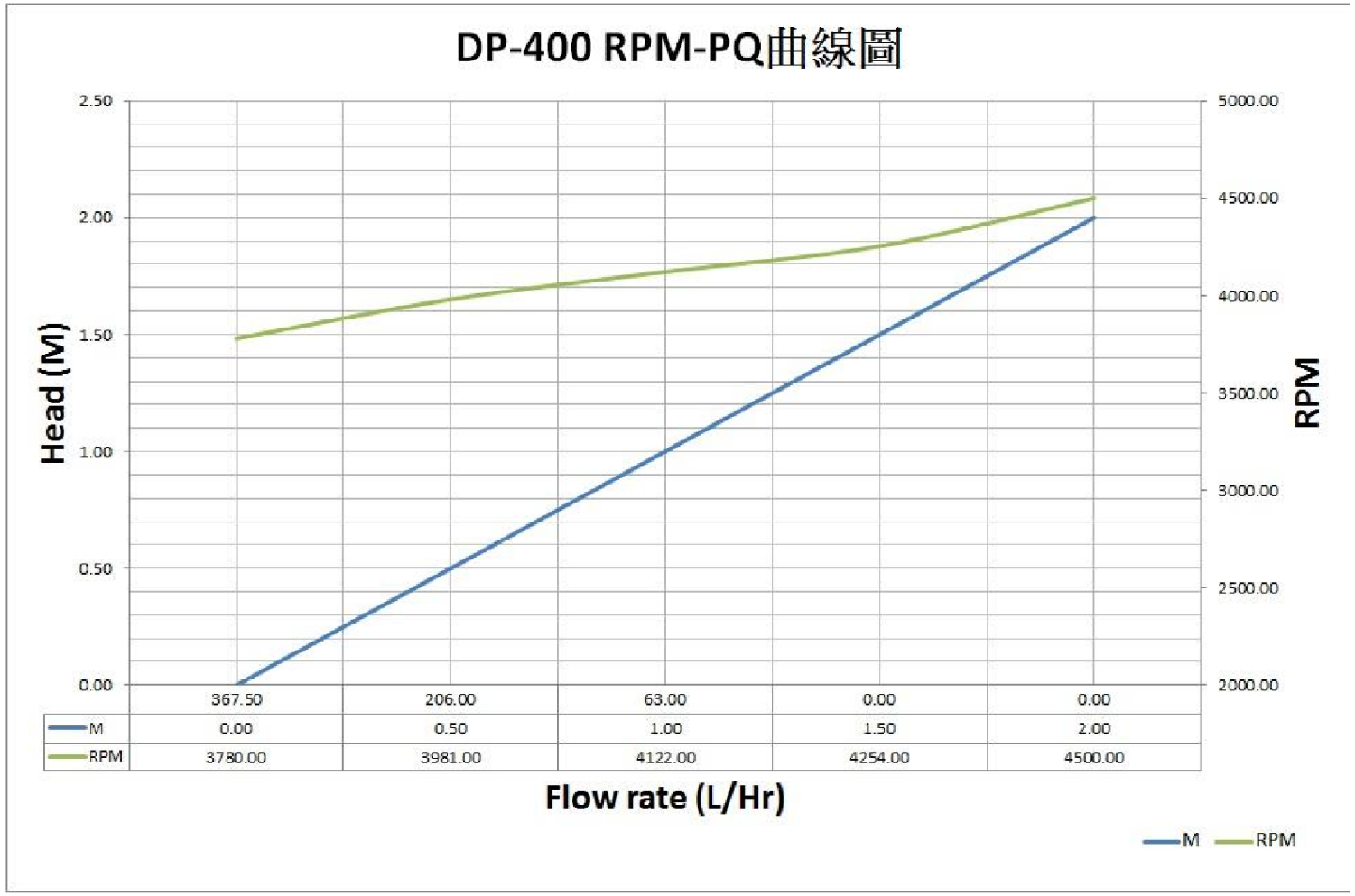
- 電子散熱少用
- 流量穩定且連續
- 自排氣性能：可△
- 價格高

Pump Information

Centrifugal Pump

N S

Model	DP-400
Rated voltage	
Starting voltage	
Power	6.5W±10%
Load current	0.62A±10%
Q-max	400L/hr±10%
	6.67 LPM
	1.76 GPM
H-max.	2.2m±10%
	0.216 bar
	3.128 psi
Size(mm)	52 x 45 x 50
Life Expectancy	
Noise	17.2 dB



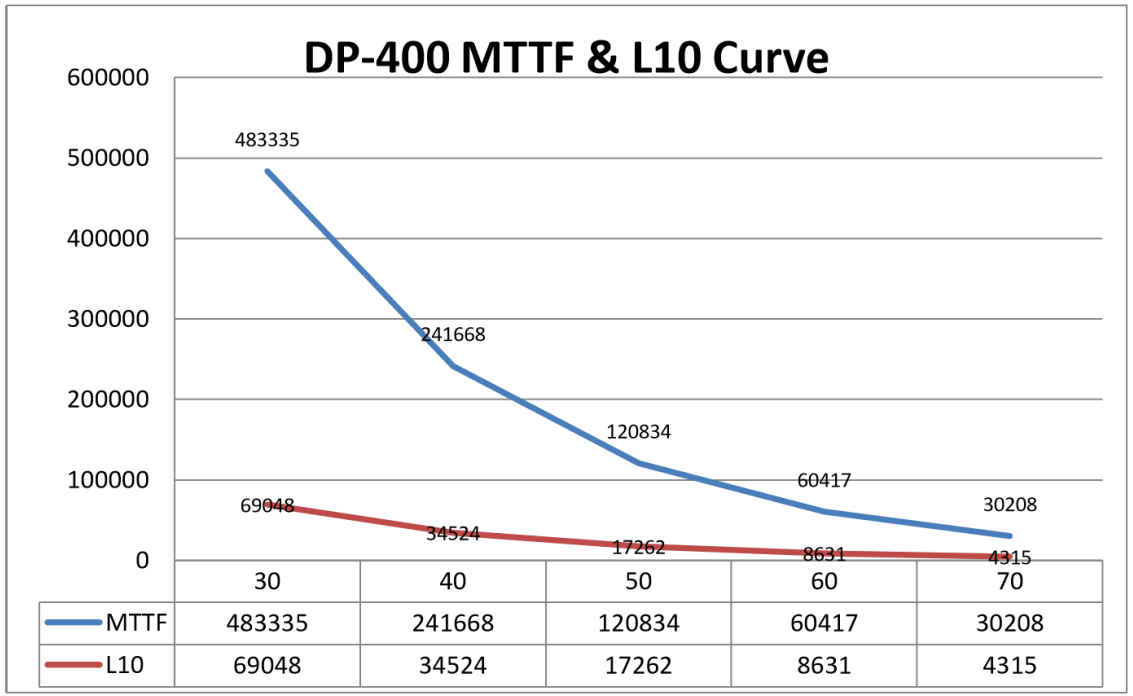
Pump MTTF

1.1測試DP-400的MTTF是否達到50,000小時。

產品	型號	生產序號	測試樣品數量	流體	設定溫度	實際測試溫度	正常環境溫度
DC 無刷 PUMP	DP-400	90105	10	水冷液	70℃	70℃	30℃

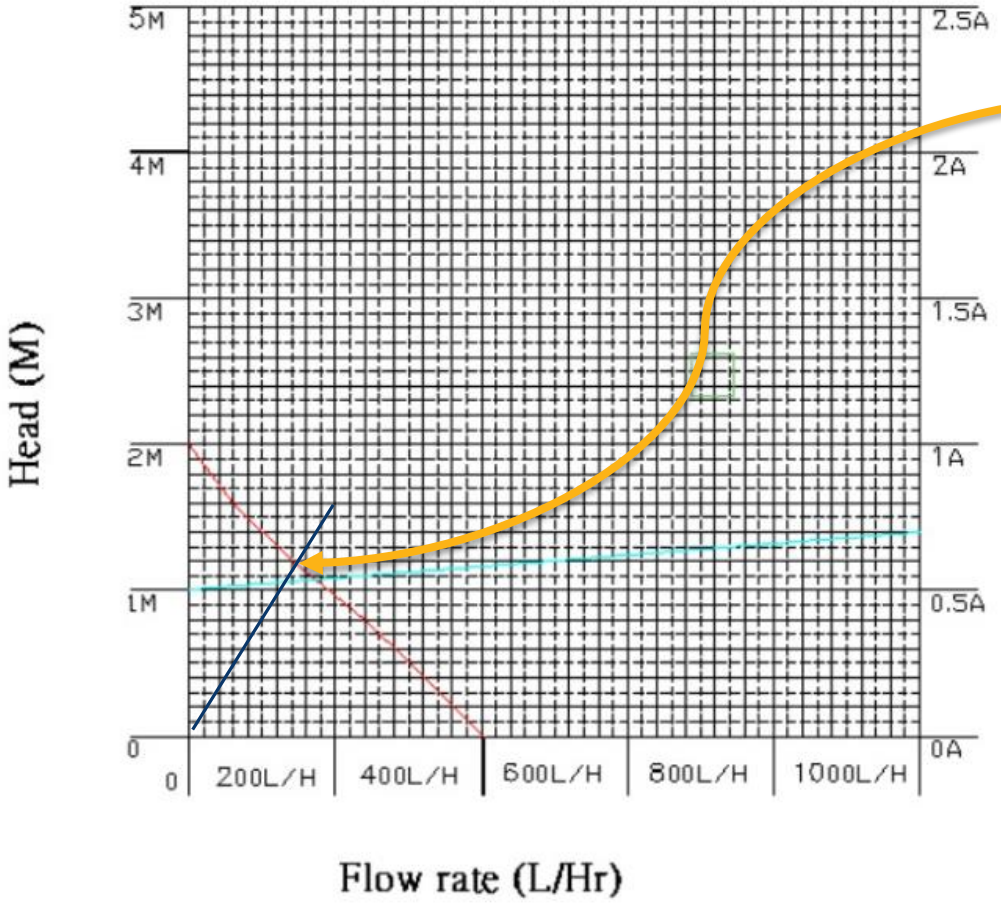
1.2故障模式定義

*停止工作
*漏水
*電子零件損毀
*異常噪音



測試溫度	環境溫度	加速因子	測試樣品數量	信賴度90%	零故障測試時間	MTTF	L10
Ts(℃)	Tu(℃)	AF	N	T(Hours)	T(Hours)	(Hours)	
70	30	32	10	2.3	4104	483335	69048
70	40	16	10	2.3	4104	241668	34524
70	50	8	10	2.3	4104	120834	17262
70	60	4	10	2.3	4104	60417	8631
70	70	2	10	2.3	4104	30208	4315

Pump operation



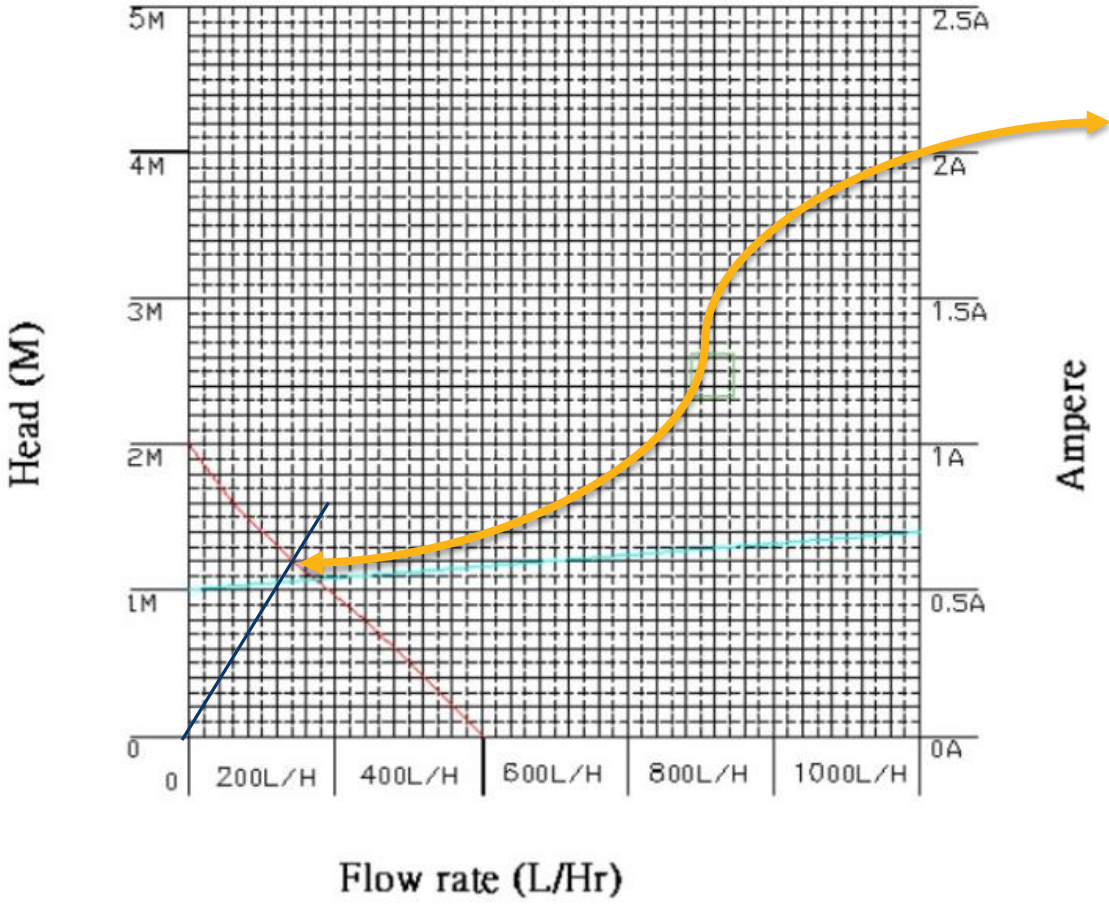
Operation Point

Head(M)	L/min	L/Hour
1.2	2.91	174.6

Current meter

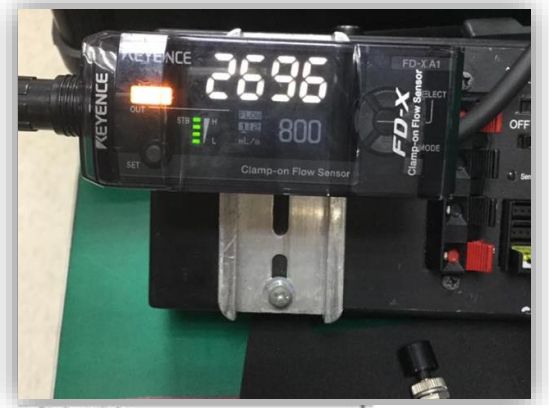
仕様	その他、不明な点につきましてはお問い合わせください。	
型式	MND10	M
呼び径	13mm	
流量範囲	1.5～20L/min	3～
精度	±5%RS	
計測基準	冷温水※1	
最高使用圧力	1MPa（液体温度20℃のとき	
液体温度範囲	0～+90℃	

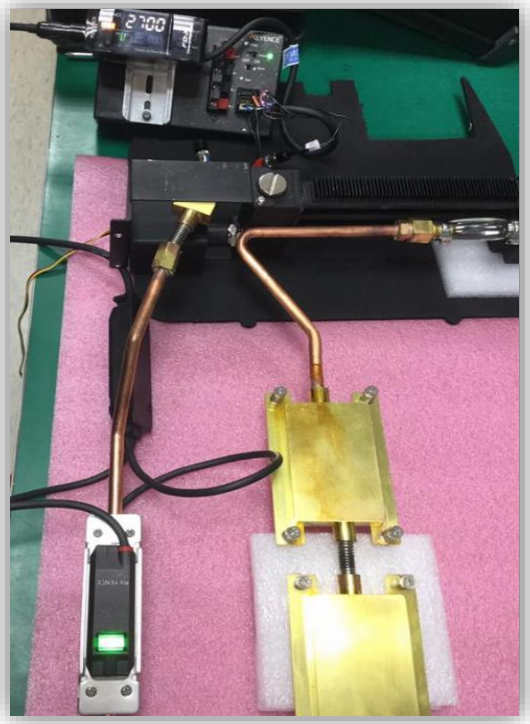
Pump operation - Ultrasonic



Operation Point

Head(M)	L/min	L/Hour
1.3	2.696	161.76





感測頭型號			FD-XS8		
支援管路材質			金屬管路、樹脂管路（軟質／硬質）*1		
支援流體			所有液體（水、油、接著劑、潤滑油、化學藥品等）*1		
支援流體溫度（管路表面溫度）			0°C（管路表面不結冰）至 100°C		
適用口徑	安裝樹脂管路時	支架組型號	FD-XC8R1	FD-XC8R2	FD-XC8R3
		管路外徑	ø6	1/4" (6.35 mm)	ø8
		可安裝範圍	ø5.5 至 6.5	ø5.9 至 6.9	ø7.5 至 8.5
	安裝金屬管路時	支架組型號	FD-XC8M		
		管路外徑	ø6	1/4" (6.35 mm)	ø8
		以 A 為單位時	—	—	—
		可安裝範圍	ø5.5 至 8.3		

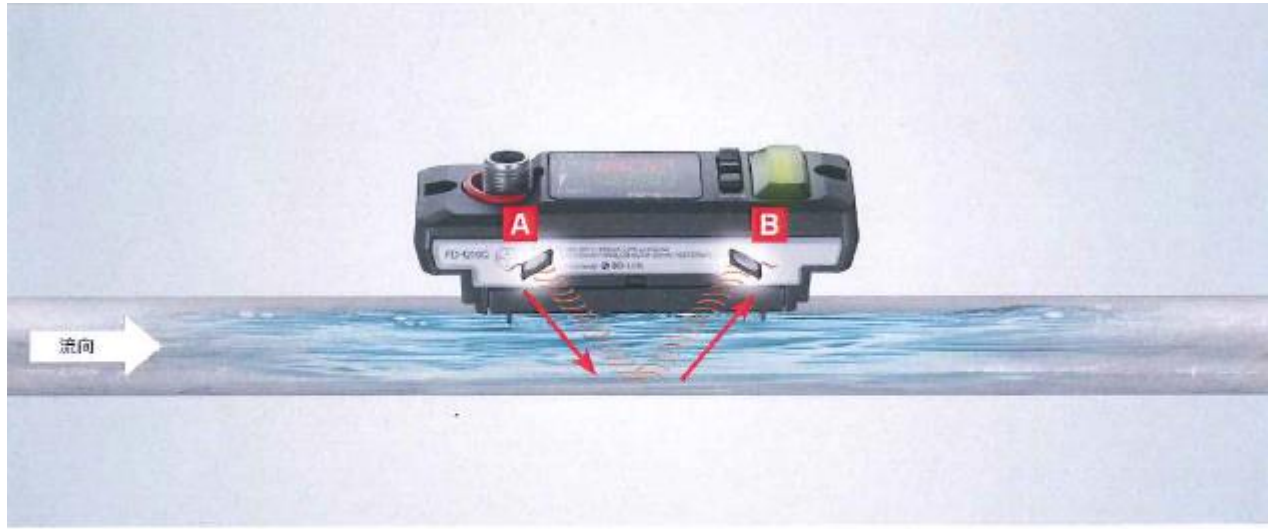
安裝傳統流量感測器

傳統方式

- 關閉機器並移除配管內的液體
- 切開配管
- 穿過各條配管
- 將感測器安裝到管套接頭上
- 將感測器和管套接頭安裝到配管上
- 開啟機器，讓液體注入配管
- 將流量調整至初始值
- 檢查流體外洩

安裝 FD-Q 系列

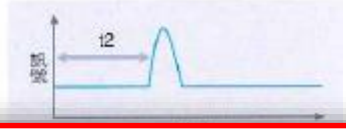
節省總成本



FD-Q 會量測將超音波訊號從感測器上的 A 點傳送到 B 點所花的時間（t1）。流速增加時，訊號從 A 點傳送到 B 點的時間將縮短，因此訊號會加速（t2）。透過流量時間長度及流速的關聯，FD-Q 便可量測即時的流速。

低流量

高流量

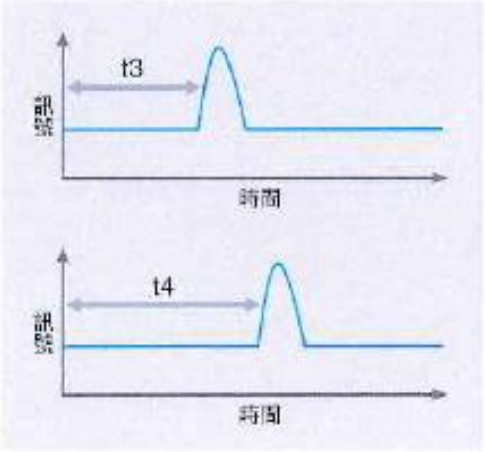


dTOF 技術

傳統超音波流量感測器容易有檢測不穩定的狀況。因為超音波訊號的速度除了受液體流量影響，也會因阻塞或溫度變動等外部因素而受影響。FD-Q 並非簡單地量測單一脈衝的持續時間，而是發射及接收兩組不同的超音波脈衝。一組從 A 點傳送到 B 點，另一組則從 B 點傳送到 A 點。FD-Q 只要比對兩個訊號，便能穩定地監控流量。這種檢測方式可消除任何外部因素的影響。

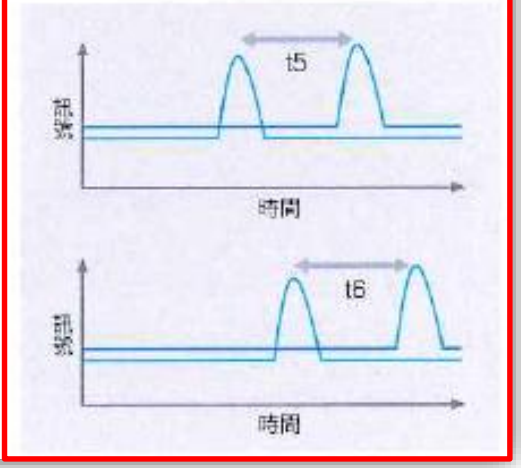
基本原理

脈衝的時間很容易被外部因素所影響。

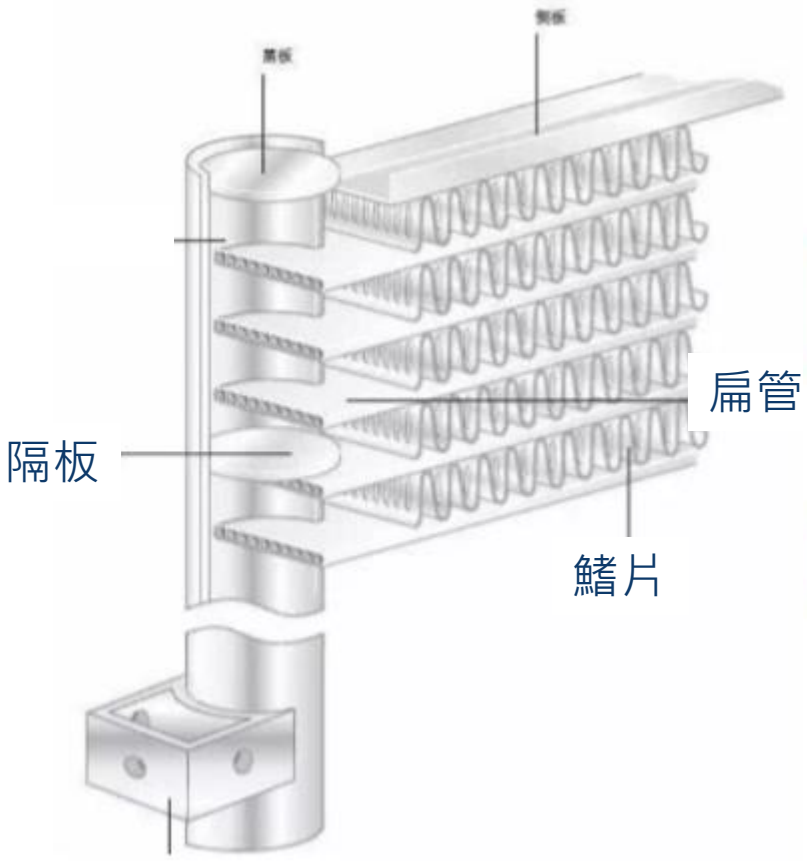


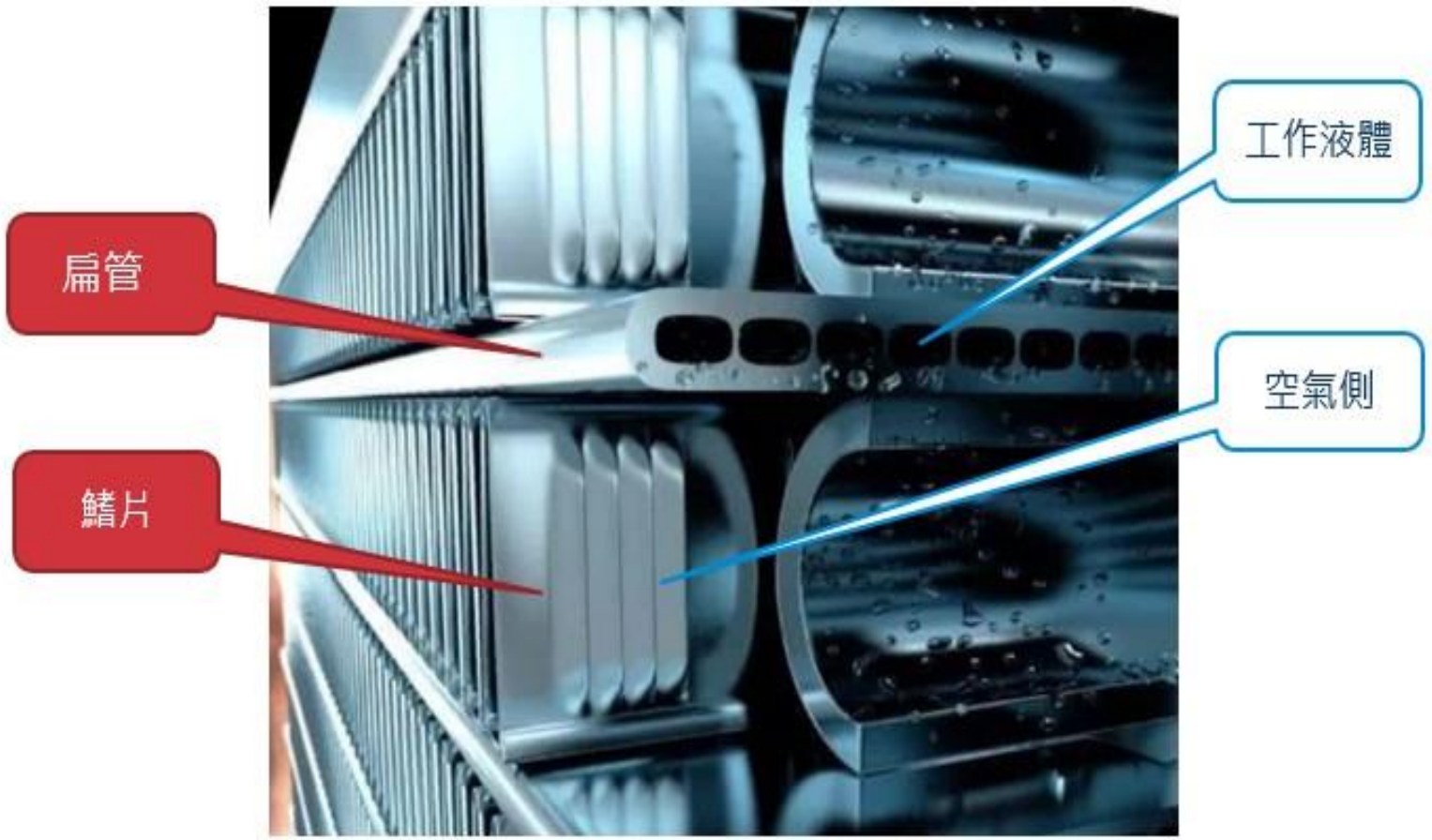
Delta TOF

外部因素不會影響檢測，因為 A 點至 B 點與 B 點至 A 點的時間差是一樣的。



Radiator

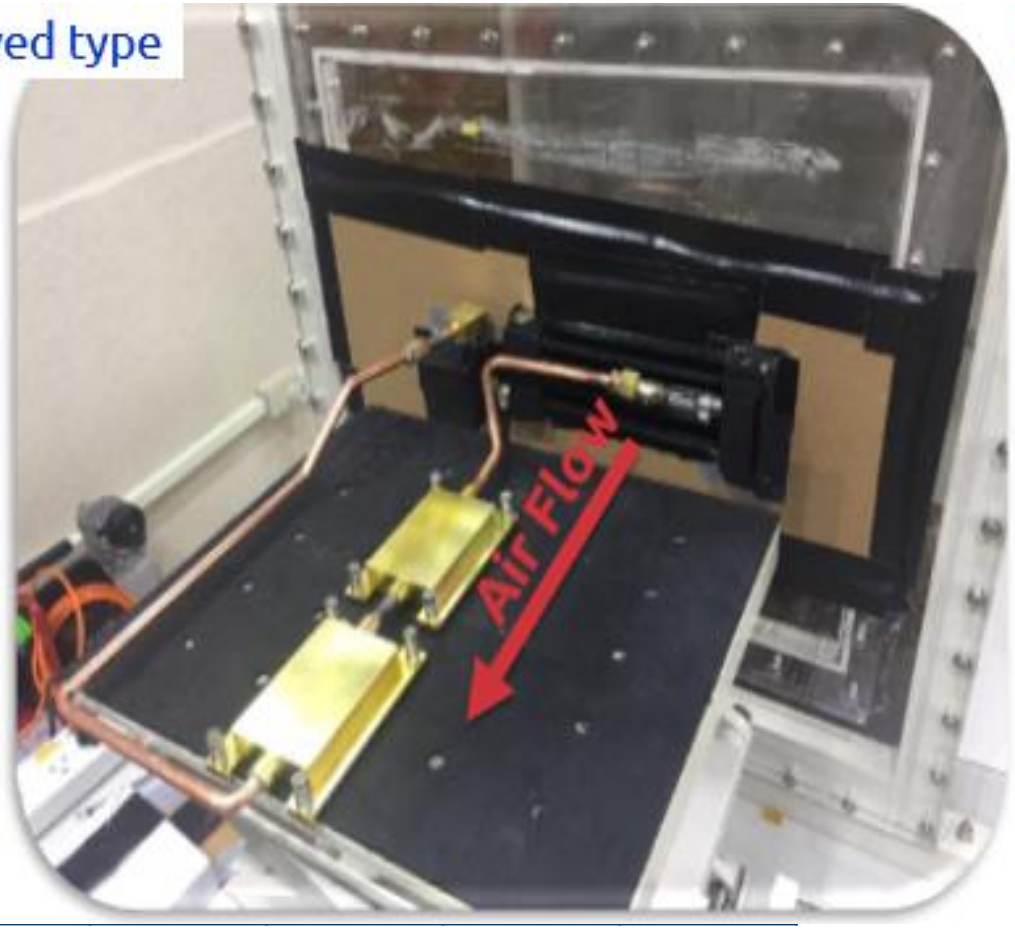




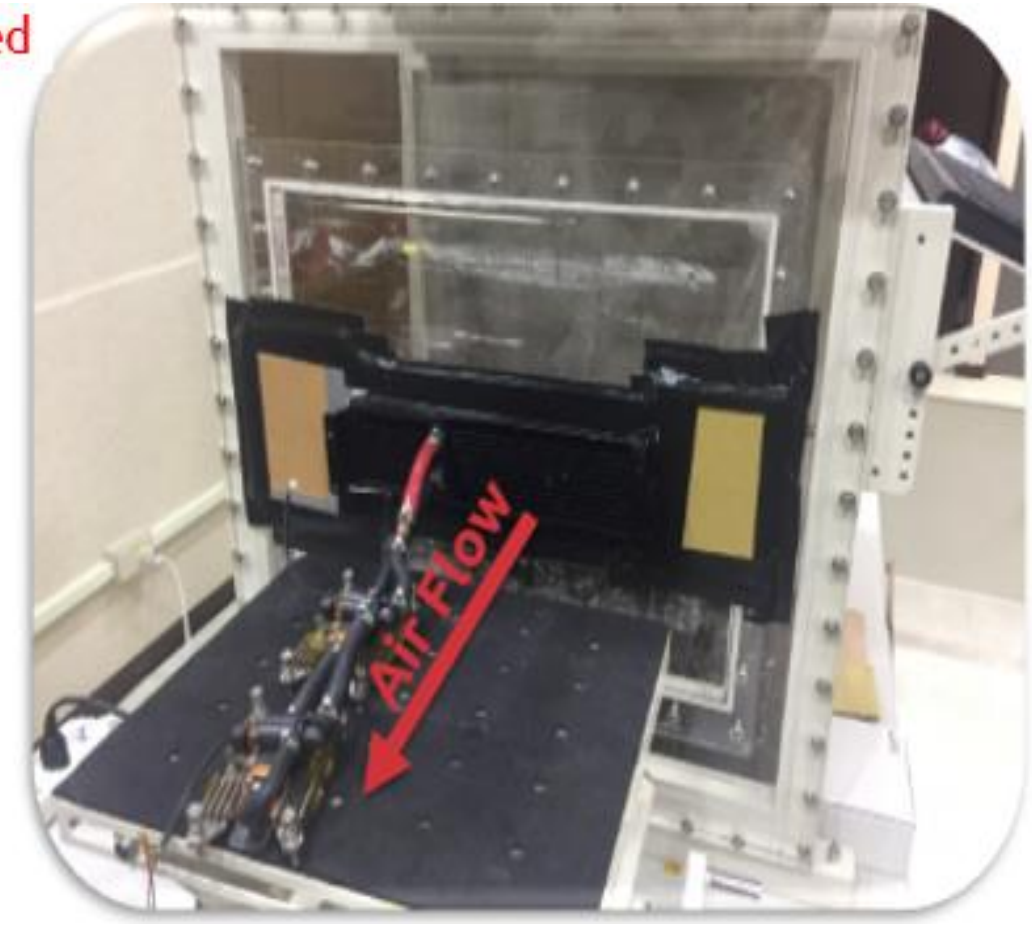
Wind Tunnel Test_Case1

Radiator impedance result

Skived type

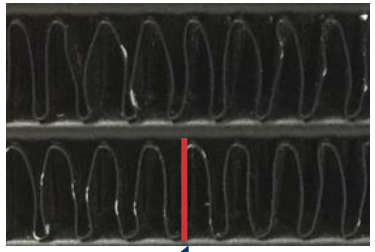


Folded

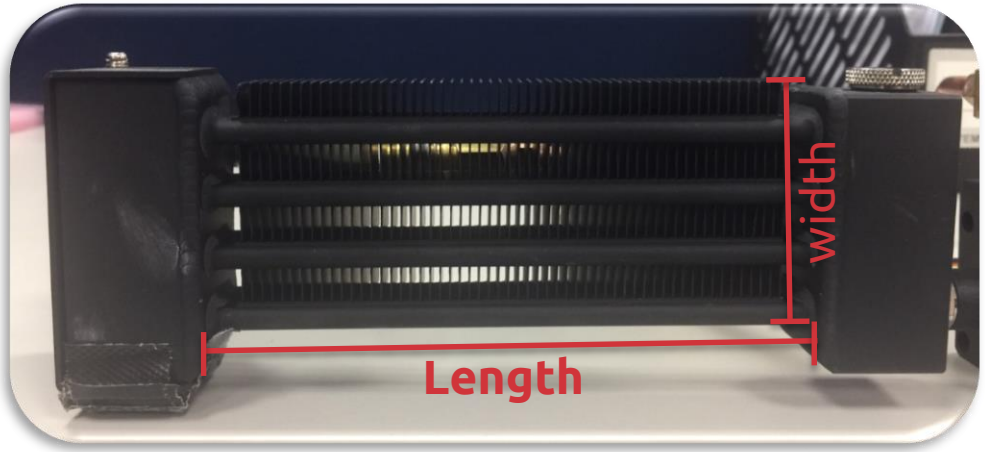


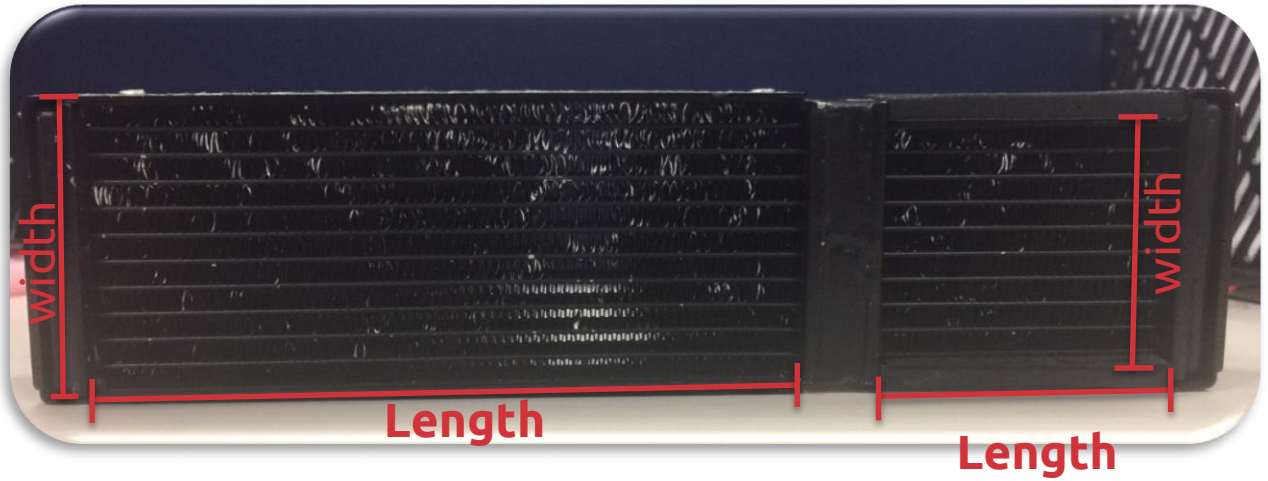
Radiator dimension

Comparison cooling area



		Length (mm)	Width (mm)	Depth (mm)	截面積 (mm²)	Fin數	Fin長 (mm)	Fin厚 (mm)	單個Fin 截面積 (mm²)	總Fin截面積 (mm²)	管子寬度 (mm)	管數	總管子截面積 (mm²)	風通道的截面積(mm²)	風通道 體積(mm³)
Radiator:**Skived**		146	60.8	22	8877	222	9	0.6	5.4	1199	5.7	4	3329	4349	95682
Radiator: folded	第一個矩形	173.4	71.5	15	16687	1716	5	0.1	0.5	1155	1.5	10	3473	12059	180885
	第二個矩形	72.7	59			594					1.5	8			

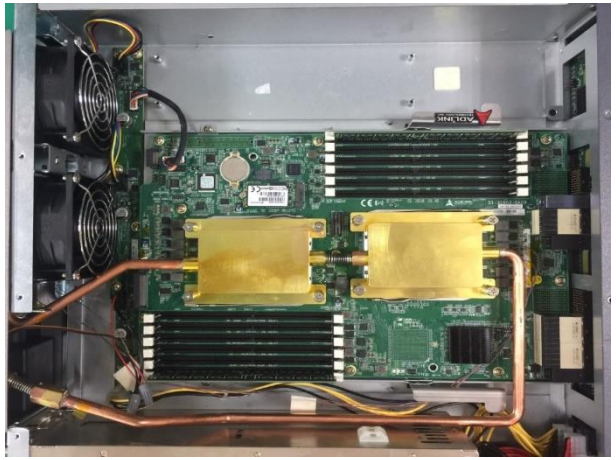


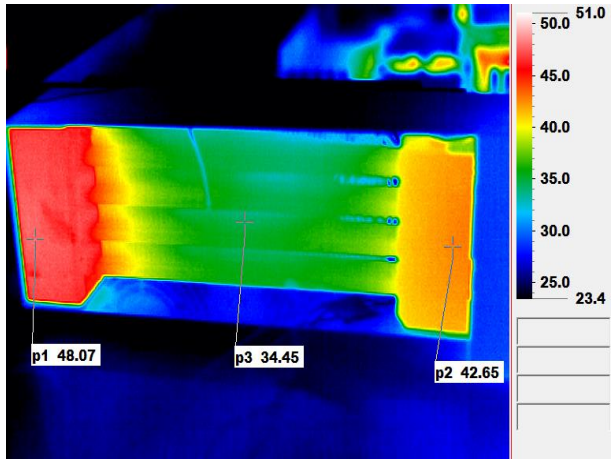


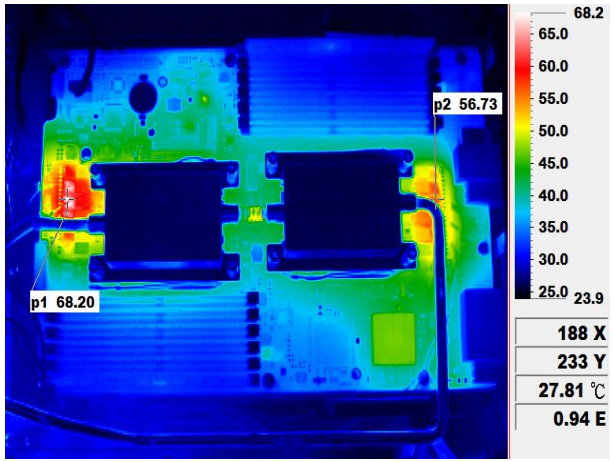
Radiator_Temp

Skived type

- Infrared camera



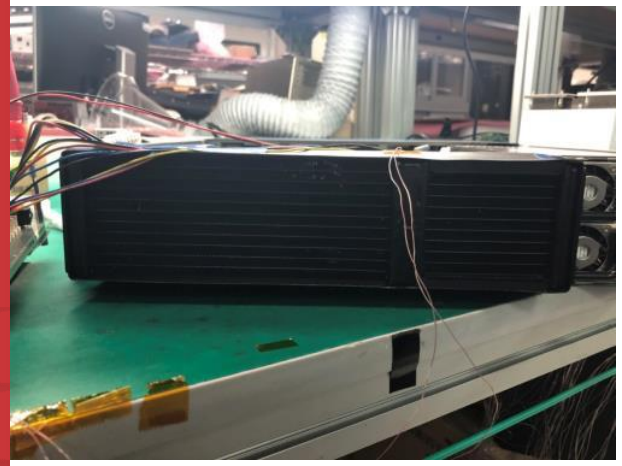




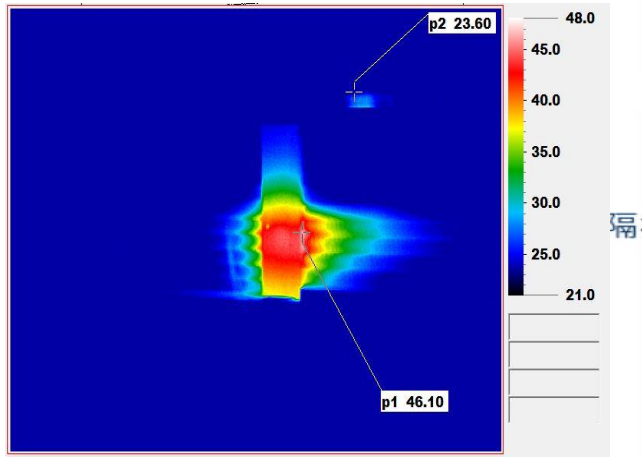
Coolant	ITEM	USAGE(%)	TEMP(C)	DTS	POWER(W)	T-Ambient	T-MARGIN
032	CPU 0	100	64	32	119.6	25	27.5
032	CPU 1	100	64	32	119.7	25	27.6

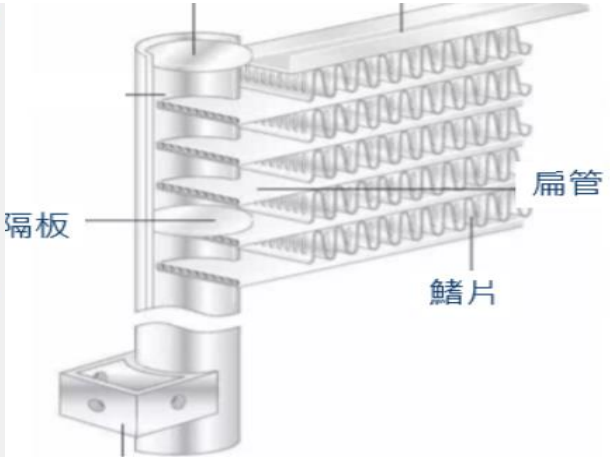
Radiator

Folded type



Infrared camera





Coolant	ITEM	USAGE(%)	TEMP(C)	DTS	POWER(W)	T-Ambient	T-MARGIN
032	CPU 0	100	54	42	119.6	25	37.25
032	CPU 1	100	67	29	119.7	25	24.28

$\Delta T = 13℃$

Wind Tunnel Test_Case2

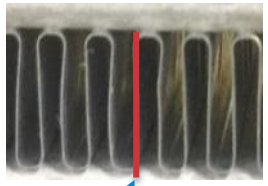
Radiator impedance result

Skived

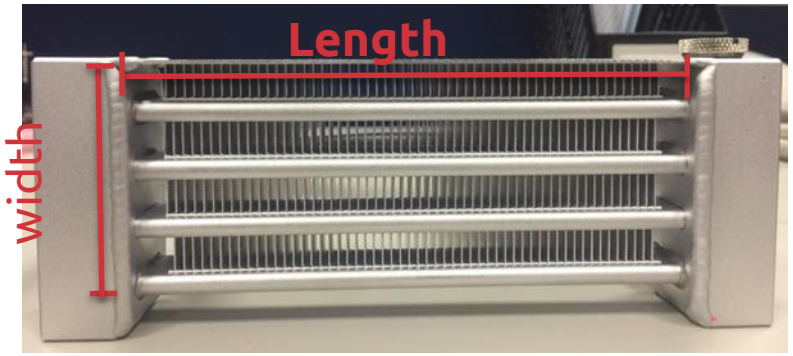
Folded

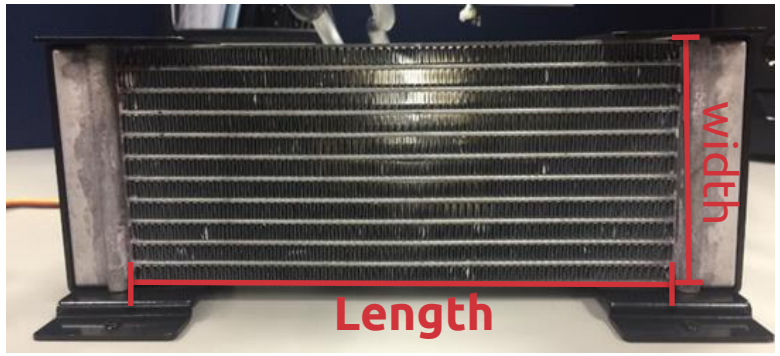
Radiator dimension

Comparison cooling area



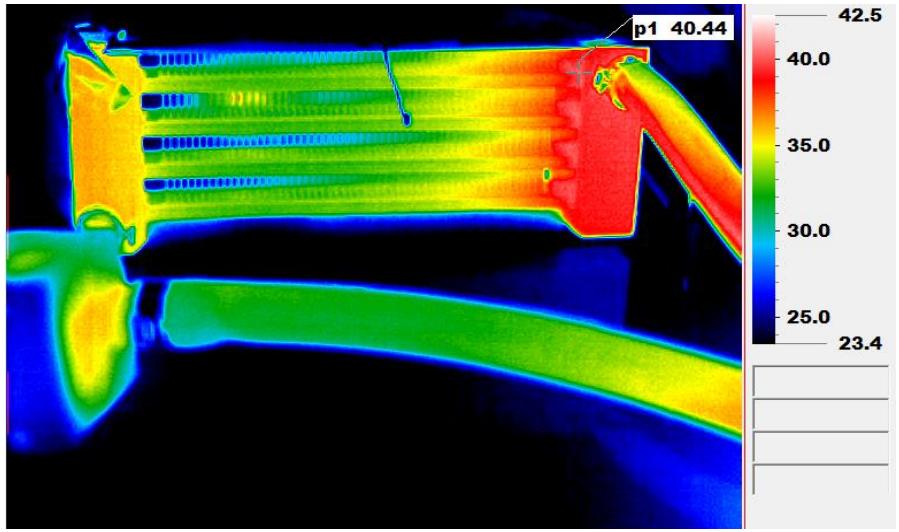
	Length (mm)	Width (mm)	Depth (mm)	截面積 (mm²)		Fin數	Fin長 (mm)	Fin厚 (mm)	單個Fin截面積 (mm²)	總Fin截面積 (mm²)		管子寬度(mm)	管數	總管子截面積 (mm²)		風通道的截面積 (mm²)	風通道的總體積 (mm³)
Liquid Cooling Module :**Skived**	146	60.8	22	8877		222	9	0.6	5.4	1199		5.7	4	3329		4349	95682
Liquid Cooling Module :**Folded**	160	71.6	27.1	11456		1595	5	0.1	0.5	798		1.5	10	2400		8259	223805

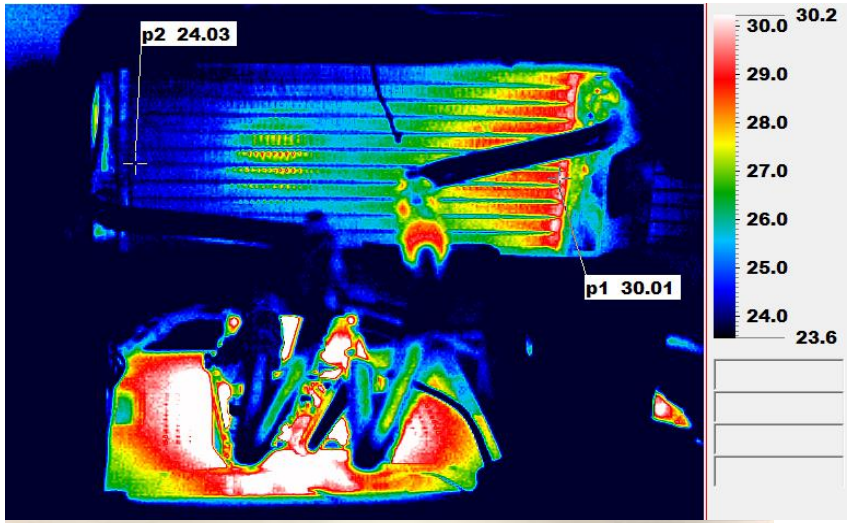




Radiator Temp

Test Data											
Item (CPU/FAN/PUMP)	Power(W)	Current(A)	Voltage(V)	Fan(%)	Pump Current(A)	Pump Voltage(V)	Tcase(℃)	Tambient(℃)	DeltaT(℃)	Resistance(℃/W)	
120W/100%/12V	119.568	2.12	28.2	100	0.4	12	54.1	23.1	31	0.259	
120W/80%/12V	119.992	2.12	28.3	80	0.4	12	55.4	23.3	32.1	0.268	





Test Data											
Item (CPU/FAN/PUMP)	Power(W)	Current(A)	Voltage(V)	Fan(%)	Pump Current(A)	Pump Voltage(V)	Tcase(℃)	Tambient(℃)	DeltaT(℃)	Resistance(℃/W)	
120W/100%/12V	119.706	2.13	28.1	100	0.16	12	50.9	23.7	27.2	0.227	
120W/80%/12V	119.706	2.13	28.1	80	0.16	12	51.6	23.7	27.9	0.233	

Coolant

ADLINK

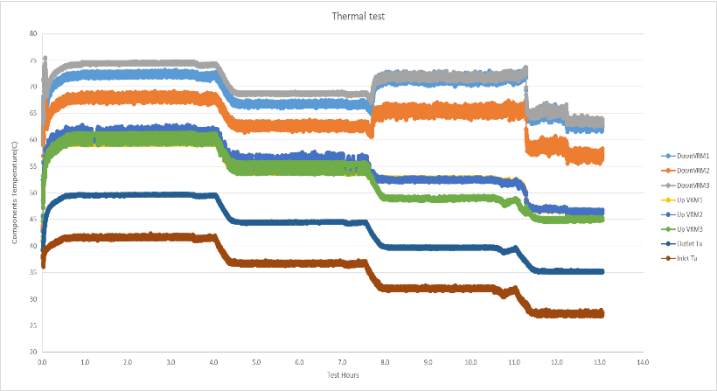
032

TEST RESULT(S) :

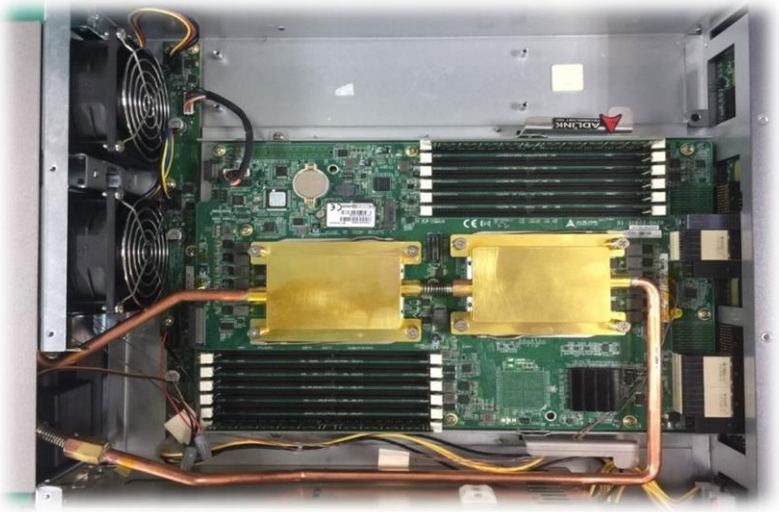
TESTITEM(S)	UNIT	METHOD	RESULT
Heat Transfer Coefficient	W/m.K	ISO 22007-2	0.6386
Viscosity,25 °C	mm2/s	ASTM 0445	2.37
Specif ic Gravity,25 °C		ASTM 04052	1.051
Density,25 °C	g/ mL	ASTM 04052	1.0442
pH Value		pH METER	7~7.5
Total dissolved solids	ppm		<100
Electrical conductivity	µS/cm		<200
Pour Point	℃	ASTM 05950	<-20
Boiling Point	℃	ASTM 01120	102
Vapor Pressure (absolute pressure)at 20 °C	kPa	With reference to ASTM 05191	1.77
Vapor Pressure (absolute pressure)at 60 °C	kPa	With reference to ASTM 05191	16.5

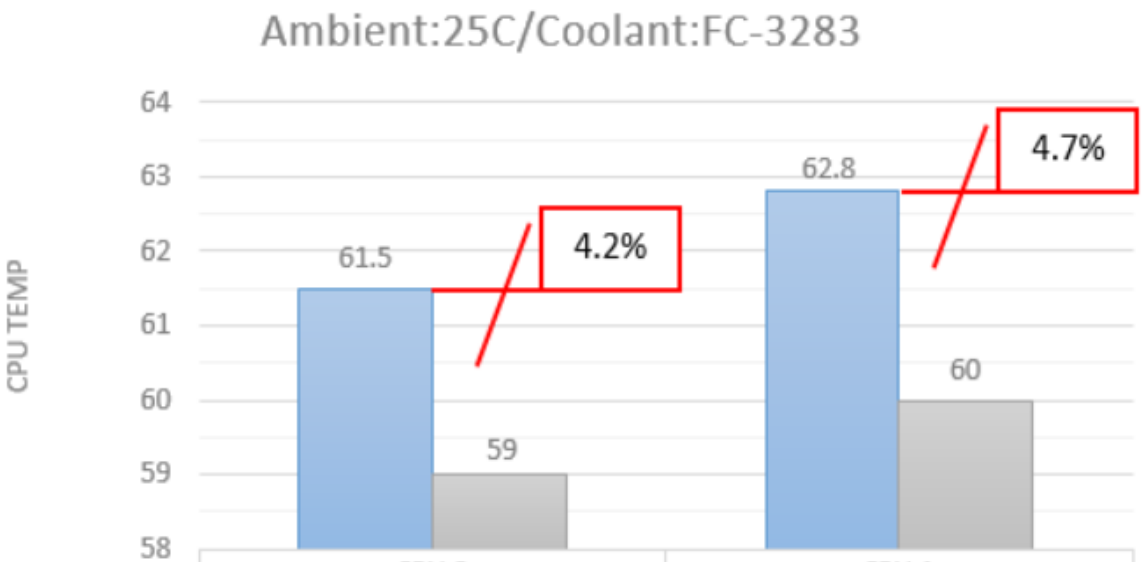
Properties	3M FC-3283
Appearance	Clear, colorless
Average Molecular Weight	521
Boiling Point (1 atm)	128°C
Pour Point	-50°C
Vapor Pressure	1.44 x 10^3 pascals
Latent Heat of Vaporization (at normal boiling point)	78 J/g
Liquid Density	1820 kg/m^3
Kinematic Viscosity	0.75 centistokes
Absolute Viscosity	1.4 centipoise
Liquid Specific Heat	1100 J kg^{-1} °C^{-1}
Liquid Thermal Conductivity	0.066 W m^{-1} °C^{-1}
Coefficient of Expansion	0.0014 °C^{-1}
Water Solubility	7 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

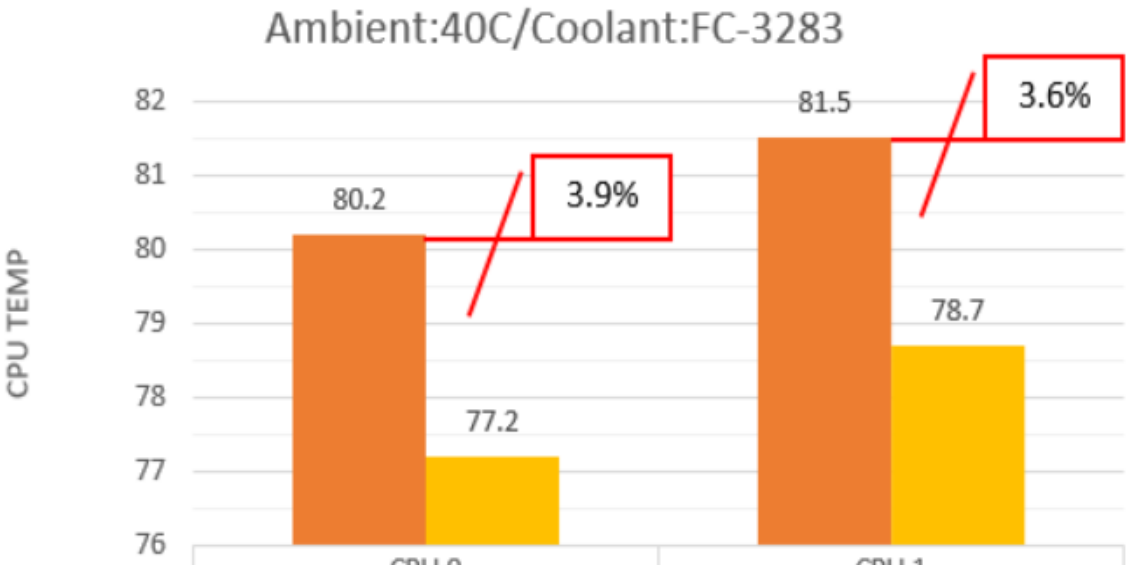
Test Summary

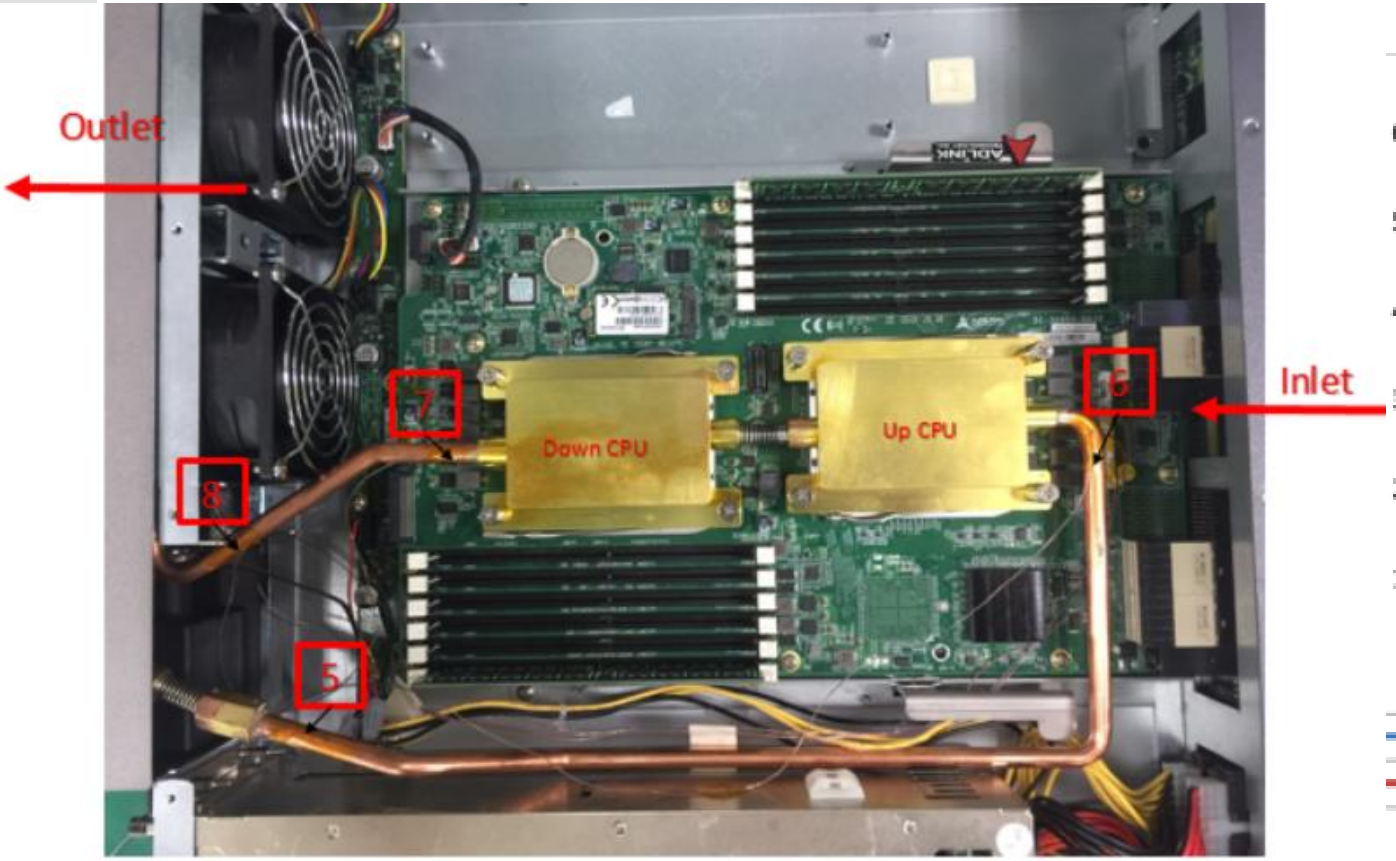


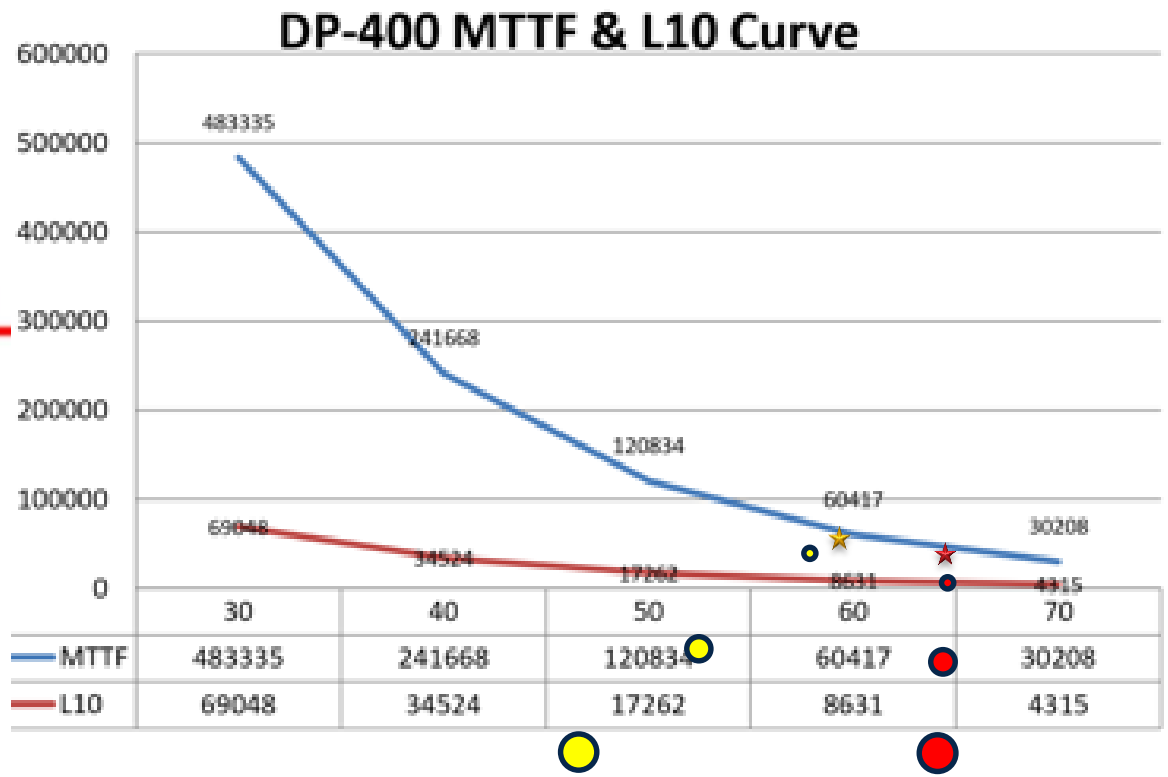
2U 19” (W*H*L=440*88*655)











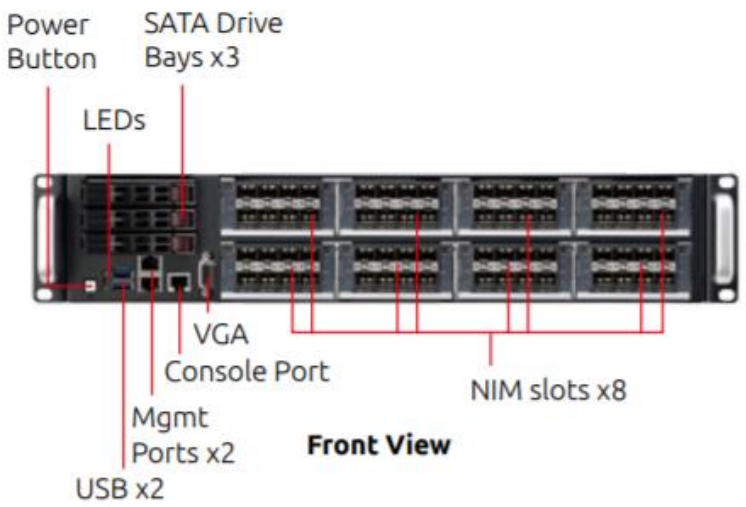
1	Inlet Ta	44.0
2	Outlet Ta	53.3
3	Up CPU	78
4	Down CPU	80
5	水排出	60.1 ★
6	CPU入	60.8
7	CPU出	67.0
8	水排入	66.5 ★

7 years

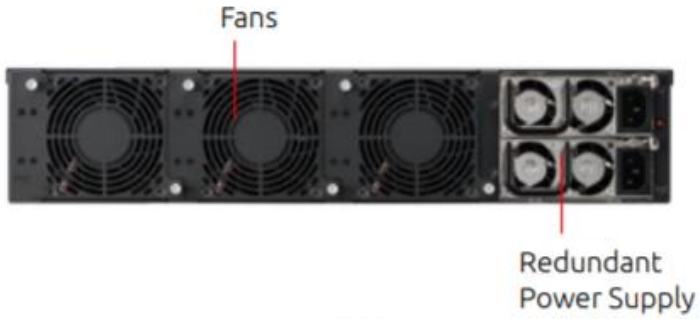
5 years

Liquid cooling system

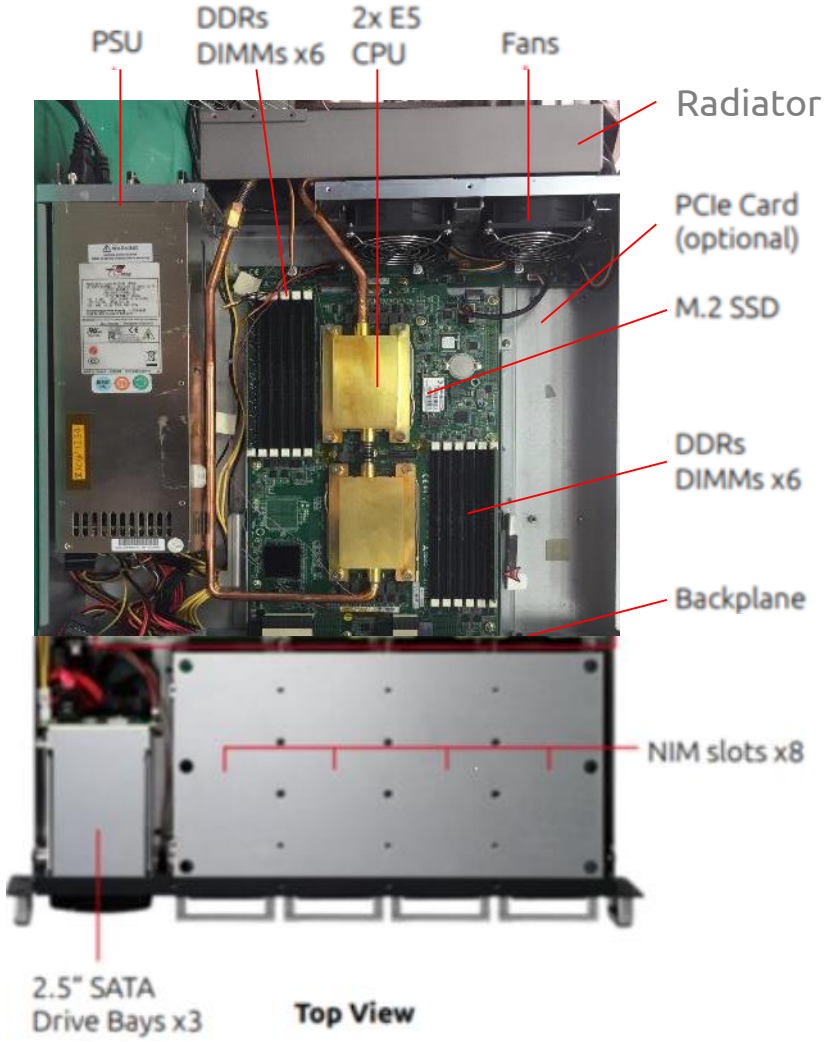
2U 19” Network server Appliance (W*H*L=440*88*655)



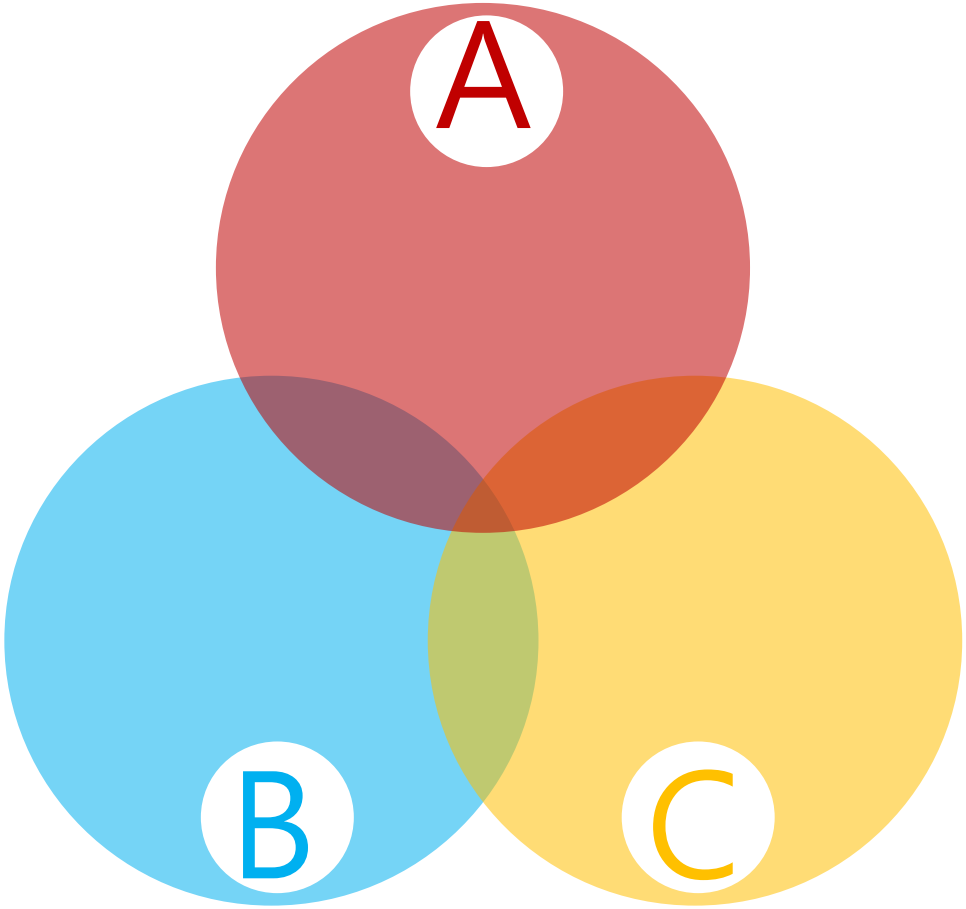
Front View



Rear View



Top View



Benefit summary

A Fan noise & Power saving

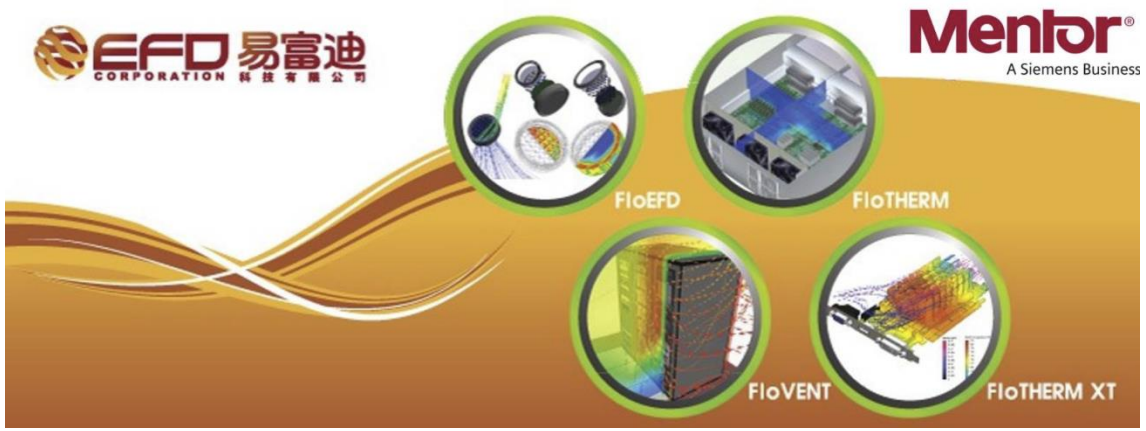
Noise »-2.8%(72>70dBA) ; Power »-33%(24W)

B Chassis size & Cable management

Chassis » +9.5%(55mm)

C Thermal management & Safety

Robust & Safety (Leaking &Non-conductive)



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Thank You for Your Attention

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