



MHP SERIES
FLAT ALUMINIUM HEAT PIPES
- PRODUCT GUIDE

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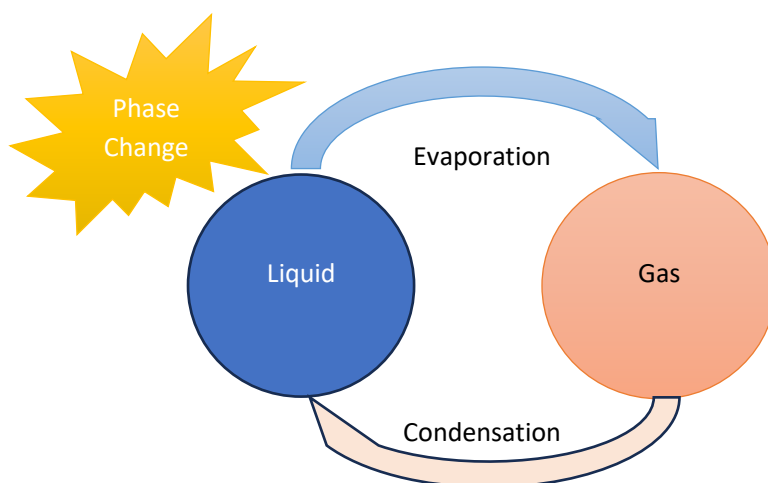
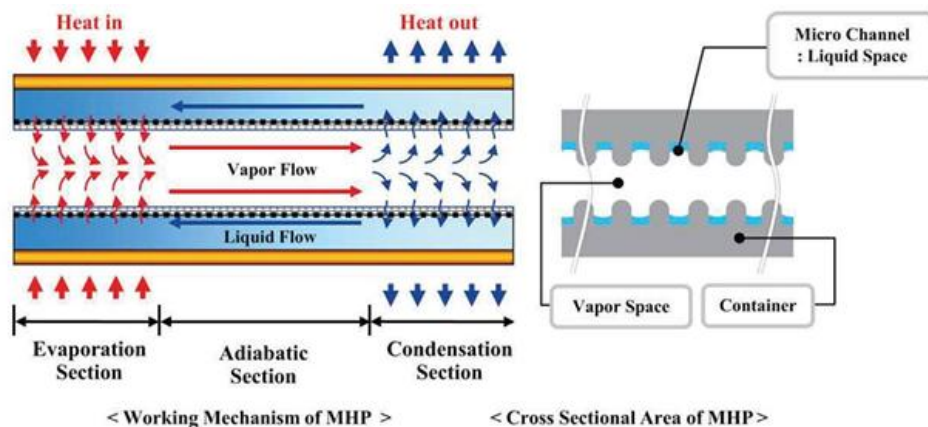
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WORKING MECHANISM

Heat pipes are used to transfer large amounts of heat quickly without requiring a power source. This is done by utilizing the phenomenon of thermal energy being absorbed when a liquid changes into a gas, and then being released when a gas changes into liquid state.

When the heat pipe is in contact with the heat source, the liquid acetone evaporates, absorbing heat in the process (evaporating end). The resulting gas/vapour moves to a lower temperature section of the heat pipe (condensing end). The liquid acetone that is in the low temperature area condenses, releasing the heat and returns to liquid form.

This is the mechanism by which heat is carried (i.e. transferred) from a high temperature area to a low temperature area. The working fluid that had condensed into liquid form returns to the heat source through the wicking structure. This cycle of vaporization, liquefaction and transfer of the working fluid occurs rapidly and continuously.



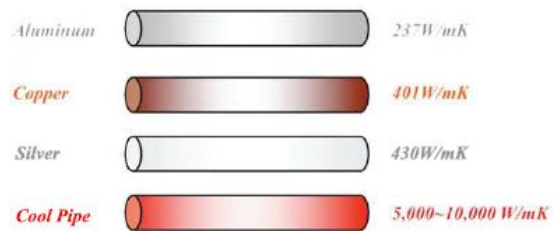
THERMAL CHARACTERISTICS OF MHPs

Feature: MHP has increased thermal conductivity compared to single metal heat pipes.

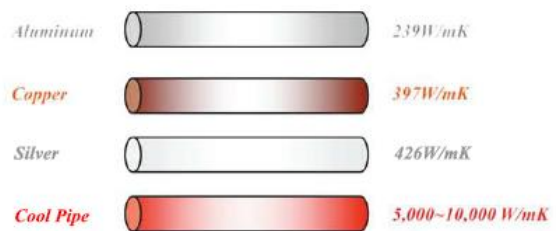
Concept: The working fluid (acetone) transfers the heat energy by phase change inside the unit.

Note: When temperature of the water (25°C, 1kg) is rising up 1°C, the heat energy is needed as 4.18kJ. When state of water (25°C, 1kg) is changed from liquid to gas (vapour) without temperature change, the latent heat energy is needed as 2422kJ.

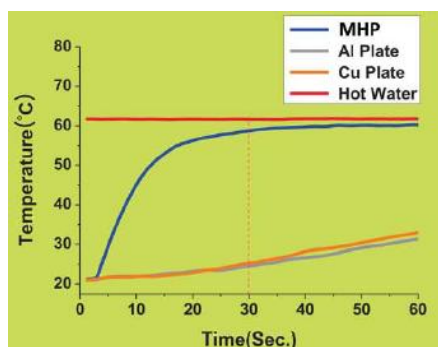
Thermal Conductivity (K) @ t=27°C



Thermal Conductivity (K) @ t=80°C

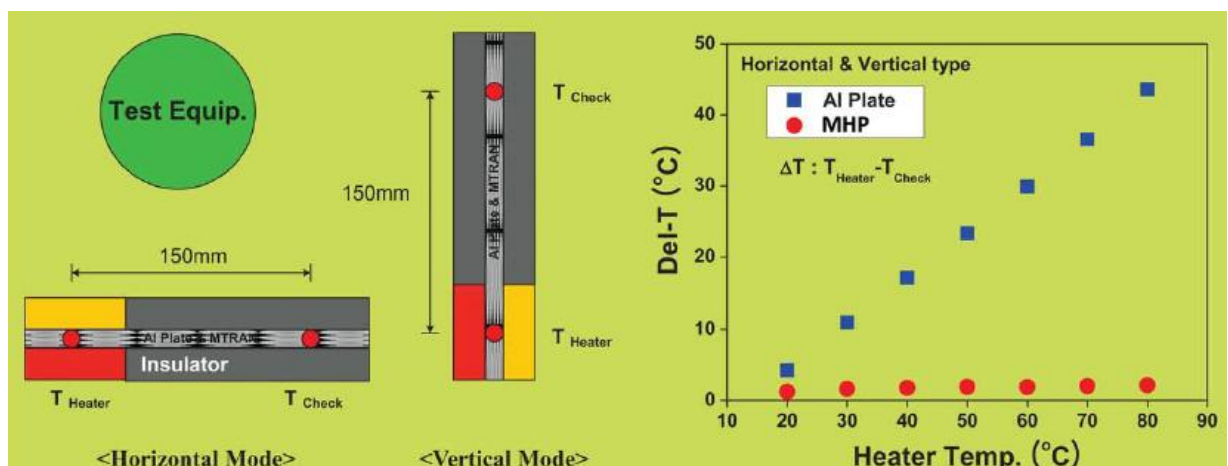


Thermal Response Test



Sample	Surface Temperature (@30s)
MHP	58.71
Al Plate	24.54
Cu Plate	25.32
Hot Water	61.61

Thermal Uniformity Test



MHP Working Range

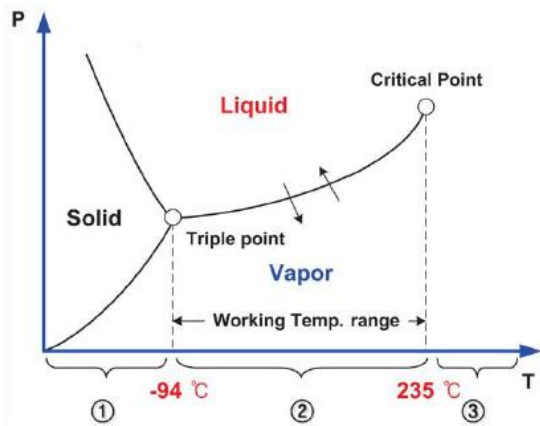
Thermodynamic working range of heat pipe exists.

- MHP works at triple point and critical point range of working fluids.

* Acetone (working fluid of cool pipe):

Triple point Temperature: -94°C

Critical Point Temperature: 235°C



Temperature ($^{\circ}\text{C}$)	Working Fluid
$-270 \sim -70$	Helium, Argon, Krypton, Nitrogen, Methane
$-70 \sim 200$	Water, Freon, Ammonia, Acetone, Methanol, Ethanol
$200 \sim 500$	Naphthalene, Mercury, Sulphur
$500 \sim 1000$	Cesium, Potassium, Sodium
$1000 \sim$	Lithium, Lead, Silver

TEST METHOD OF THERMAL PERFORMANCE

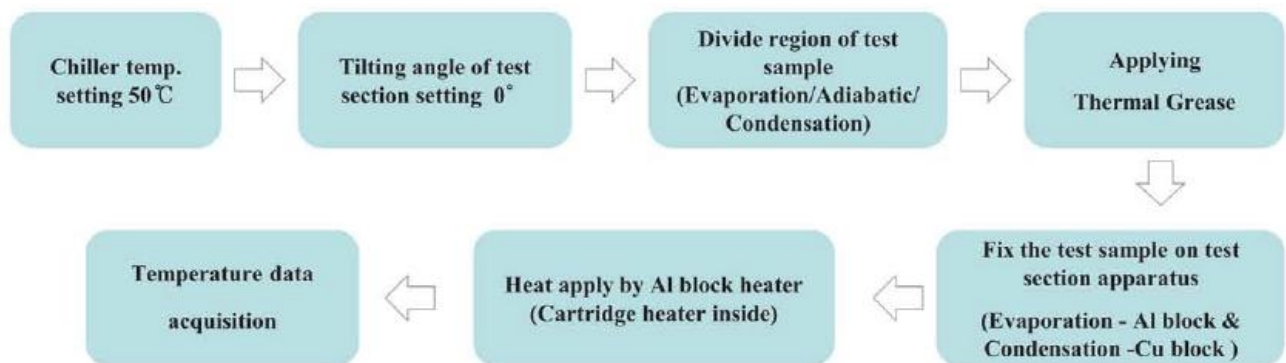
Thermal Resistance

- Thermal resistance is used to estimate the thermal performance.
- The smaller thermal resistance, the better the heat transfer capacity.

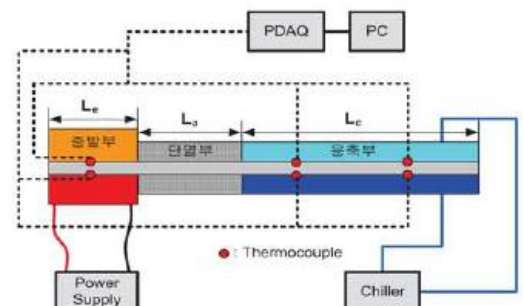
$$R^{th} = \frac{\Delta T}{Q} = \frac{T^{eva} - T^{cond}}{Q_{in}}$$

Quantity	Electrical System	Thermal System
Concept		
Driving Potential	Voltage Difference	Temperature Difference
Flow	Current	Heat
Resistance	Electric Resistance	Heat Resistance
Fourier's Law	$R = \frac{\Delta T}{q} \Big _{\text{Thermal resistance}} = \frac{\Delta V}{I} \Big _{\text{Electrical resistance}}$	

Maximum Heat Transfer Rate (Qmax) Test Procedure



[Test Section Apparatus]



[Test Section Schematic]

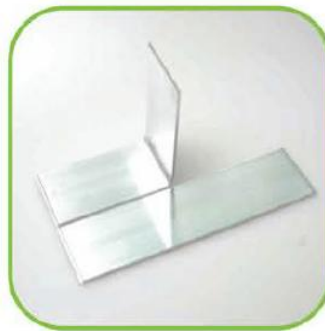
THERMAL PERFORMANCE COMPARISON

Copper Heat Pipe vs MHP Performance

Criteria	Copper Heat Pipe	MHP Series
Metal material	C1020 (Cu 99.96%)	Al 1050
Working Fluid	Deionised Water	Acetone
Wick Structure	Grooved Wick	
Working Temperature	70°C	
Length	100ml	



[Cu Heat Pipe]



[MHP]

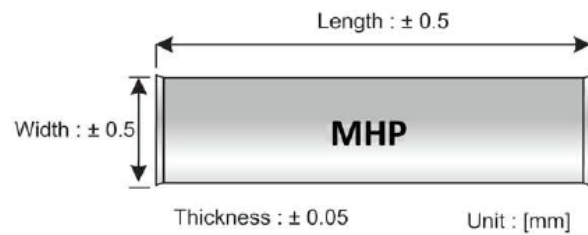
Copper Heat Pipe			
Outer Diameter (mm)	Thickness (mm)	Resistance (°C/W)	Qmax (Watt)
Ø5.0	2.0t (flattened)	0.2 ~ 0.45	5
Ø6.0		0.1 ~ 0.32	5

MHP Series		
Thickness (mm)	Resistance (°C/W)	Qmax (Watt)
2.0t	0.1	50

The MHP cool pipe provides lower thermal resistance and a faster heat transfer rate compared to standard copper heat pipe products. Therefore, the MHP heat pipe provides better thermal performance compared to the copper heat pipe.

MHP SPECIFICATION

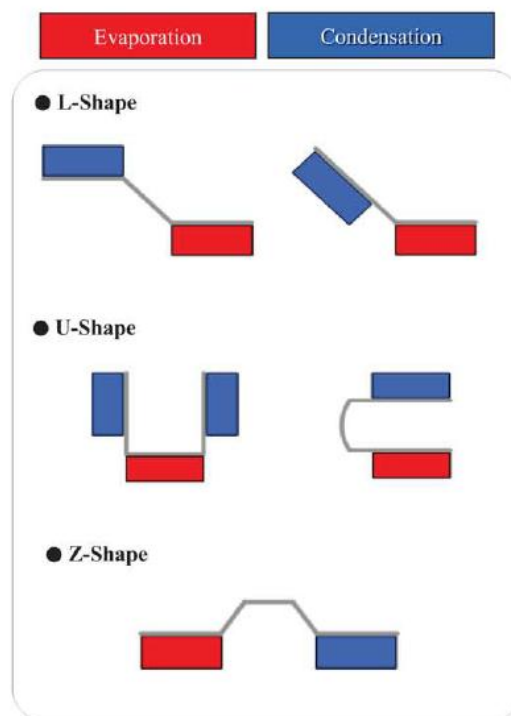
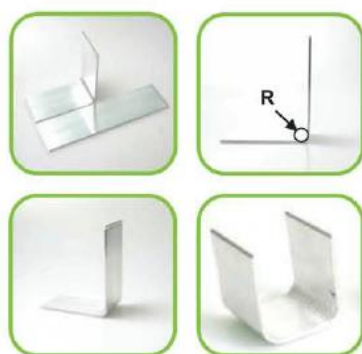
Item	Description
Container Material	Aluminium
Wick Structure	Grooved Wick
Working Fluids	Acetone
Typical Thermal Resistance	<0.4°C/W
Operating Inclination (°C)	-40 ~ 180°
Leakage Temperature	170°C



Profile	Thickness (mm)	Width (mm)	Length (mm)		Max. Heat Transfer Rate (Watt)
			Min.	Max.	
MHP-1520A	1.5	20	60	200	5 ~ 18
MHP-1630A	1.6	30	60	500	11 ~ 34
MHP-2040A	2.0	40	60	500	25 ~ 150
MHP-2550A	2.5	50	60	500	135 ~ 228

Minimum Bending Radius

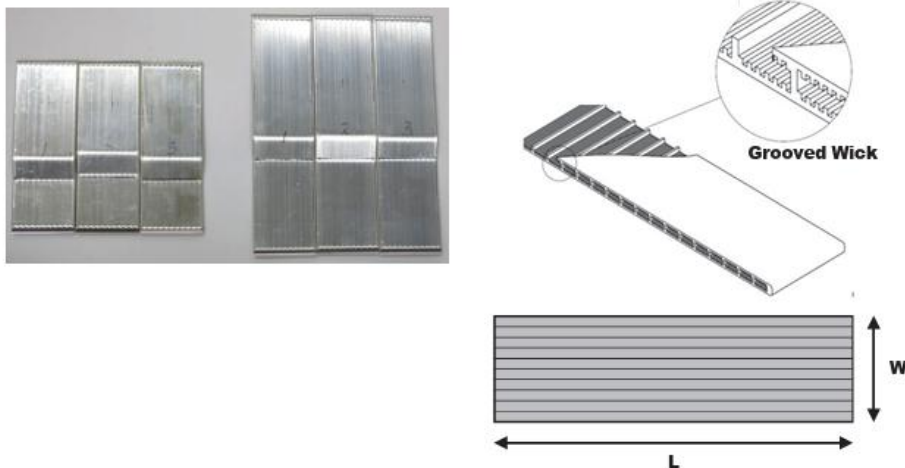
Profile	Min. Bending Radius (mm)	Bending Shape
MHP-1520A	R2	L-Shape U-Shape Or Z-Shape
MHP-1630A	R4	
MHP-2040A	R5	
MHP-2550A	R6	



ACCELERATED LIFE TEST

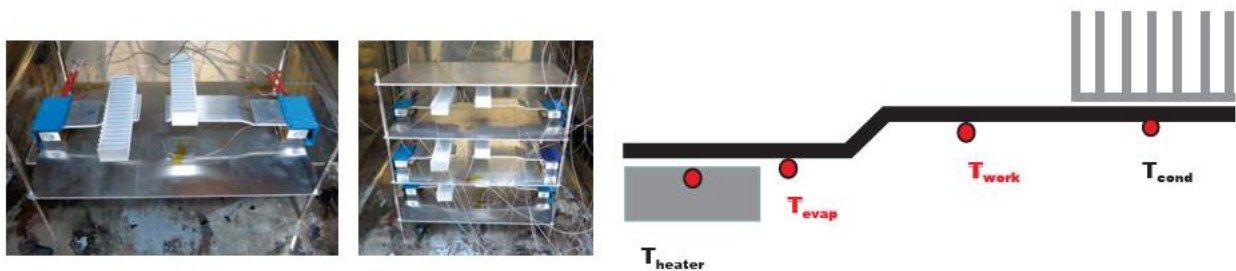
- Item: MHP (Aluminium Flat Heat Pipe)
- Test Condition: Accelerated life test (MTBF Model)
- Test Specimen

Thickness (mm)	Width (mm)	Length (mm)
2.0	40	100
2.0	40	200



Test Procedure

1. After fabricating two types of specimens, the following test apparatus is constructed under the condition of an environmental temperature of 130°C.

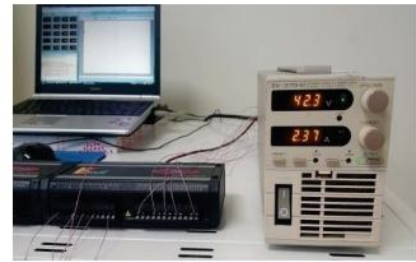


2. Using the power supply, set the operating temperature of the specimen to 135°C.
3. The change of the initial test value of the heater is observed for 30 days.
4. The temperature change of the product surface is observed for 30 days.

Testing Equipment



<Convection Oven>



Test Number	T/C Position	Initial Value (°C)	N=30 days(°C)	Change Value (°C)
SPL 1	T heater	142.3	142.9	0.6
	T eva	141.0	140.5	-0.5
	T con	139.2	140.1	0.9
SPL 2	T heater	145.8	147.0	1.2
	T eva	139.4	140.5	1.1
	T con	136.5	136.7	0.2
SPL 3	T heater	141.8	143.2	1.4
	T eva	137.9	137.9	0.0
	T con	137.6	137.5	-0.1
SPL 4	T heater	143.1	144.0	0.9
	T eva	140.9	141.0	0.1
	T con	141.2	141.4	0.2
SPL 5	T heater	143.9	143.8	-0.1
	T eva	139.6	140.2	0.6
	T con	139.0	137.9	-1.1
SPL 6	T heater	140.3	138.5	-1.8
	T eva	137.7	138.7	1.0
	T con	136.6	137.2	0.6

Check Item	Factor
Accelerated Days (Twork/Tair = 130°C/50°C)	30 days
Normal temperature of heat pipe	50°C
MTBF Model – Acceleration Factor = $2^{((130-50)/10)} = 2^{(8)}$	256
Life of MHP – 256 x 30 Days	7680 days (21 years)

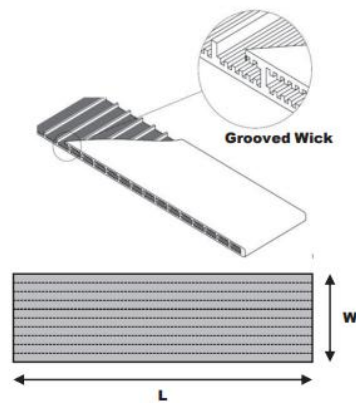
THERMAL SHOCK TEST

Item – Flat Aluminium Heat Pipe

Test Condition: Thermal Shock Test (100 Cycles)

Test Specimen:

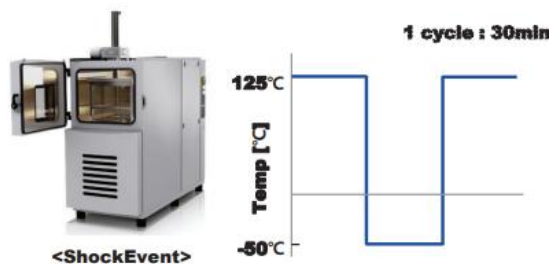
Thickness	Width	Length
1.5	20	100
1.6	30	100
2.0	40	200
2.5	50	200



Test Procedure

1. After making 3 test specimens each, the weight and performance are evaluated.
2. It is exposed to -50°C to $+125^{\circ}\text{C}$ using thermal shock test equipment, 15 minutes of exposure in each temperature range.
3. After exposure, remeasure the weight and performance of the specimen.
4. The appearance and change characteristics are compared against the original measured values.

Test Equipment



Check Item	Dry Oven
Weight	No Weight Loss
Thermal Performance	No Performance Change
Surface Flatness	No Bulging Plane

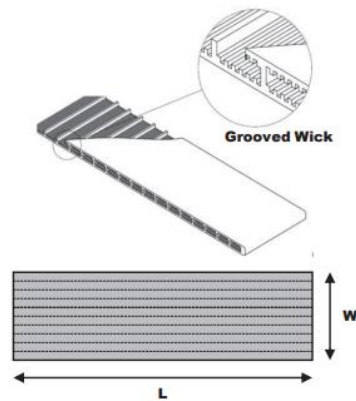
HIGH TEMPERATURE TEST

Item – Flat Aluminium Heat Pipe

Test Condition: High Temperature Exposure Test

Test Specimen:

Thickness	Width	Length
1.5	20	100
1.6	30	100
2.0	40	200
2.5	50	200



Test Procedure

1. After making 3 test specimens each, the weight and performance are evaluated.
2. Expose 2400 hours to a high temperature chamber of 125°C.
3. After exposure to high temperature, remeasure the weight and performance of the specimen.
4. The appearance and change characteristics are compared against the original measured values.

Test Equipment



Check Item	Dry Oven
Weight	No Weight Loss
Thermal Performance	No Performance Change
Surface Flatness	No Bulging Plane

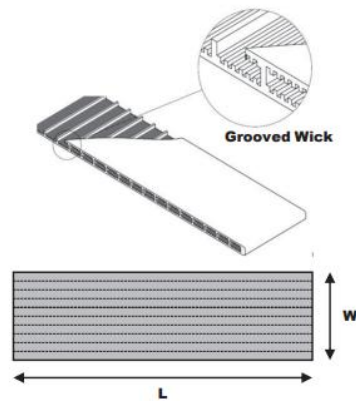
THERMAL CYCLE TEST

Item – Flat Aluminium Heat Pipe

Test Condition: Thermal Cycle Test (1500 cycles)

Test Specimen:

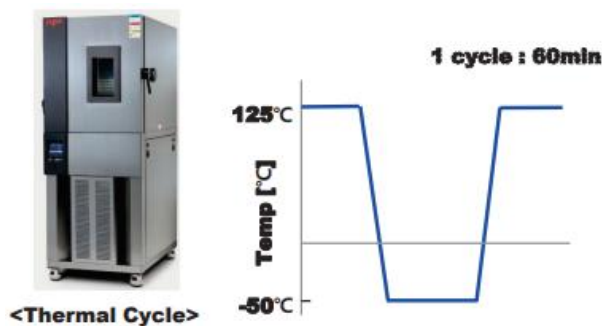
Thickness	Width	Length
1.5	20	100
1.6	30	100
2.0	40	200
2.5	50	200



Test Procedure

1. After making 3 test specimens each, the weight and performance are evaluated.
2. The test units are exposed to -50°C to $+125^{\circ}\text{C}$ using a thermal shock test equipment, 15 minutes of exposure in each temperature range.
3. After exposure to high temperature, remeasure the weight and performance of the specimen.
4. The appearance and change characteristics are compared against the original measured values.

Test Equipment



Check Item	Dry Oven
Weight	No Weight Loss
Thermal Performance	No Performance Change
Surface Flatness	No Bulging Plane